



## Geotechnical site investigations



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  - Cement Concrete and Aggregates Association
  - Consult Australia
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Australian Standard®

## Geotechnical site investigations

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## PREFACE

This Standard was prepared by the members of the joint Standards Australia/Standards New Zealand Committee CE-015, Site Investigations, to supersede AS 1726—1993.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard only, at this time, rather than a joint Australian/New Zealand Standard. This document may become a joint stand in future revisions.

The objective of this Standard is to establish the requirements for the execution of effective geotechnical site investigations and to provide a standardized system for the description and classification of soils and rocks. It addresses spatial and physical characteristics of soil, rock and groundwater, but does not cover the chemical, biological or other environmental aspects of the investigation of contaminated ground.

Commentary on the changes from the 1993 edition is set out in Appendix F.

Statements expressed in mandatory terms in Notes to Tables are deemed to be requirements of this Standard. Figures provided in this Standard are informative.

The term ‘informative’ has also been used in this Standard to define the application of the appendices to which it applies. An ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA

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**Australian Standard**

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**Geotechnical site investigations**

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## 1 SCOPE

This Standard specifies requirements for the execution of geotechnical site investigations and provides a standardized system for the identification, description and classification of soils and rocks.

This Standard applies to geotechnical site investigation of natural or filled ground for—

- (a) new construction;
- (b) maintenance of existing facilities;
- (c) the evaluation of post construction performance;
- (d) the assessment of failure; and
- (e) broad geotechnical studies.

NOTE: Commentary on the changes from the 1993 edition is set out in Appendix F.

## 2 EXCLUSIONS

This Standard does not cover the following:

- (a) The application of geotechnical site investigation outcomes for geotechnical design.
- (b) The chemical, biological or environmental aspects of the investigation of contaminated ground.

## 3 NORMATIVE REFERENCES

The following normative documents are referenced in this Standard:

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

AS

4133 Methods of testing rocks for engineering purposes

4133.4.1 Method 4.1: Rock strength tests—Determination of point load strength index

4133.4.2.1 Method 4.2.1: Rock strength tests—Determination of uniaxial compressive strength of 50 MPa and greater

## 4 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

### 4.1 Acid sulfate soil

Naturally occurring soils, sediments or organic substrates (e.g. peat) that contain sulfide minerals (predominantly pyrite) or their oxidation products. In an undisturbed state where soil is saturated, acid sulfate soils are generally benign. However, if the soils are excavated or exposed to air by a lowering of the groundwater level, the sulfides react with oxygen to form sulfuric acid.

NOTE: Refer to Appendix D.

### 4.2 Carbonate rock

A rock containing more than 50% by weight of carbonate compounds (such as calcium carbonate).

### 4.3 Carbonate soil

A soil containing more than 50% by weight of carbonate compounds (such as calcium carbonate).

### 4.4 Cemented soil

A soil bound with a cementing substance, such that if remoulded and recompacted to its original density and moisture content, exhibits a significantly lower strength than in its undisturbed condition.

### 4.5 Classification

A system which places a material into one of a limited number of groups on the basis of a defined characteristic or set of characteristics. For example, a soil classification may be based on the grading and plasticity of disturbed samples.

### 4.6 Cohesive and non-cohesive soils

Soils are conveniently divided into two groups based on the ability of a soil mass to hold together. Those capable of holding together are termed 'cohesive' and those having no ability, or strength, to hold together by themselves at very low applied total stress levels are termed 'non-cohesive'.

### 4.7 Competent person

A person who has, through a combination of training, education and experience, acquired knowledge and skills enabling that person to correctly perform a specified task.

### 4.8 Consistency

The ability of the soil, at specific moisture contents, to resist mechanical stress or manipulation (remoulding).

### 4.9 Contamination

The condition of land or water where any chemical substance or waste has been added as a direct or indirect result of human activity above background level and represents, or potentially represents, an adverse health or environmental impact. Contamination may have an impact on human health during construction or the service life of a structure erected on the site or may have detrimental effects on the environment.

