SAFETY IN GROUNDWORKS AND EXCAVATIONS

Your Practical Guide

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Introduction

This guidance document has been prepared to assist those companies and individuals that have responsibilities under the various legal statutes affecting the health and safety of employees at work. The guidance deals with the main hazards arising from excavations and groundwork's and provides risk management advice on topics such as risk assessments, excavation inspections, ground conditions, and methods of supporting excavations.

Between 1997 and 2002 there were 37 fatalities directly caused by the ground collapsing during excavation works. This was due to either the lack of support of the sides of excavations or an unsafe system of work. In almost all the fatal accidents, death was caused by asphyxiation due to the weight of the soil collapse: one cubic metre of soil weighs approximately one tonne.

It is therefore essential that the hazards and risks of groundwork's and excavations are recognised, and that safe systems of work are in place to eliminate and reduce accidents.

Definition of an Excavation

'Excavation' is defined as any earthwork, trench, and well, shaft, tunnel or underground working. Fuller details can be found in the Construction (Health, Safety and Welfare) Regulations 1996.

Risk Assessments and Method Statements

Before any excavation work is undertaken, a risk assessment must first be carried out to assess the degree of hazard. The results of the risk assessment will dictate the contents of the method statement; the method statement should then mirror the complexity of the excavation works to be undertaken.

Risk Assessment

The purpose of the risk assessment is to make an objective assessment of the hazards that will be involved in the excavation, and then to reduce or eliminate the risks.

When assessing the risks, it is useful to begin by considering the nature of the excavation itself:

- The previous use of the site.

The nature of the ground and any groundwater conditions, including:

- The type of soils conditions and its characteristics
- The groundwater level and soil permeability
- The depth of the excavation.

The nature of the work to be undertaken:

- Whether the excavated material can be re-used and, if not, disposal methods
- The type of excavation support system
- Whether there will be any temporary support (false work) and, if practicable, permanent support.

The location of the work, and any factors that can directly affect it, including:

- The proximity of roads and other activities
- The location of existing structures and services on and near to the site
- The position of new structures in direct relation to the excavation
- The amount of space available on site for storage and lay down of materials.

It is next helpful to consider the risks that will be present throughout the excavation:

- People may be
  - Struck or trapped or asphyxiated if the sides of the excavation collapse
  - Drowned if the excavation floods
  - Burned or suffer electric shock if existing underground services are damaged
- People, plant or materials may fall into the excavation
- Nearby structures may be undermined by deep construction work.

The risk assessment is also an opportunity to plan how the excavation will be conducted. The following hierarchy of risk control measures is a useful way of making sure that no risk is taken unnecessarily:

1. Wherever possible, avoid the risk in preference to applying or developing engineering type controls.
2. Use proprietary trenching systems that avoid the need for an employee to enter the trench until it is safe. You may wish to consider trench-less methods, battering the sides, trench boxes, etc
3. The use of simple drawings and sketches will be of more benefit to the employees than lengthy written documents.

The risks in excavation work should thus be reduced to as low a level as possible using the hierarchy of risk principles.

Method Statements

Method Statements are not a legal requirement, however they do provide a very effective means of communicating the agreed safe system of work to employees who will be working in and around any excavations.

The main purpose of the method statement is to pull together all the information identified in the risk assessment and to back up existing or specific training in the task to be undertaken.

In some circumstances, more complex method statements will actually specify a series of steps or the correct sequence of operations to be followed when undertaking a high-risk activity.

They can also be used to provide the principal contractor and any other contractors with information relating to health and safety that can affect their own employees who may be working in close proximity to excavations.

Management of the Work

All people who supervise with direct excavation work must be trained and experienced in excavations.

Excavation work should not begin until a risk assessment has been made and a method statement has been agreed. The method statement must always reflect the work activity to be done, and the information in it needs to be conveyed to all employees. This can be by thorough induction training or on-site toolbox talks. In all cases, employees must fully understand the system of work before they start their activities. All training and assessments that are carried out regarding the effectiveness of training must be recorded.

As the work progresses, management must regularly check that the agreed safety precautions are in place, and that the work is adhering closely to the method statement. Any changes to the system of work must only be made after consultation and agreement with everyone involved. Remember that employees may have to be retrained.

