Effective Procurement of Ground Investigation

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Effective Procurement of Ground Investigation

Prepared by
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Foreword

This document is based on the Site Investigation Steering Group (SISG) publication '*Effective Site Investigation*' which formed part of the Site Investigation in Construction series, republished in 2016 by ICE Publishing. Since much of the original document has been superseded by more recent industry publications, this document represents a major revision and includes the aim of bringing together good industry practice with regard to improving procurement of ground investigations.

The benefit of good ground investigation for the design of structures, environmental solutions, assessment of land quality and ground stability is well established. Delivery of good ground investigations is often hindered by the procurement process where cost over quality is chosen and when the process is led by personnel with a poor understanding of how the benefits are realised. Whether the project requires an assessment of ground conditions for geotechnical or land contamination, the process should be driven by an overriding requirement to assess and reduce uncertainties and the delivery of high-quality reliable data.

This document is intended primarily for Clients but construction professionals such as civil and structural engineers, architects, developers and other procurers will benefit from using this guidance. Ground engineering professionals will also find the document useful but will need to reference more detailed information elsewhere – for example, *UK Specification for Ground Investigation*.

Those involved in the procurement process must recognise that all ground investigations require combinations of equipment, methods and specialists – for example, ground investigations specifically for land contamination or waste assessments would require involvement of geoenvironmental specialists, sampling would demand different techniques, transport and storage requirements, and analytical laboratory testing for contaminants would require much shorter timescales.

The procurement of successful ground investigations can only be accomplished when there is collaboration between all stakeholders, an understanding of the complete ground investigation process, appreciation of realistic timescales, careful planning, and the employment of properly equipped and competent personnel at all stages. It is essential that competent ground practitioners with proven experience, relevant to the ground investigation required, are involved as early as possible and throughout, from planning through to post construction. Careful consideration should also be given to the conditions of contract adopted and the contractual relationships so that good communication and quick decision making are not inadvertently hindered to the detriment of the desired outcomes.

This document adopts the roles identified within the Construction (Design and Management) (CDM) Regulations 2015. The Client shall be the procurer of the ground investigation and shall appoint in writing specialists to develop, execute and manage the ground investigation. The Client shall adopt the role of, or appoint, a Designer (they may also be appointed as the Principal Designer) to develop the scope of the ground investigation. A Contractor shall also be appointed (they may also be appointed as the Principal Contractor) to execute and manage the ground investigation. The Client shall also appoint a ground investigation adviser who may be part of their team or provided from a third party and may act as the Investigation Supervisor. It has been assumed that technical direction of the investigation will be the responsibility of the Investigation Supervisor: an experienced ground practitioner who may be someone appointed by the Client, Designer, Contractor or an independent organisation. The Investigation Supervisor is required to independently assist and advise the Client and Designer. It should be recognised that organisations and individuals may also be given additional role names, such as contract-related roles (e.g. the 'Engineer') and, therefore, reference to the specific conditions of contract should be made.

This publication is intended to assist with the procurement of effective ground investigations which identify and minimise commercial, health, safety and environmental risk as well as providing sufficient technical data to enable efficient design and/or assessment of natural ground and groundwater hazards as well as land potentially impacted by contamination.

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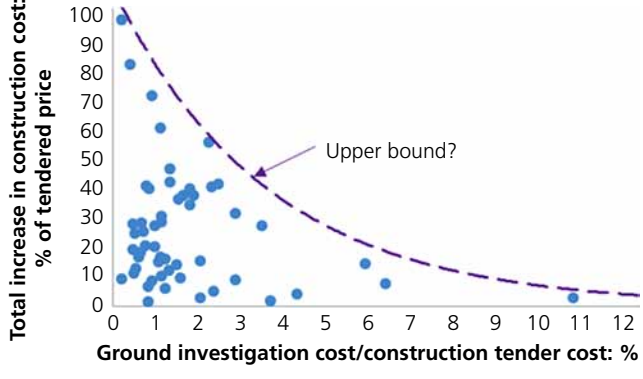
Chapter 1
Introduction

The importance of ground investigation in the construction process is now well established. Numerous projects have well-documented details of cost overruns due to unexpected/unforeseen ground conditions and numerous publications including ACE (2011), Alhalaby and Whyte (1994), Ashton and Gidado (2001), Clayton (2001), John *et al*. (2024), Kinlan (2014), Maliphant *et al*. (2015), Mott MacDonald and Soil Mechanics (1994), Peacock and Whyte (1992) and Tyrrell *et al*. (1983) have provided evidence to this effect. John *et al*. (2024) has also, more recently, discussed the link between well-designed investigations and significant reductions in project outturn costs. This link is shown in Figure 1.1.

