BRE Digest

Concise reviews of building technology

Digest 381

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CI/SfB (A3s)

# Site investigation for low-rise building: trial pits

**The main objective of a site investigation is to examine the ground conditions so that the most appropriate type of foundation can be selected. A typical site investigation begins with a desk study and a walk-over survey to establish the general geology of the site, and continues with an examination of the geotechnical properties of the ground.**

**There are many techniques but boreholes and, in particular, shallow trial pits can provide an economic and versatile way of examining and assessing the *in situ* soil conditions. The technical requirements of the investigation, rather than the cost, should be the controlling factor in the selection of the investigatory methods.**

Attention is drawn to the box on *Safety* on page 6.

Ground investigation of a building site provides geotechnical data which can be used to assess the influence of the ground conditions on the construction of the proposed building. Its success is usually dependent on the ability of the engineer to understand fully the extent of the problems which the soil conditions may impose on the building's foundations.

The main advantages of trial pits over boreholes are that they allow a detailed examination of the ground *in situ* and that they provide an indication of the 'digability' and subsequent stability of the ground. Their disadvantages are that they are usually limited in depth and that undisturbed sampling from trial pits is not always straightforward.

The soil properties that must be considered, either *in situ* or by laboratory testing, are determined by:

- the soil types involved;
- the layout of the proposed building;
- the building loads imposed on the ground.

The extent of the ground exploration and the selection of appropriate techniques for foundation studies depend on:

- the topography of the site, and the anticipated geological and groundwater conditions;
- the type and size of the building and its foundations;
- the amount of existing geological and geotechnical information;
- the possible presence of aggressive chemicals; if this is suspected, carry out a detailed soil analysis;
- external constraints, such as cost and time available for completing the construction.

**Fig 1** A trial pit

Building Research Establishment

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Ground investigation is normally conducted using trial pits and boreholes.

In *A review of routine foundation practice* [1], BRE reports on a survey of current practice in the design of foundations for buildings up to four storeys in England and Wales. The report concludes that for foundations for low-rise buildings, where only shallow depths are to be investigated and where groundwater problems are not anticipated, trial pits may prove to be both versatile and economical. The survey reviewed details of 288 site investigations; about 50% were carried out by soft-ground percussive boring, and about 35% by excavating 'shallow' trial pits – see Fig 2. The survey also draws attention to the unsatisfactory manner in which many trial pits were logged, indicating the need for the guidance provided in this Digest.

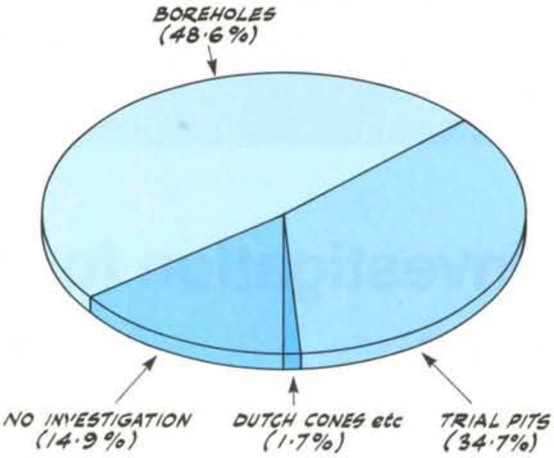



**Fig 2** Results of a survey of different investigation procedures used for site investigations for low-rise buildings

## TRIAL PITS

Trial pits are dug mechanically or by hand and are generally used:

- To facilitate detailed examination of ground conditions down to about 4 m (defined as *shallow*). Disturbed samples may also be taken for water content and liquid and plastic limit determinations; simple tests, such as hand vane strength measurements, can be made to aid soil descriptions.
- To obtain 'undisturbed' samples, by driving sample tubes into the base or side face of the trial pit ( a process not as easy as it seems) or by taking high quality block samples, which may be cut from a bench formed in the trial pit – see Fig 1. Such samples are used for laboratory testing to determine the engineering properties relevant to the foundation design.
- For more intensive *in situ* testing, such as plate bearing tests.
- To examine the ease of excavation or the subsequent behaviour of excavated ground.