NOTE: While this Standard does not address investigation of the presence of contamination or management of such contamination, the possibility of the presence of contamination should be considered during the planning and conduct of geotechnical site investigations.

### 4.10 Controlled fill

Any fill for which engineering properties are controlled during placement. Sometimes referred to as structural or engineered fill.

### 4.11 Description, soil or rock

A statement of the physical characteristics of a sample of soil or rock.

### 4.12 Desk study

A study to collate and review the existing information relevant to the site.

### 4.13 Dispersive soils

Those soils, which by nature of their mineralogy and pore water chemistry, are susceptible to separation in water of individual clay particles.

NOTE: Refer to Appendix D.

**4.14 Duricrust**

A cemented zone occurring in weathered rock or soil formed by the mobilization and deposition of minerals.

**4.15 Engineered fill**

Refer to 'Controlled fill'.

**4.16 Fill**

A volume of material that has been placed by anthropogenic processes.

**4.17 Geotechnical**

Pertaining to the nature, condition and physical properties of the earth's crust (whether soil or rock and including water and gases therein), which affect its engineering performance.

**4.18 Geotechnical model**

The interpretation of ground conditions in a form useful for engineering design or assessment. It may contain a surface and subsurface model detailing the geological and engineering characteristics of the various materials and groundwater.

**4.19 Geotechnical site investigation**

The process of assessing and evaluating the geotechnical characteristics of a site.

**4.20 Groundwater**

Water located beneath the earth's surface in pore spaces, fractures and voids in soil and rock.

**4.21 In situ**

In the place and condition in which it exists naturally.

**4.22 Liquid limit ( $w_L$ )**

Moisture content at which the soil passes from the plastic to the liquid state as determined by the liquid limit test.

**4.23 May**

Indicates that a statement is an option.

**4.24 Monitoring**

Recording observations and/or measurements over a period of time.

**4.25 Mottled**

Having areas of two or more colours or shades in a spotted or blotched, irregular configuration.

**4.26 Plastic limit ( $w_P$ )**

Moisture content at which the soil becomes too dry to be in a plastic condition as determined by the plastic limit test.

**4.27 Plasticity index ( $I_P$ )**

Numerical difference between the liquid limit and the plastic limit of a soil.

**4.28 Project**

The wider project for which a geotechnical site investigation is carried out.

**4.29 Shall**

Indicates that a statement is mandatory.

#### **4.30 Should**

Indicates that a statement is a recommendation.

#### **4.31 Soil**

Particulate materials that occur in the ground and can be disaggregated or remoulded by hand in air or water without prior soaking.

#### **4.32 Rock**

Any aggregate of minerals and/or organic materials that cannot be disaggregated by hand in air or water without prior soaking.

#### **4.33 Uncontrolled fill**

Materials that have been deposited by anthropogenic processes, which do not meet the definition of 'controlled fill'.

#### **4.34 Undisturbed sample**

A term applied to samples obtained using techniques designed to minimize changes in the properties of the sample.

### **5 OVERVIEW OF GEOTECHNICAL SITE INVESTIGATIONS**

#### **5.1 Process**

##### **5.1.1 General**

The delivery of geotechnical site investigations should follow an iterative process in which the outcomes of the investigations are reviewed against the purpose for which the investigation is being carried out and further investigations are planned as required. This process is illustrated in Figure 1. Quality assurance and work health and safety programs should be in place during this entire process.