Excavation Inspections and Reports

A key management task is to measure the effectiveness of procedures. This forms part of the requirement to monitor and review health and safety precautions. Site supervisors need to be able to show this has been achieved, particularly in the case of high-risk operations.

There are specific requirements for inspection and reports, as laid down in the Construction (Health, Safety and Welfare) Regulations.

Contents of a Report

The report should contain the following information:

- The name and address of who the inspection was carried out for
- The location of the workplace inspected
- A description of the workplace, or the part of the workplace that was inspected (including any plant, equipment and materials)
- The date and time of the inspection
- Details of any matter that was identified which could constitute a risk to health and safety
- Details of the action taken when a risk to health and safety is identified
- Details of any further action considered necessary
- The name and position of the person making the report.

A report must be kept on the site where the work is being carried out, and retained for a further three months after the completion of the contract.

A typical inspection report form can be found in HS(G) 150: Health and Safety in Construction (ISBN 0 7176 1143 4).

Ground Conditions

The need for support

Excavation in loose sand or gravel, soft clays or silts always needs to be supported to prevent ground movement. This will often require the use of a support system which must be driven into the ground before beginning the excavation work.

If the excavation is in cohesive soils and in weak rock it may be able to stand unsupported, but this is still risky as the degree of support required will never be clear. In practice, therefore, excavations should always be supported.

The risks from surcharging

Surcharging – i.e. placing stored materials or spoil heaps too close to excavations, or operating plant (including vehicles) close to the trench – is a major factor leading to the collapse of excavations. It has the effect of introducing horizontal loading forces on the excavation sides. Surcharging must be avoided whenever possible, but if the nature of the site makes storage close to the excavation unavoidable, the assessment and design of the support system must take this factor into account.

To reduce the risk of surcharging, the following measures should be regarded as best practice.

- All spoil from the excavation should be located at least 1.5 metres away from the edge of the excavation
- As the depth of the excavation is greater than 1.5 metres, the edge of the spoil heap should be the same distance away. For example, if the excavation is 3 metres deep, the spoil heap should be 3 metres away.
- Loose boulders should be pushed into the spoil heap to prevent them from rolling down into the excavation and causing injury
- Temporary support structures must be increased if the excavation is adjacent to buildings and other structures
- Excavations on roads must always take account of the weight of passing vehicles
- Vehicle routes must be planned so as to maintain a safe distance from the excavation edges at all times.

Surcharging can sometimes be an inevitable result of the location of the site. Excavations on gradients or slopes will experience a loading on the side of the excavation caused by the extra weight from the uphill side, and the design of the supports needs to reflect this.

Risks which can lead to collapse

In addition to surcharging, a number of hazards will increase the danger of the excavation collapsing:

- Loose and uncompacted granular soils that contain sand or gravel
- The presence of heavy groundwater, and the effect on the sides of the excavation sides from surface water running into the excavation
- Loose blocks of faulted rock
- Excavations through different soil strata – for example, a weak layer (e.g. sand or gravel) lower down in an excavated face will generally undermine more stable layers above (e.g. clay)
- Weathering caused by rain, drying out or the effects of freezing and thawing (known as exfoliation)
- The proximity of earlier excavations, where the ground is likely to be loose and uncompacted
- Made-up ground, such as loosely consolidated fill material, old refuse tips, etc.;
- The proximity of loaded foundations
- Damage to the support system by personnel climbing in and out or when materials are lowered into the excavation
- Undercutting of a road pavement structure or kerbs and gullies
- Vibration from plant, equipment, road or rail traffic.

Risks from surface and ground water

- Surface water features such as streams and ditches need to be diverted if they cross the excavation
- If the site tends to attract surface water, the use of cut-off ditches should be considered to cope with surface run-off, particularly during rainy periods
- If land or field drains exist on the site, they should also be cut off and re-routed
- The presence of ground water is more difficult to deal with than surface water, as the sides of the excavations can be affected to the point where material is washed out from behind the support material
- In certain conditions the bottom of the trench can 'boil up', leading to the total collapse of the trench. In these extreme situations, careful analysis is required before excavation begins.