*In situ* tests can usually be omitted for low-rise buildings if accurate soil descriptions can be made.

## EXCAVATION OF TRIAL PITS

Many different types of machinery can be used, including drag-line excavators and front-bladed crawler tractors. The most appropriate excavators, though, are back-actors (back-hoes); they consist of a power unit operating through a hydraulically powered, jointed arm which draws the bucket towards the machine. Because of the back-actor's configuration, the excavated face is normally below the level of the machine; this makes it efficient and well suited to ground excavation. The excavating bucket can also be articulated relative to the jib, making it possible to dump the excavated material into lorries.

Most wheeled back-actors are similar in size and weight (about 80 kN); tracked back-actors vary in size from the very small (50 kN), through the commonly available medium (150 kN), to the large (300 KN) machines. Tracked back-actors require low-loader transporters to travel on surfaced roads (or matting to protect the road surface for short distances) and they can travel only slowly from pit to pit. However, they cause negligible damage to soft surfaces and are more efficient for excavating deep trial pits. The main advantage of wheeled over tracked back-actors is that they can move to the site of excavation independently and can travel quickly between trial pits.

For shallow trial pits, a back-actor of the JCB 3C-type is generally most appropriate. For deeper pits, down to about 6 m, tracked excavators are generally more satisfactory [2].

### Hand excavation

If conditions make it difficult to excavate with mechanical excavators, pits must be excavated by hand. This is discussed in BS 6031 but might occur:

- where the ground surface is steeply inclined, or where working space is restricted;
- at road and railway crossings, where a machine would interfere with traffic;
- on sites where there are services, such as electricity cables, drains, water or gas mains;
- on very poor ground which is incapable of supporting the weight of a machine;
- where it is economically justified to use hand labour.

## SUPPORTS FOR TRIAL PITS

Soil descriptions and disturbed samples can sometimes be taken from excavated material as it is brought to the surface. If a pit is to be entered, it *must* be properly supported, unless it is shallower than about 1.2 m

It is not generally necessary to design specifically support systems but in shallow pits the soil type may well determine the type of support used. There is an unavoidable conflict between the need to support the sides of the trial pit, and to have access to the side of the pit to be examined. Individual judgement will be required in every case to ensure that the support system is adequate for the nature of the ground.

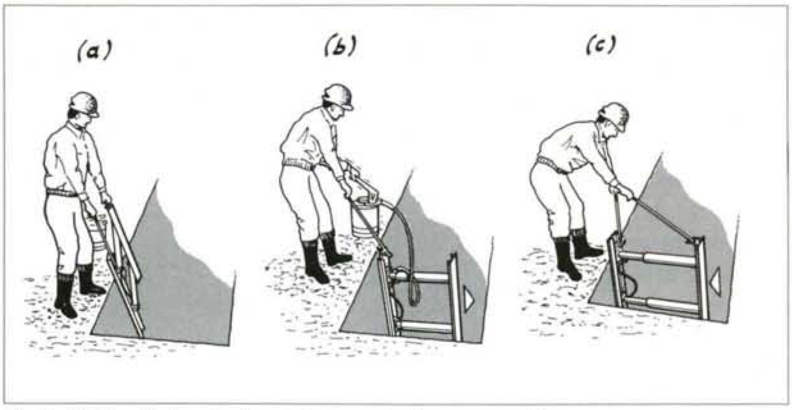



**Fig 4** Hydraulic trench shores; they need only one operative
(a) and (b) installation
(c) removal

If it proves impossible to install supports to the sides of the trial pit, or if there is any doubt as to the stability of the pit, *do not descend into the pit,* but examine material as it is brought to the surface.

### Clay soils

The installation of supports is straightforward if one of the proprietary systems of lightweight aluminium hydraulic shores is used. Widely available, they are ideal for use in the stiffer clay soils; with care, they can also be used in softer clays. They consist of strutted shores, pre-assembled in rectangular units (frames), that can be lowered into the trial pit and then expanded by means of a hand-operated hydraulic pump – see Figs 3 and 4. This type of trench-shore should be used wherever possible because operatives do not need to enter the unsupported trial pit either to place or to remove the shores.