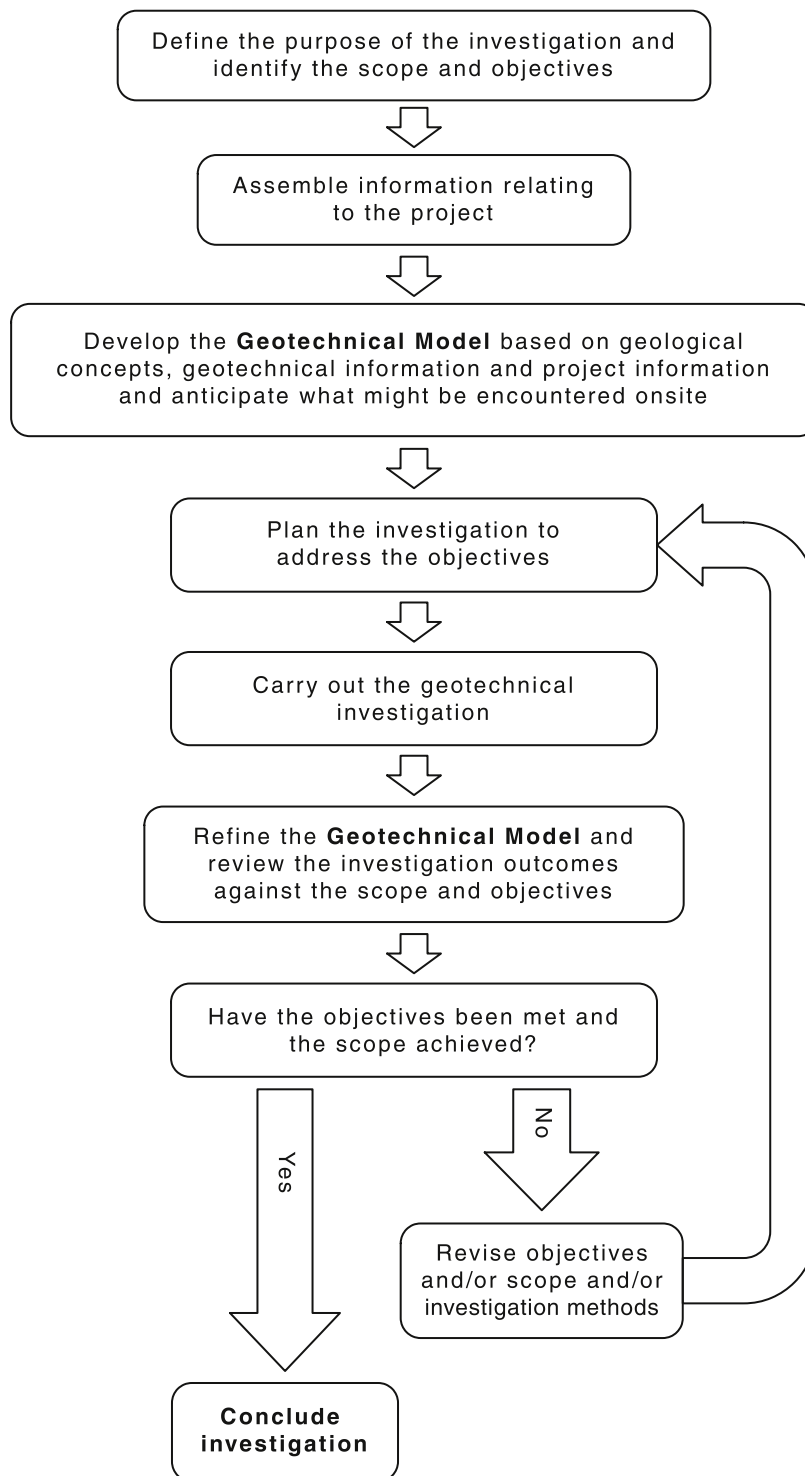


FIGURE 1 GEOTECHNICAL INVESTIGATION—OVERVIEW

### 5.1.2 Project description

Geotechnical site investigations are usually carried out in service of a wider activity, such as land development, infrastructure, mining, or assessment of landslide risk. This wider activity is usually referred to as ‘the project’. The entire area that could affect the project or be affected by the project is referred to as ‘the project area’ and the immediate area of the project itself is referred to as ‘the site’. A description of the project, the project area and the site shall be provided.