To cope with the hazards caused by ground water:

- Careful analysis of the site is required before the excavation begins wherever ground water is known or suspected to be a problem
- The use of de-watering systems such as well-pumping and well-pointing should be considered
- More recent technological advancements include ground stabilisation by freezing – which is usually extremely effective – or by chemical injection, when grout is injected into fissures, cavities or pore spaces. If draw-off sumps are used they can affect the stability of the excavation.

These remedies can sometimes bring their own problems, however.

- With de-watering systems there can be a tendency to draw silt with the water, thus creating voids which cause settlement of the adjacent ground. This in turn can lead to subsidence or collapse of adjacent structures. There is also the problem of how to dispose of the dirty or contaminated water. Such water must be considered as a pollutant and gives rise to the risk of pollution and the need for the resultant clean-up.
- When grout is injected, it may be difficult to be certain where the grout has gone into the ground.

Other risks caused by the ground conditions

- You should also consider the risk of loose rock falling from the face of the excavation, injuring someone in the trench or weakening the support system.
- When working in single-sided excavations (as in the case of a retaining wall construction), people can become trapped between the excavated face and the wall or shuttering.

Methods of Ground Support

Introduction

Whatever system of support is selected, it must always provide the highest level of safety to the user. In practice, this will mean the use of a proprietary system. The main benefit of using a proprietary system is that the installer does not need to enter the excavation until it is safe to do so.

Types of Proprietary System

Five main types of proprietary systems are available:

- Hydraulic walling frames
- Manhole shores
- Trench boxes
- Drag boxes
- Slide rail systems.

The use of commercially available proprietary ground support systems offers a number of distinct advantages over the more traditional systems:

- Operatives can install most proprietary ground support systems without the need to enter the excavation, so reducing the risk of injury to themselves
- Proprietary Systems are available to suit a wide range of applications
- Increased working space is provided to facilitate excavation pipe and cable laying
- Good technical advice is readily available on the selection, installation and use of the appropriate system
- Most of these systems can be hired.

Proprietary ground support equipment needs to be installed, removed and stored when not in use, all in accordance with the manufacturer's instructions.

Proprietary Systems Descriptions

- Hydraulic walling frames generally comprise two aluminium or steel beams braced apart by struts containing integral hydraulic rams. They can be used in a variety of configurations to support sheeting whether closed or open, i.e. 'hit and miss'.

- Manhole shores *are four-sided adjustable frames with integral hydraulic rams and are designed for supporting manholes. However they can be used for any four-sided excavation, including tanks pits, foundations, etc. Both manhole shores and walling frames require support to prevent displacement, and they are usually supplied with chains (or similar) so that they can be hung from the trench sheets or other frames.*
- Trench boxes *consist of modular side panels kept apart by adjustable struts to suit the width of the trench. The height can be increased by the addition of extension panels. The location of the struts is variable within limits, depending on the ground clearance required. The lower edges of the side panels are tapered to form a cutting edge. Boxes can be progressively dug in as the excavation work proceeds, or they can be lowered by an excavator or crane into a pre-dug trench. Where more than one box is required because of the depth, the boxes should either remain connected if they are lowered into a pre-dug trench, or they should be connected/disconnected at ground level by progressive excavation and back filling. Sufficient boxes need to be installed so that the full depth of the excavation is supported before any employees enter the excavation. If the excavation is overdug (widened), backfill needs to be placed between the excavation side and the box to prevent both the risk of people falling into the gap and/or rotation of the box following ground movement. If required, trench sheets can be positioned at the open ends to prevent material falling inwards. Some configurations of the box may be unstable when standing upright on the surface, and they should be either laid flat or 'dug in'.*
- Drag boxes *comprise two flat-bottomed side panels with tapered cutting edges to the leading ends. They are braced apart by tubular struts, with the leading strut strengthened to allow for the effect of dragging the box through the excavation. The use of box systems is limited to areas free of underground services or other obstructions. Box systems will provide safety to those using them if they are installed and removed in accordance with the manufacturer's instructions. As part of the safe system of work to prevent people from accidentally falling, the extension of the sheets or frames above the ground may afford some edge protection.*