Frames are available in a variety of sizes up to 2 m deep for vertical shores, and capable of supporting pits up to 5 m wide. For convenience, the excavator bucket should be the same width as the shores to be used, and the trial pit excavated to the width of the bucket.

Shallow trial pits are best excavated 1 m wide, or slightly greater, and about 4 m long. At this length, at least two sets of hydraulic shores should be used, equally spaced within the pit. With soft clays, more support may be needed.

Vertical timbers, or metal trench sheets supported by Acrow props, are not recommended because installation and removal are difficult unless someone enters the unsupported trial pit.

### Granular soils

The most important aspect of trial pit excavation in granular soil is the depth of the water table. If the soil is dry, and the water table is below the base of the trial pit, there will be some collapse of the sides with coarse grained soil. Finer-grained soils (predominantly sands or silts), particularly if dense, will stand quite steeply and allow the placing of trench shores. However, the supports may need to be closely spaced to avoid progressive deterioration of the sides of the pit.

If the water table is encountered in the depth of the pit, collapse can be expected; except in exceptional circumstances, the excavated ground must be examined from the surface. There may still be merit in excavating trial pits even under these circumstances, since the pits will provide information on the excavation and groundwater problems that could be encountered when construction begins.

**Fig 3** Hydraulic trench shores and hand-operated hydraulic pump; the lowering handles also operate the pressure release valves

### Back-filled ground

Particular care should be taken to support trial pits excavated in soil used as backfill ('made ground') as this will have less strength than natural soil with an apparently similar composition.

## LOGGING TRIAL PITS

The primary purpose of excavating trial pits is to examine the type and sequence of geological deposits present at the site. An essential part of the examination is a complete description of the soils (including fill) or rocks present.

In most cases, it will be sufficient to measure and describe in detail the sequence of soil types encountered in the trial pit, taking soil samples for water content and index tests where appropriate. Occasionally, however, the project may demand more sophisticated detailed logging of the trial pit, including precise measurement of features encountered, such as landslide shear surfaces.

It is usually easiest to describe and log the vertical side as the pit is deepened. It is always helpful to watch the excavation process; important evidence concerning the ground conditions may be lost if this is not done, particularly in clay soils where the sides of the pit are often smeared by the digger bucket. Shear surfaces in landslides are often most easily discovered as they are exposed in the base of the pit, and can sometimes be followed for some distance by careful digging with a small spade. Once exposed in this way, the position of such features should be carefully recorded so that they can be relocated after the pit has been deepened and included in the trial pit log.

In clay soils, the smeared side of the pit will have to be removed by hand to expose the undisturbed soil beneath. This can be done with a broad-bladed knife or small garden trowel. In harder soils, such as chalk or soft rock, the pick of a geological hammer can be used.

### Profile logging

This is the usual type of logging for low-rise buildings; it is the only way if logging is carried out on disturbed material as it is brought to the surface. In this case, depths must be determined by frequent plumbing with a tape measure; close-focusing binoculars can be used to inspect the sides of the pit.

It is usually better to examine the ground *in situ.* Expose a vertical strip of soil, about 0.5 m wide, by removing the smeared surface of the side of the pit with trowel or knife. A tape suspended from the ground surface will provide a useful reference for the logging process. Examine the exposed strip first to decide the number of soil strata present, and then describe each stratum.

Take particular note of depths at which samples are taken for index tests or to determine water content. Add the results of these tests to the soil profile.

### Detailed logging

It can be valuable to log the whole of the face of the pit, for example when landslide shear surfaces are encountered. The starting point, as with profile logging, is to expose sufficient of the smeared face of the pit to enable the undisturbed soil to be examined in detail.

Mark the face of the pit with a grid of horizontal and vertical lines (at about 0.5 m spacing), scribing the lines with the point of a knife in clay soils. Spray paint or a felt-tip marker can be used for some soft rocks or coarse granular soils. Use a 1 m bricklayer's level to mark out the horizontal lines, and a plumb line for the verticals.

When the grid has been marked out on the face of the pit, it can be transferred to a sheet of graph paper. Use A3 paper on a clip-board and draw to a scale of 50 mm to 1 m for the graphical log. A polyethylene bag, large enough to take the clip-board, will help to protect the graphic log in a wet and muddy pit.

