Purposes of site investigations

The purpose of a site investigation is to identify the ground conditions which might affect the proposed development. It enables better understanding of the site and immediate surroundings, which will enable safe and economic developments. They are a common requirement of the investors as well as the regulatory authorities.

In the broadest sense, the ground conditions are understood to include not only the underlying soils and rocks but also the groundwater regime, any contamination and effects of any previous uses of the site

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1. 1. 1 The scale of problem

Various reports over the past 25 years have shown that the largest element of technical and financial risk normally lies in the ground. Ground related problems have led to late completions and high cost overruns on the national scale.

In an analysis of 8000 building projects, National economic Development office (NEDO) stated that one third of the projects overran by more than a month, a further one third overran up to a month due to delays due to unforeseen ground conditions.

1. 2 Why carry out site investigations?

The characterization of ground conditions whether for a ‘ greenfield’ or a previously developed ‘ brownfield’ site will include both the geotechnical and the geo-environmental issues. Site investigations can be required for both

geotechnical and geo-environmental purposes and for many projects it would be advantageous to combine the investigations with resulting economics in cost, time and site disruption.

The investigations should allow a comprehensive risk assessment of the ground conditions to be made from which a programme of risk management can be developed,

The risks which may be defined can be health risks (from previous contamination of land), engineering risks (posed by difficult ground conditions), regulatory risks or financial risks, all of which may arise from unforeseen ground conditions and liabilities.

The object of the site investigation is to characterize the ground conditions sufficiently to allow safe and economic design to be developed and to reduce, as far as possible, the occurrence and impact of unforeseen conditions.

Objectives of Site Investigation

The principal questions for site Investigation would be as follows:

- Suitability: Are the site and surroundings suitable for the project?
- Design: Obtain all the design parameters necessary for the works.
- Construction: Are there any potential ground or ground water conditions that would affect the construction?
- Contamination: Any possibilities of the site being contaminated?
- Materials: Are there any materials available on site, what quantity and quality?

- Effect of changes: How will the design affect adjacent properties and the ground water?

In addition to these, it is necessary to investigate existing features of the natural ground.

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What does site investigation involve?

Site Investigation is the gathering of information about the proposed location of the project. The process of site investigation can be separated into the following areas:

Objectives of Site Investigation (SI)

- Desk study
- Planning
- Ground investigation (GI)
- Trial Pits
- Boreholes
- Sampling
- Reporting

The sequence of a site investigation is as follows:

Desk Study

Site Reconnaissance -Walk-over study

Preliminary report or feasibility study

Preliminary Ground Investigation – Planning of main GI

Preliminary report

Main Ground Investigation

Laboratory testing

Final report

On-site Groundbreaking Work

Trial pits – by hand or excavator

‘ Lightweight’ and ‘ Heavyweight’ boring and testing equipment

Laboratory soil testing (eg. plasticity of Clays

1. 3. 1 Desk Study

According to the NHBC standards chapter 4. 1, all sites must be assessed by a Desk Study and Walkover Survey (Clauses D1-D3).

Desk Study should be carried out for every development prior to any intrusive site investigation.

The desk study is work taken up prior to commencing the work on site and the Ground Investigation. It should always be the first stage of the Site Investigation and is used to plan the Ground Investigation. The work involves researching the site to gain as much information as possible, both geological and historical.

The desk study examines and draws together existing information from a variety of sources to form an initial appraisal of possible ground conditions and to consider past uses and current status of a site.

This provides a preliminary assessment of the geotechnical and geo-environmental risks which may be associated with the site.

Records of Previous SI reports are also helpful in a desk study. The many sources of SI data include previous company reports,

Services records are also an essential part of the desk study, necessary to locate hidden services such as electricity cables, sewers and telephone wires. This in formation is usually provided free of charge by the relevant service provider. A suggested list of sources is: Local Authority; British Telecom; Electricity Company; British Gas; Water Companies.

It is also essential to check for the location of former mine workings as these can considerably affect construction and lead to cost increases. The location of these mines may be difficult but help can be found from the Divisional Plans Record Offices of the National Coal Board

It is essential when conducting a desk study that as much information as possible is obtained. Work at this stage of the Investigation saves much time later and vastly improves the planning and quality of the Investigation.

1. 3. 2 Walk-over survey

Walk -over survey of a site can give valuable insight into potential ground condition problems (for example slope instability or shallow groundwater)

and contamination issues. Such site visits often give rise to anecdotal contributions by local residents.