Many industry practitioners suggest that the typical cost of a ground investigation is in the range of 1–2% of the project cost, but that project cost increase due to ground related issues is typically in the range of 10–50%. The research and data obtained shows that the cost of ground and groundwater-related issues often significantly and disproportionately impacts on project outturn costs but when the cost of the ground investigation increases this risk is significantly reduced. However, the data also indicates that the typical cost for a ground investigation is actually between 0.11 and 0.33% of the project cost, which indicates that Clients are still not recognising the benefits of procuring adequate ground investigations.

It is not just project costs, however, that are affected by the adequacy of the ground investigation. Appropriate ground investigation in relation to any specific project will reduce risk (see Chapter 3), enhance health and safety for the construction workforce, increase quality, protect the environment, help to meet sustainability goals, as well as enhancing public perception of the enterprise.

Figure 1.1 Relationship between ground investigation cost as a percentage of project award cost and project escalation costs (Mott MacDonald and Soil Mechanics, 1994)



Although the importance and relevance of good ground investigation is becoming embedded in the 'thought processes' of many organisations involved in the construction process, the method of procuring such investigations still leaves much room for improvement. It is vital that the procurement process involves not only the relevant stakeholders, but also that these stakeholders create a team that is competent to specify and procure ground investigations that are relevant to the projects in question. Table 1.1 shows the types and sources of geotechnical risk. It is worth noting that all the issues marked with (*) result from failings with one or more of the stakeholders in the ground investigation procurement process.

Table 1.1 Sources of geotechnical risk (after Baynes, 2010)

Type of geotechnical risk		Hazard	Source
Project management		Poor management of entire geo-engineering process	An inadequate understanding of the importance of ground conditions (*), resulting in poor management of the entire geo-engineering process – for example, a decision to submit a tender price with no risk weighting for geotechnical factors
Contractual		Poor management of ground investigation and contract documentation	An inadequate understanding of the importance of ground conditions (*), resulting in poor acquisition, understanding and/or communication of ground investigation information; this often leads to claims based on unforeseen ground conditions
Technical	**Analytical**	Unreasonable analytical model chosen	An inadequate understanding of ground conditions (*) and analytical methods, resulting in an unreasonable choice of analytical models
	Properties	Unreasonable design values chosen	An inadequate understanding of ground conditions (*) and field and laboratory testing, resulting in an unreasonable choice of design values
	Geological	Unforeseeable geological details	Geological conditions are variable and investigation of all geological details is impracticable
		Inherently hazardous ground conditions	Geological conditions and geological processes that involve hazards such as large ground movements, voids, aggressive chemistry, erosion and so on
		Unforeseen ground conditions	Inadequate understanding of geological conditions (*), resulting in unforeseen ground conditions being encountered during construction, often because of an inadequate ground investigation due to poor management

Professionals involved with the construction process typically comprise architects, structural and civil engineers, and building contractors, all of whom ultimately work for the Client. All too often, ground engineering practitioners are missed out from this list when investigations are procured. When this happens and investigations are procured by individuals who lack a complete understanding of appropriate ground investigation techniques in relation to ground conditions and/or the proposed structures, inadequate investigations ensue.

With so much historical and recent evidence linking the value of properly procured ground investigations to enhanced construction key performance indicators, this document is intended to provide a valuable tool in the overall procurement process. The contents have been carefully considered to provide up-to-date guidance on the procurement process. By drawing on examples of where best practice in procurement has been adopted, this document will aid the user by highlighting the key considerations when embarking on the ground investigation procurement process.

There are various standard conditions of contract that may be used to procure a ground investigation, each with their own advantages and disadvantages. It is helpful if the conditions of contract selected are readily able to cope with the unknowns and inherent variability in scope of a ground investigation.

Chapter 5 provides guidance on typical contracts used, together with their advantages and limitations when used for ground investigations.