Record the pit outline, followed by the logged soil details, especially structural features and soil-type boundaries. These details can be plotted quickly and with considerable accuracy using a tape, measuring from the grid lines.

A blank form for trial pit logging is on page 7.

Examples of profile and detailed logs for two trial pits are shown on pages 8 to 11.

## UNDISTURBED SAMPLING IN TRIAL PITS

Tube sampling is often attempted in trial pits at 38 mm diameter using U38 sampling tubes, and at 100 mm diameter using U100 sampling tubes. U38 tubes can be pushed in by hand and retrieved by digging out with a spade. This is not easy with U100 tubes so the bucket of the digger is often used, but as the bucket moves across the long axis of the tube, the tube tilts and disturbs the sample. A better method is to lock the excavator bucket in position and use the bucket as support for a jack to drive the tube into the side or base of the pit.

Block sampling is described in detail in the *Site investigation manual* [(2)]. It is often carried out in trial pits though not usually for low-rise construction.

## BACKFILLING

Move the turf and top soil to one side before excavating the main body of the trial pit. Backfill the pit as far as possible by compacting in layers, tamping each layer thoroughly with the bucket of the machine. Place any excess material in a mound over the the pit to accommodate any future subsidence. Replace the top soil and turf.

On contaminated sites, it may be necessary to arrange for the disposal of at least some of the excavated material to a properly licensed disposal site. Backfilling should be completed using 'clean' material, imported to the site if necessary.

**IMPORTANT POINTS ON A TRIAL PIT LOG**

- date of excavation;
- location of pit on the site;
- ground level of pit;
- overall dimensions of the pit;
- excavation techniques used;
- ease of excavation;
- groundwater conditions encountered;
- stability of sides of trial pit;
- whether logged from the surface or *in situ*;
- full soil descriptions and stratum depths;
- where undisturbed samples are taken, the exact location and orientation of the sample relative to the pit floor and walls;
- where disturbed samples are taken, or *in situ* tests are carried out, the exact location relative to the pit floor and walls;
- *In situ* testing.

The experience of the digger operative may be of value in reporting the 'digability' of the ground.

**EQUIPMENT FOR TRIAL PIT LOGGING**

- trowel and/or broad-bladed knife;
- geological hammer;
- notebook, pencil, eraser;
- graph paper;
- clip-board (with polyethylene bag cover);
- tape measure;
- compass/clinometer;
- sample containers (tins; polyethylene bags; cling film);
- spade;
- bricklayer's level;
- plumb line.

**SAFETY**

The length of time that a trial pit remains stable depends largely on the soil type and the groundwater conditions. Trial pits in clay soils are at their most stable immediately after excavation but stability then reduces, owing to the progressive weakening of the clay forming the sides of the pit.

With free-draining soils (sands and gravels), any instability generally develops within a much shorter time than with clay soils, collapse often occurring as the pit is dug.

Once excavated, trial pits should never be left open when unattended unless they are properly fenced.

The risk of collapse is increased significantly if the trial pit is excavated in sloping ground or at the bottom of a slope. The risk is even greater if the slope is subjected to landsliding. It is good practice on slopes to align trial pits directly down the slope. Not only does this usually provide more information, but the potential stability is improved.

Because trenches are inherently less stable than pits, their use is discouraged.

The risk of failure is increased by the weight of excavated soil or construction vehicles loading the sides of the pit. Always place spoil away from the excavation and keep vehicles clear.

There is a risk of failure if the pit is dug close to previous excavations, even if they were backfilled years earlier. These excavations may have been dug for investigation purposes, or for the installation of services.

If the sides of the trial pit are not supported, or if there is any doubt as to the stability of the pit, *do not descend into the pit*, but examine material as it is brought to the surface.

An observer should always be present at the side of the pit when anyone is in the pit, particularly when the pit sides are being logged.

Always wear safety clothing, such as hard hats and steel-capped footwear, when entering pits.

Consider oxygen deficiency and the presence of toxic or flammable gases and other contaminants.

Gases can originate from sources such as landfill waste and coal measures (these include carbon monoxide, carbon dioxide and methane), or even exhaust gases from the excavator.