The Site Reconnaissance phase of a site investigation is normally in the form of a walk over survey of the site. Important evidence to look for is:

- Hydrogeology: Wet marshy ground, springs or seepage, ponds or streams and Wells.
- Slope Instability: Signs of slope instability include bent trees, hummocks on the ground and displaced fences or drains.
- Mining: The presence of mining is often signs of subsidence and possibly disused mine shafts. Open cast mining is indicated by diverted streams replaced or removed fence/hedge lines.
- Access: It is essential that access to the site can be easily obtained. Possible problems include low overhead cables and watercourses

The combination of desk study and walk-over survey is an extremely cost-effective first stage in an investigation. It provides early warning of potential problems and a sound basis for the scope of intrusive investigation which is to follow.

The desk study and walk-over survey can also provide early recognition of site

issues such as ecology and archaeology which may have profound implications in both programme and financial terms.

1. 3. 2 Planning a Site Investigation

Dumbleton And West2 have discussed the planning and direction of site investigations. They state that " the main investigation is the full investigation of the site using boreholes and trial pits and includes the preparation of the site-investigation report with revised plans and sections, interpretation and recommendations for design."

They consider that there are two aspects to the site investigation.

- The geological structure and character of the site and
- the testing of the soil both in the laboratory and in-situ.

They suggest that the planning should consider the following questions.

Is the succession of strata known over the whole site and is there correlation across the whole site known?

Are the different strata fairly homogeneous over the site or do local variations exist? Are there more complex areas of strata that require investigation or closer examination during construction? Will there be areas where the excavated material will be unsuitable for fill and will need to be replaced?

Are there areas where needs to be assessed to ascertain working methods?

Will any part of the site be subject to flooding? What contact will there be with water bearing strata and will ground water lowering methods be required during construction?

Do requirements for the carrying out of special in-situ tests or the taking of undisturbed samples affect the conduct of the qualitative investigation? For example, with forethought a single trial pit may be made to serve both for examining ground materials and structure, and for the in-situ testing and the taking of block samples.

1. 4 Ground Investigation

Ground investigation is taken to be that other than the information available from the walk over survey as discussed previously.

There are two principal methods of investigating the ground conditions, trial pits and boreholes. In addition, the reader should be aware of geophysical techniques such as seismic surveys, which are not discussed here.

1. 4. 1 Trial Pits

Trial pits are shallow excavations going down to a depth no greater 6m. The trial pit as such is used extensively at the surface for block sampling and detection of services prior to borehole excavation.

Depth

Excavation Method

0-2m

By Hand

2-4m

Wheeled Back Hoe

4-6m

Hydraulic Excavator

An important safety point to note is that ALL pits below a depth of 1. 2m must be supported. In addition care should be taken as gases such as methane and carbon dioxide can build up in a trial pit. Breathing apparatus must therefore be used if no gas detection equipment is available.

Support for a trial pit generally takes one of three forms:

Timbering

Steel frames with hydraulic jacks

Battered or tapered sides

Three types of sample can be taken from a trial pit:

Disturbed Sample – Samples where the soils in-situ properties are not retained.

Block Sample – A sample that is not undisturbed but retains some in-situ properies.

Push in tube sample – Tube samples of the soil in a trial pit.

When preparing a trial pit log, the following information should be included. The location, orientation and size of the pit; sketches of faces; depth scale; root structur; water level; seepage. In addidtion the weather at the time of sampling should be noted as many soils are weather dependant.

It is extremely important when finished to reinstate the trial pit as well as possible.

1. 4. 2 Boreholes

A borhole is used to determine the nature of the ground (usually below 6m depth) in a qualitative manner and then recover undisturbed samples for quantitative examination. Where this is not possible, for in gravelly soils below the water table, in-situ testing methods are used.

Obviously the information gained from a borehole is an extremely limited picture of the subsurface structure. It is therefore essential to compare the results obtained with those that could have been expected from the desk study. The greater the number of boreholes the more certain it is possible to be of the correlation and thus to trust in the results.

The two principal types of boring machine used for Site Investigation in the United Kingdom are light percussive and drilling machines.

Light Percussive is the process of making boreholes by striking the soil then removing it and the most common method is the shell and auger. This is a general term to describe various tools suspended from a triangular tripod incorporating a power winch. The tools are repeatedly dropped down the borehole while suspended by wire from the power winch.

The different tools used include:

- Clay Cutter – Used in cohesive materials and is raised and lowered, using it’s own weight to cut into the material.