This publication references and signposts other key industry publications to assist the user in developing ground investigations that are 'fit for purpose' and provides an industry best practice guide to the effective procurement of ground investigations. It is intended for use by Clients and all those construction professionals that either procure or have a stake and an interest in ensuring that ground investigations deliver information key to the design process and risk management process.

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Chapter 2
Planning

2.1. Introduction

Planning is key to the successful procurement and execution of any ground investigation. The thought process that identifies exactly what is required in terms of input and output from a ground investigation should be transparent to all parties involved and must be documented so that what has been considered is available for reference.

The input to the planning of the ground investigation, in terms of project team, is likely to depend on the size and complexity of the project. Factors affecting the complexity of a project may include

- the nature and variability of the specific ground conditions anticipated
- the importance and sensitivity of the project
- the size of the project
- the complexity of the working arrangements (e.g. working airside at an airport, over water, etc.).

A ground investigation for a large linear infrastructure project is likely to require a significantly greater level of expertise in the planning than a ground investigation for a small housing project. Similarly, the ground investigation for a project involving complex analysis and complex ground conditions might be expected to require a greater level of specialism than is required for a project involving simple ground conditions or analysis. A structured planning process should be followed, regardless of project size and complexity.

2.2. CTQ (cost, time and quality) triangle

2.2.1 Introduction

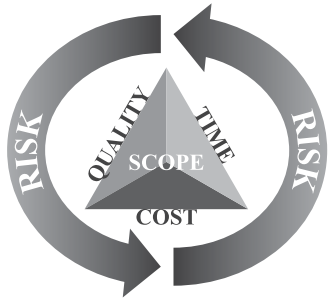
The Project Management Triangle developed by Barnes (1969) has been modified in Figure 2.1 to reflect procurement within ground investigation. It shows three elements of procurement – cost, time and quality (CTQ) – each of which when altered will affect the scope. Balancing the so-called CTQ triangle so that all stakeholders are satisfied is the holy grail for most projects. If this process is carried out properly during planning, the output document (which is the scope of the ground investigation) should provide a framework for delivering a ground investigation that is wholly appropriate to the site in question. By following a structured planning methodology regarding procurement (as described within this section), the key elements of cost, time and quality can be achieved for all projects.

2.2.2 What goes wrong?

Very often, one or more of the elements of the CTQ triangle get skewed – for example, the time available for the investigation may get shortened, and this can have an inverse effect on the cost – that is, the cost increases as more resources are required. At the same time, overall quality of the investigation may be reduced as less time is available to perform tasks correctly.

There is, however, another variable that is often not included in the CTQ triangle, namely risk, as shown in Figure 2.1. Every facet of ground investigation procurement is affected to a greater or lesser extent by the perceived risk and this can be seen as a 'cloak' that wraps around all the CTQ elements.

Figure 2.1 Modified cost, time and quality (CTQ) triangle for ground investigations



Alterations to the cost, time or quality elements of the procurement process can also change the level of risk. In many ways risk is even more emotive and important to Clients than cost, since perceived risk often shapes the whole thought process for a project. In extreme cases, the perception that risk is too great and will impact on long-term trading can lead to the abandonment of a ground investigation.

2.2.3 The ideal

Ideally, when cost, time and quality are being considered for a new project, in-depth risk assessment should be added in at the same time. By considering and including risk in the process, a more complete procurement process is achieved and this will inevitably lead to a more robust ground investigation document for all stakeholders to use. Chapter 3 provides guidance to help Clients identify and manage risk.

2.3. Ground investigation adviser

It is essential that the Client has a clear understanding of why the ground investigation is required and what its objectives are for them to procure an effective ground investigation. To achieve this, the Client should employ or consult with a ground investigation adviser. This individual or organisation, often the Designer, should be an experienced ground practitioner who is formally appointed to ensure that ground-related risks are fully understood and addressed by the proposed scope of investigation. It is beneficial for the ground investigation adviser to communicate the objectives to the other stakeholders as well as the Client so that they understand what they are paying for and why, and to the ground investigation contractor so that they can ensure that the objectives are achievable. They should communicate not only what is required, but also why it is required. This is particularly important on large/complex projects where there may be multiple stakeholders each seeking information on ground conditions. In such circumstances, good communication and coordination can generate efficiencies in the delivery of the ground investigation, perhaps the most obvious example being ensuring that geotechnical and geoenvironmental issues are addressed by a single combined investigation where feasible, rather than as separate investigations. The ground investigation adviser may on some projects also act as the Investigation Supervisor.