### 5.1.3 Purpose of investigation

The general purpose of the geotechnical site investigation and its specific investigation objectives within the context of the project shall be clearly defined and documented to the satisfaction of all parties involved.

### 5.1.4 Scope of work

The proposed scope of work shall reflect the investigation objectives and shall be clearly documented.

### 5.1.5 Staging

Geotechnical site investigations are usually carried out in stages, with the number of stages dependent upon the geotechnical complexity of the site.

A program of staged investigation should be developed to implement the selected investigation activities. This program should recognize that, during the investigation, conditions may be revealed which were not anticipated or which trigger a need for review of the remainder of the program. For larger or more complex investigations it may be appropriate to include one or more reporting and review stages in order to refine or revise the latter stages of the investigation.

The stages may include the following:

- (a) Literature review.
- (b) Site walkover.
- (c) Field investigation staged in order to retrieve data most economically (e.g. carry out cone penetrometer testing first before deciding where to position boreholes with *in situ* testing and sampling).
- (d) Review after each stage to assess the need to carry out further stages.
- (e) Laboratory testing, staged and optimized for the development of geotechnical design parameters and the soil-groundwater chemistry (e.g. testing to identify acid sulfate soils).

Investigations should be executed in such a way that adequate data are obtained to refine the geotechnical model at the end of each stage, to allow advancement of wider studies or to guide subsequent investigations. Each stage may involve interpretation, analysis and reporting.

## 5.2 Geotechnical model

A geotechnical model shall be developed for every geotechnical site investigation.

The level of refinement and model detail will depend on the complexity of the project. In its most basic form the geotechnical model may consist of a simple description of the local geology derived from existing data together with some of the engineering characteristics of the project area. More usually, the geotechnical model would include a geological map and cross-section depicting the strata likely to be encountered and information on the engineering characteristics of the soils and rocks and the groundwater levels.

On some large projects, a more sophisticated geotechnical model, based on a large data set and presented as a 3D visualization, may be developed to present the interaction between a large complex structure and a variable soil/rock/groundwater system.

The geotechnical model should be based on factors such as the following:

- (a) The nature of the project.
- (b) The regional geological and hydrogeological setting.
- (c) The stratigraphic succession, including the presence of significant aquifers.

- (d) Expected groundwater levels.
- (e) The geological structure.
- (f) Geomorphology and surface processes.
- (g) Engineering properties of the soils and rocks encountered.

The geotechnical model shall provide a consistent explanation of the concepts, observations and interpretations associated with the geology, geomorphology, hydrogeology, hydrology and engineering characteristics of the project area that are relevant to the project.

The geotechnical model should be used to communicate geotechnical information about the site to all interested parties involved in the project. This information may include:

- (i) Past and present surface processes/activities.
- (ii) Types of soil or rock units and their distribution.
- (iii) Groundwater levels and groundwater flow directions.
- (iv) Preliminary geotechnical characteristics of soil and rock units.
- (v) The types of geological structure and their orientation.
- (vi) Seismic risk.
- (vii) Potential occurrence of contaminated ground or groundwater that might be hazardous to people, the environment or the durability of construction materials.
- (viii) Potential occurrence of hazardous gases.

### **5.3 Execution of geotechnical site investigation**

#### **5.3.1 Health and safety**

Relevant work health and safety legislation applies to all geotechnical site investigations. Site-specific risk assessment and work method statements should be established. All significant risks associated with the geotechnical site investigation should be assessed, and control measures implemented.

#### **5.3.2 Competency**

All personnel involved in geotechnical site investigations shall have geotechnical experience, training and qualifications appropriate for their role in the investigation.

#### **5.3.3 Literature review**

A literature review shall be carried out as part of the geotechnical site investigation. This review should include the assembly of reports, maps and other information pertaining to the site. In selecting relevant information, the site should be considered in terms of its position in the overall landscape and the broader geological setting, prior to the investigation focusing exclusively on the immediate area of the site.