- Shell – Used for boring in silts and sands. Similar to the clay cutter, but has a trap door at the bottom to catch material.
- Chisel – Used for breaking up hard material such as boulders or rocks. Additional payment is required for chiselling as per the Bill of Quantities and permission is normally required from the Resident Engineer before work can start.

Drilling is the process of boring normally by using a combination of a rotating action and a hydraulic ram. There are many different types of rig depending on access and type of ground expected. Hollow drilling rods enable a flush of water, air, foam or mud which is used to carry the cuttings to the surface as well as lubricating and cooling the drill bit. The three main types of drill bit are:

Double tube is where the outer tube rotates and allows for the removal of the cuttings while the inner tube is stationary and prevents the core from shearing. There are different designs of tube varying the location of the flush discharge so as to prevent sample erosion. It is necessary for the hole to be bigger than the tube and so the diamond bits are attached to the outside of the hole, thus allowing the flush to return to the surface.

Triple tube in corporates a third tube to protect the core even further during extrusion and can have either a split tube, which is removed, or a plastic tube to provide longer term protection. A less effective alternative is to incorporate a nylon liner in a double tube.

Retractable triple tube is a variation where the inner tube is attached to a retractor and can extend beyond the cutting edge. This gives complete

protection to the core in softer rock whilst in harder rock where this is not necesary, it retracts to become a standard triple tube. This is used in alternating soft/hard rock, typical of a weathered profile.

Core bits are usually diamond tipped and are either surface set, where diamonds are mounted into a matrix, or impregnated where a fine diamond dust is used in the matrix. In softer rocks, the cuttings can clog up the matrix so the softer the rock, the larger the diamonds need to be. Tungsten carbide bits can also be used in the softer rocks.

Sampling

Sampling can be either undisturbed, of which in-situ testing is a form, or disturbed. The principal sampling methods used in boreholes are:

SPT test: This is a dynamic test as described in BS1377 (Part 9) and is a measure of the density of the soil. The test incorporates a small diameter tube with a cutting shoe known as the ‘ split barrel sampler’ of about 650mm length, 50mm external diameter and 35mm internal diameter. The sampler is forced into the soil dynamically using blows from a 63. 5kg hammer dropped through 760mm. The sampler is forced 150mm into the soil then the number of blows required to lower the sampler each 75mm up to a depth of 300mm is recorded. This is known as the “ N” value. For coarse gravels the split barrel is replaced by a 60 degree cone.

Core Sample: Core samples must be sealed with parafin to maintain the water conditions and then end sealed to prevent physical interferance. The mpst common of these is the U100 (see below) although other sizes from 54mm to 100mm diameter are used. The standard U100 has a sample area

ratio of 30% so large ammounts of soil are displaced. A thin walled Piston Sampler reduces this to 10%. The sample is pushed or jacked into the ground as opposed to a dynamic action.

U100: This is a 450mm long, 100mm diameter undisturbed sample. The tube has a cutter at one end and the driving equipment at the other. Behind the cutter is a core catcher, incorporating 3 arms that go into the sample as it is withdrawn, to prevent the sample from falling out. Care should be taken to ensure that the cutting shoe is as clean and sharp as possible.

Bulk Samples: Usually taken from trial pits or in soils where there is little or no cohesion. Often called block samples.

WaterSamples: Water samples should be taken as soon as water is first struck and the depth recorded. After a suitable period of time (usually 10-15 mins) the depth should be re-recorded and a further sample taken. A final sample should be taken at the end of the borehole and the depth to water regularly recorded. The sample is taken using a device known as a bailer, made from teflon or plastic it incrporates a float to trap the water and should be cleaned after each sample.

The sampling procedure varies according to the type of strata in which the investigation takes place. A reccomended sampling procedure is listed below.

Clays: Normally need undisturbed samples

U100 every 1. 5m or change of stratum. Blow count and penetration should be noted.

If unable to obtain a U100 then bulk samples as above.

If U100 does not full penetrate SPT test is required.

Sands & Gravels: Undisturbed samples are not practical due to the lack of cohesion.

SPT every 1m or change of stratum. Number of seating blows should also be recorded.

Bulk samples to be taken between SPT's.

Silts:

Alternate SPT and U100 samples at 0. 75m intervals

1. 5 Reporting

The Site Investigation report should answer all the questions set out in the planning phase of the Investigation This should include an assessment of the viability of the proposed project.

Included in the report should be a location of all the boreholes, trial pits, other excavations and their logs. These logs should give as much information as possible on the soil and rock structure as it is possible to obtain.

Case studies

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