Contaminants might remain from previous industrial use of the site, such as steelworks and gasworks, and include heavy metals, coal tars and phenolics.

On contaminated land, do not excavate before making a full assessment of possible health and safety and environmental implications of the operation. Logging should normally be done from the surface and appropriate protective clothing should be worn.

For more information, refer to *Protection of workers and the general public during the development of contaminated land.*

**ENVIRONMENTAL PROTECTION**

On contaminated or potentially contaminated sites, take care to ensure that trial pits do not penetrate a confining low-permeability layer protecting an underlying aquifer. Do not allow excavated material to be washed or blown from the site and ensure that the site is left safe.

**TRIAL PIT No:** **JOB No:** **JOB NAME:**

**Logged** *in situ / from ground surface:* by .................................................... on: ...............................

**Ground level:**

**Date excavated:**

**Weather:**

**Excavator type:**

**Bucket width:**

**Pit support system:**

**Pit stability:**

**Groundwater observations:**

**Sketch of trial pit:**
(dimensions in metres)

**Trial pit log:**
Depth (m) Soil description and sample depths

**TRIAL PIT No:** 1 **JOB No:** 124 **JOB NAME:** BUSSINGBY

**Logged** *in situ* / ~~*from ground surface*~~: by RJC on: 07-09-89

**Ground level:** 89·6 M OD

**Date excavated:** 07-09-89

**Weather:** FINE

**Excavator type:** JCB 3C

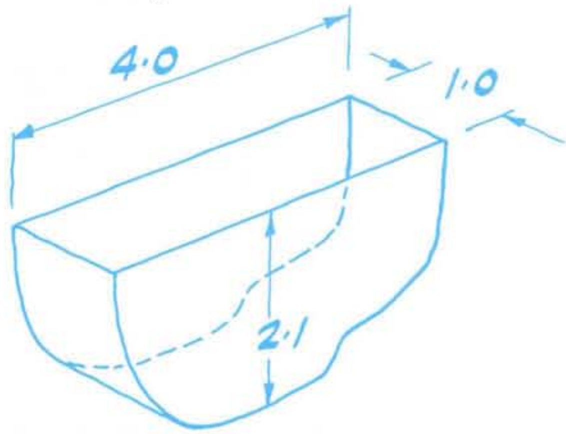
**Bucket width:** 1 M

**Pit support system:** HYDRAULIC SHORES

**Pit stability:**
NO INSTABILITY PROBLEMS

**Groundwater observations:**
NONE ENCOUNTERED

**Sketch of trial pit:**
(dimensions in metres)



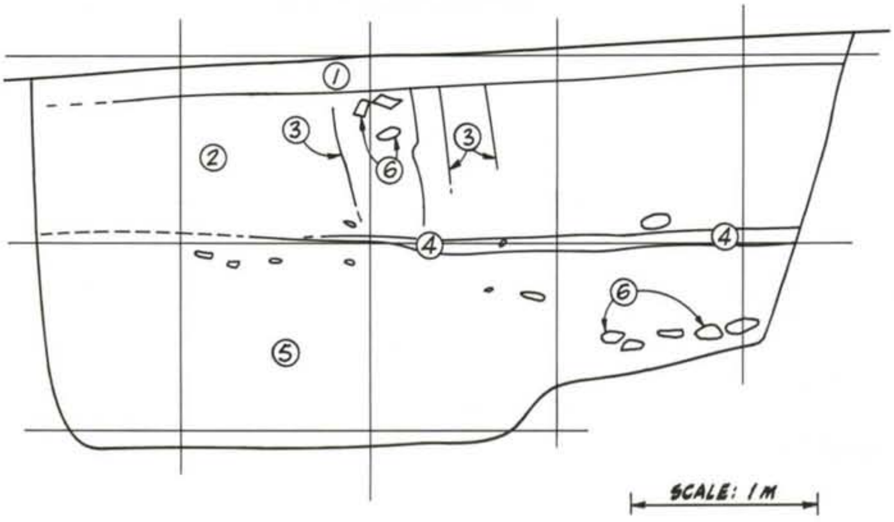

**Trial pit log:**

| Depth (m) | Soil description and sample depths |
|---|---|
| 0 - 0·17 | FRIABLE, DARK GREY ORGANIC SANDY SILT (TOP SOIL) |
| 0·17 - 0·92 | STIFF, MEDIUM BROWN MOTTLED ORANGE SILTY CLAY, WITH RARE ANGULAR FRAGMENTS OF SANDSTONE AND SILTSTONE UP TO 150 MM MAXIMUM DIMENSION. OPEN, NEAR-VERTICAL CRACKS (UP TO 5mm WIDE), INCLINED SLIGHTLY DOWN-SLOPE; SURFACES SMOOTH, WITH CLAY COATING. (HEAD) |
| 0·92 - 1·00 | HARD, FRIABLE, DARK BROWN MOTTLED YELLOW CEMENTED SILTY CLAY. (PRECIPITATED 'IRON PAN'?) |
| 1·00 - 2·10 | SOFT TO FIRM GREY MOTTLED PALE BLUE SILTY CLAY; STRUCTURELESS, BECOMING FIRMER, MORE FRIABLE, AND FINELY FISSURED WITH DEPTH. (COAL MEASURES) |

(BASE OF PIT AT 2·10M; NO SAMPLES TAKEN.)

Profile log for a trial pit in Coal Measure shales

*Photograph and section drawing of the trial pit logged on page 8. The smeared clay has been removed from the whole of the face of the pit. Note the lines scribed on the pit sides for logging purposes.*




1 Friable, dark grey organic sandy SILT (TOP SOIL)
2 Stiff, medium brown mottled orange silty CLAY, with rare angular fragments of sandstone and siltstone up to 150 mm max dimension
3 Open, near-vertical cracks (up to 5 mm wide), inclined slightly down-slope; surfaces smooth, with clay coating (HEAD)
4 Hard, friable, dark brown mottled yellow cemented silty CLAY (Precipitated 'iron pan'?)
5 Soft to firm grey mottled pale blue silty CLAY; structureless; becoming firmer, more friable, and finely fissured with depth (COAL MEASURES)
6 Angular siltstone fragments to 150 mm (base of pit at 2.10 m; no samples taken)