Information that can be used to gain an understanding of the site prior to fieldwork includes, but is not limited to, the following:

- (a) Geological maps and memoirs of the site.
- (b) Existing geotechnical site investigation reports for the site or nearby sites.
- (c) Topographic or bathymetric information.
- (d) Maps or photographs, which may show topographic features such as swamps or creek lines that have been subsequently obscured by human activities.
- (e) Aerial photographs (vertical and oblique).
- (f) Large scale geological maps.

- (g) Geohazard maps.
- (h) Published soils maps.
- (i) Acid sulfate soil risk maps.
- (j) Maps of vegetation.
- (k) Previous local and anecdotal experience from the area.
- (l) Historical records such as newspaper articles.
- (m) Mine working maps.
- (n) Construction records for the site or nearby projects.

#### **5.4 Initial assessment of site conditions**

An initial assessment shall be made of the conditions in the area to be investigated, which could be expected to influence the investigation. This may be drawn from site reconnaissance, earlier studies, experience, background reports and published information. This assessment of site conditions influencing the design of the field investigation should include, but not be limited to—

- (a) accessibility;
- (b) hazards to health, safety and environment;
- (c) proposed geotechnical model;
- (d) structures or services which could affect or be affected by the investigation;
- (e) groundwater conditions;
- (f) geographical, geomorphological and geological features;
- (g) seismic setting;
- (h) potential for encountering contamination and hazardous gases; and
- (i) regulatory approvals required.

The initial assessment of the site should include an appraisal of the area and volume of ground that would affect or be affected by the project.

#### **5.5 Fieldwork**

##### **5.5.1 General**

Fieldwork should typically include the following:

- (a) Mapping of the topography, geology, geomorphology and other relevant features.
- (b) Logging of cuttings or other exposures.
- (c) A program of sub-surface works (such as boreholes, test pits and probe tests such as cone penetration tests).
- (d) Measurements, e.g. recording of groundwater levels and *in situ* testing.
- (e) Collection of soil, rock and groundwater samples for subsequent testing.

Fieldwork may also involve use of indirect methods, e.g. seismic or resistivity surveys and use of satellite and airborne sensing.

All observation locations (especially pits, boreholes and probe tests) shall be surveyed to the required level of accuracy.

### 5.5.2 *Selection of investigation methods*

The methods to be used for investigation should be selected taking account of—

- (a) objectives of the investigation;
- (b) site conditions;
- (c) available equipment;
- (d) cost and time constraints;
- (e) health, safety and environmental considerations; and
- (f) regulatory requirements.

#### NOTES:

- 1 A list of some of the available field investigation methods is provided in Appendix A. Laboratory studies may also be required to measure the properties of materials.
- 2 A list of some of the available laboratory investigation methods is provided in Appendix B.
- 3 Notes on groundwater considerations are provided in Appendix C.

### 5.5.3 *Data collection and record keeping*

Results from routine field tasks shall be recorded in the field (either electronically or on paper). In addition to the results of the field task, records should reference the project, the date, the location and the person carrying out the work.

The records of the results of fieldwork and laboratory testing should be maintained in a form suitable for archival and information transfer. Ideally, this should be in a digital form consistent with standards expected by the client and other professionals contributing to the project.

### 5.5.4 *Sample handling and management*

#### 5.5.4.1 *Soil*

Geotechnical site investigation often involves taking soil samples, which may be either disturbed or undisturbed. Project specific procedures for sample handling and labelling, transport and storage, and chain of custody, shall be developed in order to reduce deterioration in sample quality and the potential for errors.

All samples shall be clearly labelled and logged with a unique reference number immediately after being taken. Samples suspected of contamination shall be identified on the label. Samples taken for geotechnical purposes should be maintained in a temperature range to avoid freezing or heat damage and wide temperature variations.