Safe System of Work with Proprietary Systems

- Always obtain and follow the manufacturer's instructions for installation and use
- Always inspect the equipment before bringing it into use
- Always train and supervise the people who will be using the equipment
- Always use the correct tools for connecting and disconnecting hydraulic hoses and for releasing hydraulic pressure in the rams
- Always ensure that all hydraulic components are pressurised to the manufacturer's recommended working pressure – and are not over-pressurised
- Always use supporting chains or slings
- Always use additional equipment, if required, for stop-end protection
- Always inspect the installation regularly and in particular its hydraulic system (if fitted) – and if necessary carry out remedial or maintenance work to the system
- Always take care that equipment is not damaged by plant or by rough handling, and replace any equipment that is damaged – using only equipment or parts that are approved by the manufacturer
- Always clean, inspect and maintain the equipment following use, and store it in a suitable manner
- Always ensure that workers stay inside the protected area.

Other Types of Excavations and Supports

When working in much larger excavations such as reservoirs, single-sided supports may be used with some degree of safety.

Two main types of support are available:

- traditional raker shores with walrus and sheet piles
- self-supporting driven sheet piles.

Both these types of support need specialist design by competent engineers in order to calculate loadings and to determine the safety factors. Always make sure their advice is carefully followed.

Any instructions and directions need to be relayed to the work force and recorded. Additional information about the stability of the excavation must be included on any method statements, sketches or drawings that are provided for use.

In some cases, a single-sided excavation may be of rock, and thus may not require support. However, loose material may still fall down, and if there is any risk of this happening, the use of sprayed concrete or geotextile netting should contain the rock face.

In medium-sized excavations, i.e. for site drainage interceptors, the use of hydraulic walling frames – comprising large sections of steel beams braced apart by hydraulic jacks – will provide a safe excavation. In these circumstances, the wall support will normally be of heavy-duty sheet piles rather than trench sheets. Specialist design input is required by a competent engineer, and any special instructions need to be given to the employees and supervisors working in this area. As with all such information, it should be recorded.

Specially designed boxes are also available for grave excavations in cemeteries. The current good practice is to ensure no section of an excavation is started unless it can be made safe and secure before the end of the working shift.

Battering or Stepping

By battering back – or stepping – an excavation, the likelihood of an accident is reduced significantly, provided the correct angles are maintained. All soils have a safe angle of repose and under normal conditions should be self-supporting.

Safe angles of different soils and materials are likely to be:

- Wet earth 50°2
- Drained clay or rubble 45°3
- Gravel 40°4
- Shingle 39°5
- Dry sand 38°6
- Dry earth 28°7
- Gravel with sand 25°8
- Wet sand 22°9
- Wet clay 16°

Stability of Adjacent Structures and Services

Any excavation will cause ground movement because it creates unequal pressure on the ground. If an excavation is close to a building or other structure or services, it may cause undermining which results in damage to the structure. Worse, it could lead to collapse, and people could be trapped in the excavation.

Where the distance between an excavation and a building or other structure is less than twice the excavation depth, there is a potential for the ground to move. If this movement is resisted during excavation, there could still be a problem during backfilling operations – unless a sequenced backfill operation is strictly adhered to.

Backfill needs to be compacted in layers. All spaces or voids must be backfilled, including those created by the support equipment. The correct sequence must be followed, and the support equipment must not removed prior to completion as this may cause a collapse.

Underpinning Works

This type of excavation has the risks that the structure being underpinned may collapse and the working space available is often restricted. Good excavation principles must be followed at all times, but – depending on nature and size of the excavation – it may be necessary to limit the amount of material removed.

Special consideration is required during the design stage, as the support material may have to be 'concreted-in'. Normally, the underpinning is completed in blocks of four to maintain stability to the structure.

Only competent operatives, experienced and trained in this type of work, should be allowed to undertake it.

Overhead Power Lines

Although the main risk of striking an electric cable is underground, overhead power lines still represent a major hazard.

Modern plant and excavating equipment have a large enough operating scope to make contact with overhead power lines, or to operate close enough to them for a proximity discharge to occur (an electrical flash- over). The risk does not only arise from the use of excavators, but can include tipper trucks, mobile cranes, and other forms of mobile construction plant.