2.4. Managing ground investigations

In developing the scope of a ground investigation, Clients should ensure that planning considers arrangements that are appropriate to manage both the safety and quality of the work. The requirements may come from several of the project stakeholders, including

- Client requirements
- Designer's requirements
- Contractor's processes
- third party requirements (e.g. Network Rail, Transport for London, Coal Authority, utility companies, landowner, etc.).

The relative impact of the different stakeholders will vary from project to project and may depend on the perceived level of risk that a project presents to each stakeholder. It might be expected that more onerous requirements might be put in place where the stakeholder perceives the risk to be greater. This risk might be technical, safety related or risk to the stakeholder's operations (Burland *et al*., 2024).

2.5. Creating the competent team

There are a number of roles required for the delivery of an effective ground investigation; some are defined in legislation – for example, Construction (Design and Management) Regulations, 2015 (CDM Regulations) (HSE, 2015a), Control of Asbestos Regulations, 2012 (HSE, 2012); others are set out in the specification used – for example, UK Specification for Ground Investigation (AGS, 2022) (*UK Specification*) or the Conditions of Contract. The Client has a legal obligation as well as a commercial interest to ensure that these roles are carried out by competent individuals. Competence is a combination of experience, skills, ability, training and qualifications (professional or vocational).

The CDM Regulations define roles for the safe delivery of a construction project (including ground investigation). It is important to note that anyone appointed to undertake roles within the scope of the regulations is required by law to have the knowledge, skills, experience and organisational capability to fulfil the requirements of the role.

The main roles defined in the CDM Regulations are

- Client
- Principal Designer (if required)
- Designer
- Principal Contractor (if required)
- Contractor.

A description of the roles and their requirements is beyond the scope of this publication. For more information see *Managing Health and Safety in Construction: Construction (Design and Management) Regulations 2015: Guidance on Regulations L153* (HSE, 2015b).

The *UK Specification* defines roles for the delivery of a ground investigation project. A key role is that of an Investigation Supervisor who is defined as

> the named individual having responsibility to see that the technical objectives and quality of the investigation are met with the programme and cost constraints.

The *UK Specification* goes on to state that the Investigation Supervisor requires

> an appropriate level of knowledge and working experience… [and] they may require the assistance of one or more specialists… dependent on the nature, size and complexity of the investigation.

The *UK Specification* makes provision for several other roles who may be engaged in the project including a number of supervisory roles, such as

- project manager
- planner/programmer
- site agent
- health, safety and environment coordinator
- technical lead
- drilling supervisor
- technical drilling supervisor
- logging and sampling supervisor
- field testing supervisor
- instrumentation and monitoring supervisor
- other specialists.

The requirement for these roles should be determined as part of the process for scoping the ground investigation to address identified risks or areas that may be particularly critical to the interpretation of the ground investigation results – for example, a logging and sampling supervisor might be required where there are concerns about ensuring consistency of logging or the need to recover high quality samples for specialist laboratory testing; a field testing supervisor might be required where the scope includes less common field (in situ) testing, or where the results of the field tests are particularly critical to the design.

However, the ground investigation contractor might decide to make use of such specialists as part of their own assurance or quality management processes or to develop the competence of their staff through training and mentoring.

As with the appointment of the Investigation Supervisor, the use of additional supervisory staff should be dependent on the nature, size and complexity of the works being carried out.

When assessing the competence of the Investigation Supervisor, Clients should check their professional qualifications and experience. Clients can further check if they are registered with the UK Register of Ground Engineering Professionals (RoGEP) (ICE, 2023) or, for environmental investigations, a Specialist in Land Condition (SiLC, 2024) as a means of demonstrating their competences.

Larger, more complex or more critical projects may necessitate higher levels of competence for those undertaking the works. In addition, for larger, more complex or more critical projects, it may be appropriate to follow a formal competence assessment process to manage the competence of those undertaking the work. Even for the simplest projects, it is essential that all those involved have a sufficient level of experience to allow them to carry out their duties safely and competently.