As soon as practicable after sampling, samples should be stored in airtight bags or containers. Where the intention is to limit disturbance, samples should be coated with wax (preferably microcrystalline) or retained in sealed sample tubes in order to reduce moisture changes during transit to the laboratory. Excess moisture associated with sample collection, such as from drilling fluids, should be removed prior to storage. Soil should be removed from the ends of tube samples to a depth of about 25 mm, and the air gap filled by custom made plugs or molten wax, followed by end caps and adhesive tape.

Undisturbed block samples should be cut and trimmed by hand and wrapped in cloth and coated with molten wax. At least three layers of cloth and wax should be applied on each surface. The sealed sample should then be placed into a wooden box with the air gap between the box and sample, filled with packing material.

Sample tubes containing soft soil should be transported and stored in a vertical orientation to reduce the potential for sample disturbance, and rough handling should be avoided.

Samples taken for the purpose of testing of the soil chemistry (such as for acid sulfate soil analysis) require special handling, and should be managed in accordance with regulatory guidelines pertaining to the relevant state or territory.

#### **5.5.4.2** *Rock*

Project-specific procedures for core handling and labelling, transport and storage, and chain of custody shall be developed in order to reduce deterioration in core quality and the potential for errors. The same storage temperature control criteria used for soil should be adopted for rock.

Measures should be taken to mitigate moisture loss of rock core while working with it in the field. Rock core shall be placed as soon as practicable into a core box in order of increasing depth, left to right, and top to bottom. The core box shall be uniquely identified and labelled with borehole number and core run depths. In order to provide a permanent visual record, all rock core shall be photographed moist under uniform lighting conditions as soon as practicable after placement in core boxes, and prior to sampling or disturbance during logging. Each photograph should include a reference colour chart.

When core is prone to degradation on drying, the core should be wrapped in plastic film after field logging to reduce changes in moisture content. When core is fragile and may break up in the core box, it should be placed into PVC splits located within the core box.

When rock core specimens are sub-sampled from the core tray for laboratory testing, a process for sample handling and management should be developed to reduce the likelihood of damage of the samples during handling and transport. Intervals of core loss or where core is extracted for testing should be marked as such, and in-filled with polystyrene or similar.

Where core is observed to have degraded during handling or storage, this shall be noted on logs.

#### **5.5.4.3** *Groundwater*

Groundwater samples may contain dissolved or suspended materials. The method of collection, storage and treatment of samples can affect the results obtained from subsequent laboratory testing. The field procedure used to collect samples shall be recorded and reported, indicating—

- (a) time of sampling;
- (b) purging prior to sample collection;
- (c) whether field filtering of the groundwater sample was carried out and if so, the type of filter;
- (d) preservation methods employed after sampling and prior to delivery to a laboratory for testing; and
- (e) quality control and assurance methods employed.

#### **5.5.4.4** *Identification and labelling of samples*

Sample identification shall be shown on sample bags, labels or tags and shall be secure and legible. Where bottles or containers are used to store samples, the identification should be placed on the vessel and also on the lid or cap as required.

Each sample retained during the geotechnical site investigation shall be labelled, including a unique identifier. The following details should be included:

- (a) Project or job number.
- (b) Date sampled.
- (c) Test pit, borehole, or hand auger hole number.

- (d) Sample location and depth.
- (e) Sample reference number.
- (f) Any other relevant information such as requirements for special handling.

Samples suspected of containing hazardous materials should be labelled and packaged such that those handling the samples from accidental exposure are protected.

#### **5.5.4.5 Storage of samples**

Prior to and during testing, samples should be stored in designated areas within the laboratory. Samples should be stored in a manner that provides protection from damage, corrosion or contamination that may invalidate test results. All samples should be stored away from direct sunlight and rain.

Careless handling of undisturbed samples after they have been received by the laboratory may cause disturbance that could influence test results, potentially leading to serious design and construction consequences. All tube or block samples should therefore be handled by a competent person and stored in an upright position until required for testing, and in a location where they are not likely to be knocked over or dropped.