If work is adjacent to the overhead lines, it is good practice to liaise with the National Grid company and the local electricity supply company for competent advice on safe heights and distances. On larger site and works of longer duration, it is not uncommon to have overhead supplies diverted away from the areas of concentrated plant use and general construction activity.

As an additional control it may be considered prudent to 'limit' the degree of elevation on excavating equipment by retro-fitting devices called **limiters**. These prevent the boom or excavator arm from coming so close to an overhead power line that a proximity discharge could occur.

Where it is unavoidable to cross the path of the overhead lines, a safe route should be designated and agreed using 'goalposts' to mark the route and restrict the height of any plant that may cross below. All such instructions and sketches showing safe routes and height restrictions need to be formally acknowledged and recorded by everyone operating on the site. 'Goalposts' usually consist of plastic drainage pipes or wooden posts, painted red and white, with appropriate warning signs; any barriers should also be painted red and white to make them more visible.

Falls into Excavations

The risk of people falling into excavations is almost as serious an issue as falls from height or the ground collapsing.

Where there is a risk of someone falling into or onto something, all excavations must be fitted with suitable edge protection, i.e. double guard rails and toe boards. Although the legal requirement is that edge protection is not essential unless the depth of the excavation exceeds 2 metres, the profusion of reinforcing bars, water and other debris accumulated on sites can cause serious injury from a relatively small fall – for example, if the excavation is less than 1 metre. In practice, therefore, risk assessment guidelines should be drawn up and rigorously followed.

Plant and equipment can also fall into an excavation, and this too requires serious consideration. Any plant or traffic should be routed away from the excavation as a matter of good safety management. Where there is a need for plant to dump material into the excavation, suitable stop blocks and a banksman need to be provided.

If an employee needs to cross a trench, a properly constructed access should be provided, i.e. a walkway at least 600 mm wide, with guard rails and toeboards where necessary.

Where an excavation is in a public area, a much higher standard of protection must be adopted to prevent members of the public from inadvertently trespassing on to the site and injuring themselves as a result. The provision of barriers and/or fencing is essential. Several types of fencing are available to suit most applications. All fencing and hoarding needs to be maintained, with records kept of inspections and of any remedial works that is carried out.

Access and Egress from Excavations

A safe means of access and egress is essential for employees in excavations. This will usually be provided by means of a ladder.

Any ladder used for access must be positioned at a 4 in 1 angle – so that there is a height to base ratio of 4 metres up to 1 metre out. Ladders must be secured at their highest point, with a protrusion of at least 1 metre above the point of landing in order to provide an adequate handhold.

A safe means of egress is also essential in case of an emergency, such as if the trench collapses, there is a build-up of fumes, the excavation suddenly floods or indeed any other emergency occurs. The means of egress must form part of any emergency plan for the site.

Walking up the battered end of the trench is unsafe and must be strongly discouraged: this section of trench is often unsupported and there is a significant risk of collapse and injury.

Use of Construction Plant

One of the main hazards for construction plant is the risk of driving or toppling into the excavation.

This most frequently occurs if the plant is driven to the edge of the trench for the purpose of discharging, but fails to stop. Providing stop blocks and banksmen will prevent this from happening.

Another potential hazard is ground collapse. This can happen because the extra loading that results from the presence of plant and equipment renders the support to the excavation sides inadequate. Most plant is mechanical and the subsequent vibration from its operation can also cause collapse.

Plant should always be directed away from the edges of the excavation by carefully planning and providing suitable traffic routes. Employees must be made aware of these basic principles and they should adhere to them at all times.

Any plant used to lift materials and support equipment must comply with the Lifting Operations and Lifting Equipment Regulations 1998. The lifting equipment must always have a sufficient load lifting capacity for the task.

Lifting operations must always be planned with care. Special consideration should be given to:

- The ability of the ground to support the lifting equipment and the load
- The load and the working radius anticipated
- Any extra loading on the adjacent ground that could affect the excavation
- The need always to use the correct lifting attachments and lifting equipment, such as chains and shackles.

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