**TRIAL PIT No:** 2 **JOB No:** 160 **JOB NAME:** CHATTENDON

**Logged** *in situ* / ~~*from ground surface*~~: by RJC and AHH on: 16 & 17-07-90

**Ground level:** 16·2M OD

**Date excavated:** 16 & 17-07-90

**Weather:** FINE

**Excavator type:** JCB 3C

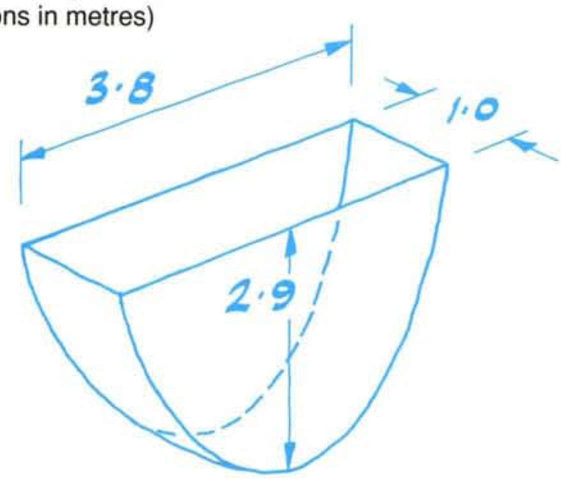
**Bucket width:** 1 M

**Pit support system:** HYDRAULIC SHORES

**Pit stability:**
NO INSTABILITY PROBLEMS

**Groundwater observations:**
DRY LAND DRAIN AT 0·85M; SLIGHT SEEPAGE AT ABOUT 2 M

**Sketch of trial pit:**
(dimensions in metres)

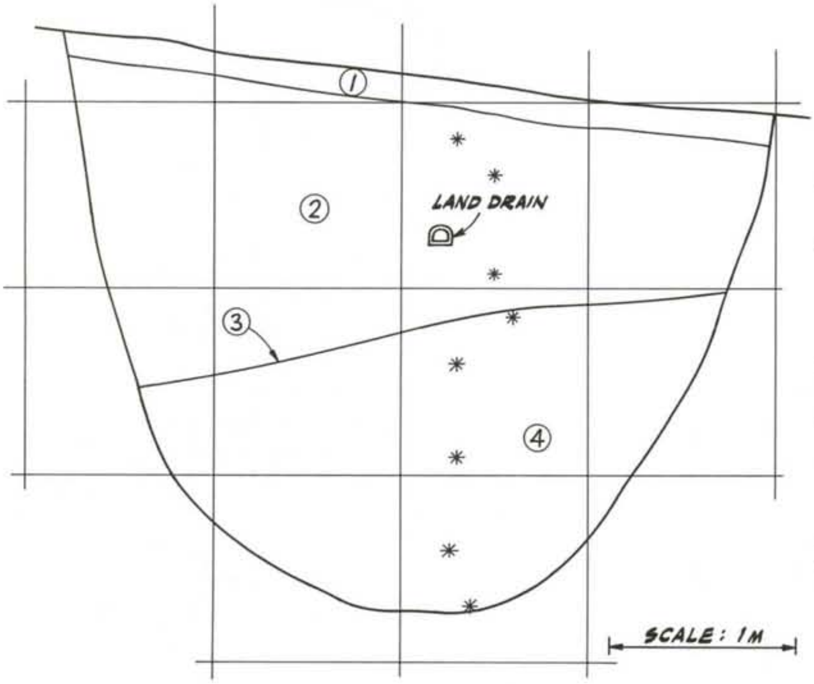



**Trial pit log:**

| Depth (m) | Soil description and sample depths |
|---|---|
| 0 – 0·30 | GREY-BROWN FRIABLE SILTY CLAY WITH FINE ROOTLETS AND FRQUENT ROUNDED MEDIUM GRAVEL (TOP SOIL) |
| 0·30 – 1·35 | SOFT TO FIRM BROWN CLOSELY FISSURED SILTY CLAY WITH OCCASIONAL ROUNDED FLINT GRAVEL FRAGMENTS BETWEEN 0·30 AND 0·50M<br>NEAR VERTICAL CRACKS TO 1·10M, AND OCCASIONAL FINE ROOTLETS TO 1·3M (HEAD)<br>* DISTURBED SAMPLES AT 0·30M 0·50M 1·00M 1·20M |
| 1·30 – 1·50 | POLISHED AND STRIATED SHEAR SURFACE, DIPPING AT ABOUT 0·8°, STRIATIONS AT N009°E |
| 1·35 – 2·90 | FIRM BROWN CLOSELY FISSURED SILTY CLAY; SOME BLUE-GREY STAINING ON FISSURE SURFACES. FISSURE SPACING INCREASING TO 20–100MM AT 2·20M AND BELOW, WITH OCCASIONAL SELENITE CRYSTALS BETWEEN 2·1 AND 2·4M (LONDON CLAY)<br>* DISTURBED SAMPLES AT 1·50M 2·00M 2·50M 2·80M |

Profile log for a trial pit in London Clay. The site is on a gentle slope; there is a solifluction layer which overlies the *in situ* London Clay, with a polished and striated shear surface at the base of the solifluction layer.

*Photographs and section drawing of the trial pit logged on page 10.*
*The view from above shows the shear surface underlying the solifluction layer in the trial pit. The whole of the shear surface was exposed at an intermediate stage in excavating the pit.*
*Note the high polish of the surface and the grooves and striations which show the direction of movement.*




1 Grey-brown friable silty CLAY with fine rootlets and frequent rounded medium gravel (TOP SOIL)
2 Soft to firm brown closely fissured silty CLAY with occasional rounded flint gravel fragments between 0.30 and 0.50 m. Near vertical fine (1-2 mm wide) cracks to 1.10 m, and occasional fine rootlets to 1.3 m depth (HEAD)
3 Polished and striated SHEAR SURFACE, dipping at about 8° striations at N009° E
4 Firm brown closely fissured silty CLAY; some blue-grey staining on fissure surfaces. Fissure spacing increasing to 20 - 100 mm at 2.20 m and below, with occasional selenite crystals between 2.1 and 2.4 m (LONDON CLAY)

* disturbed samples
(base of pit at 2.90 m)

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