The potential for disturbance, moisture migration and corrosion within tube samples increases with time. It is therefore important that samples are prepared and tested in a timely manner. When samples are tested more than 30 days after their retrieval, this should be noted on the laboratory data and test results sheet.

### **5.6 Reporting and interpretation**

#### **5.6.1 General**

A report (or reports) shall be produced that presents the information obtained from the geotechnical site investigations. The report content may include—

- (a) factual information and observations;
- (b) interpretations; and
- (c) opinions.

The type of report is dependent on the requirements of the project objectives and shall be as agreed during the planning stage. The various types of geotechnical engineering reports are further explained in Clauses 5.6.2 and 5.6.3.

NOTE: A list of graphical symbols that may be useful for reporting purposes is contained in Appendix E.

#### **5.6.2 Geotechnical data report**

This report documents the procedures employed and the data collected, and despite the fact that soil and rock logging has an interpretive nature attached to it, a geotechnical data report is considered predominantly factual and may also be referred to as a factual report.

A geotechnical data report should include but may not be limited to the following information:

- (a) Objectives and agreed scope.
- (b) Location and description of the project site and its history.
- (c) Plan showing investigation locations.
- (d) Description of the regional and local geology.
- (e) Records of fieldwork, including methods and results.
- (f) Laboratory testing and summary of results.

### 5.6.3 Geotechnical interpretive report

Interpretation is a continuous process, which should begin in the preliminary stages of data collection and should proceed as information from the ground investigation becomes available.

The interpretive report should include but is not limited to the following components:

- (a) Reference to the data upon which the interpretation has been made.
- (b) An interpretation of the site geology and the development of the geotechnical model.
- (c) A summary of the geotechnical properties of the ground applicable to the project.
- (d) An engineering interpretation of the implications of the ground conditions for the project.
- (e) An assessment of potential geotechnical risks to the project.
- (f) Recommendations for further work, if relevant.

In developing geotechnical interpretive reports, there are important aspects to be mindful of, which include the following:

- (i) *The nature and constraints of the project and proposed development* These define how and where structures or facilities will interact with the ground, including the type, degree and period of loading and any site constraints. Possible impacts on the nearby built or natural environment and potential future uses of the site should be considered.
- (ii) *The nature and limitations of the geotechnical model* The geotechnical model is an interpretation that will change both during the course of the investigations and the development of the overall project, as more information becomes available. Reporting of the geotechnical model should clearly indicate the information on which it is based, the varying reliability of the interpretation and the process whereby an acceptable level of reliability will be achieved.
- (iii) *The nature and limitation of data* Consistency and reliability of data should be assessed (previous work may have been done by different consultants to varying standards of work and assumptions). Cross-checking and verification to the degree practicable should be undertaken. The limitations of the data collected during the investigation program should be highlighted.

A geotechnical interpretive report may also contain expressions of professional opinion. A professional opinion is dependent on conclusions derived from consideration of relevant available facts, interpretations and analysis and judgement. Since the process involves interpretation and judgement, opinions of professionals may differ, although substantial agreement is expected.

### 5.7 Review of geotechnical site investigation

On completion of a geotechnical site investigation, the findings of the investigation should be reviewed against the objectives of the investigation. Where critical objectives are not adequately achieved, the consequence of this inadequacy should be considered, the risks to the project assessed and recommendations for further investigation developed.

Geotechnical project risks identified in the geotechnical interpretive report may be mitigated by review of geotechnical conditions exposed during construction or by monitoring of performance (such as ground movement monitoring or groundwater level monitoring). Recommendations for such review and monitoring should form part of the geotechnical interpretive report. This may include the recommendation for development of a formal risk assessment and risk management plan.

## 6 SOIL, ROCK AND GROUNDWATER

### 6.1 Soil description and classification

#### 6.1.1 General

The classification system adopted in this Standard differs in a number of important respects from the Unified Soil Classification System (USCS) and AS 1726—1993 and may result in some soils being named and classified differently from USCS and AS 1726—1993. A major difference is the criteria used to distinguish between coarse and fine-grained soils. A behavioural approach has been adopted in this Standard when identifying, naming and classifying soil. However, the boundary defining the change in behaviour between coarse and fine-grained soils is not a precise one. Nevertheless, this boundary has been defined in Clause 6.1.4.2, Table 1 and Figure 2.

#### 6.1.2 Basic approach

Description of soil is the process of identifying its components and assessing their relative proportions and behavioural characteristics, observing the condition and structure of the soil and interpreting its origin. Classification of soils involves allocating the soil into different soil groups on the basis of different observable characteristics.

Soil description and classification requires, as a minimum, the identification of the engineering characteristics and properties of the soil through a visual and tactile assessment. Observation and identification of a soil should be carried out in a series of logical steps where the components of the soil are considered and assessed individually.

The visual–tactile assessment process may be augmented by laboratory testing. Where laboratory tests are carried out subsequent to visual–tactile assessment, and where these indicate that the visual–tactile assessment was inaccurate, logs and other records of the assessment shall be adjusted if required, and any adjustments made to the logs and other records shall be documented.

Soils may be disturbed or undisturbed but if the soil is disturbed there are limits to what can be described.

The approach described in this Standard is equally applicable to both natural and artificial soil materials.

Although systematic description of the soil composition must be completed before classification can occur, the soil group is usually reported at the beginning of the full description and classification.

#### 6.1.3 Systematic description

A soil description should be presented as a series or list of specific terms, separated by semi-colons, generally without these being formed into sentences. A systematic and standardized order of description shall be used. When it is possible, the following characteristics shall be described:

- (a) *Composition of soil (disturbed or undisturbed state)* The description shall include the following:
  - (i) Soil name (use BLOCK LETTERS).
  - (ii) Plasticity, behavioural or particle characteristics of the primary soil component.
  - (iii) Colour of the soil.
  - (iv) Secondary soil components' name(s), estimated proportion(s), plasticity, behavioural or particle characteristics, colour.
  - (v) Minor soil component's name, estimated proportion, behavioural or particle characteristics, colour and, where practical, its plasticity.

The presence of FILL and TOPSOIL shall be indicated at the beginning of the description using BLOCK LETTERS.

- (b) *Condition of soil* The description shall include the following:
- (i) Moisture condition (disturbed or undisturbed state).
  - (ii) Consistency of fine-grained soils (undisturbed state only).
  - (iii) Relative density of coarse-grained soils (determined by *in situ* tests).
- (c) *Structure of soil* In the undisturbed state, the description shall include the following:
- (i) Zoning.
  - (ii) Defects.
  - (iii) Cementing.
- (d) *Origin of soil*.
- (e) *Additional observations*.

NOTE: The order of descriptions given above is recommended.

#### 6.1.4 Composition of soils

##### 6.1.4.1 General

Observations of the primary, secondary and minor soil components are used to construct the soil name, which describes the composition of the soil.

##### 6.1.4.2 Soil components

Soils are composed of solid particles, water and gas, sometimes with the inclusion of organic substances. Soil particles are differentiated on the basis of size, according to the definitions in Table 1.

**TABLE 1**  
**PARTICLE SIZE DEFINITIONS**

| Fraction                  | Components | Subdivision | Size*<br>mm |
|---------------------------|------------|-------------|-------------|
| Oversize                  | BOULDERS   |             | >200        |
|                           | COBBLES    |             | 63–200      |
| Coarse<br>grained<br>soil | GRAVEL     | Coarse      | 19–63       |
|                           |            | Medium      | 6.7–19      |
|                           |            | Fine        | 2.36–6.7    |
|                           | SAND       | Coarse      | 0.6–2.36    |
|                           |            | Medium      | 0.21–0.6    |
|                           |            | Fine        | 0.075–0.21  |
| Fine<br>grained<br>soil   | SILT       |             | 0.002–0.075 |
|                           | CLAY       |             | <0.002      |

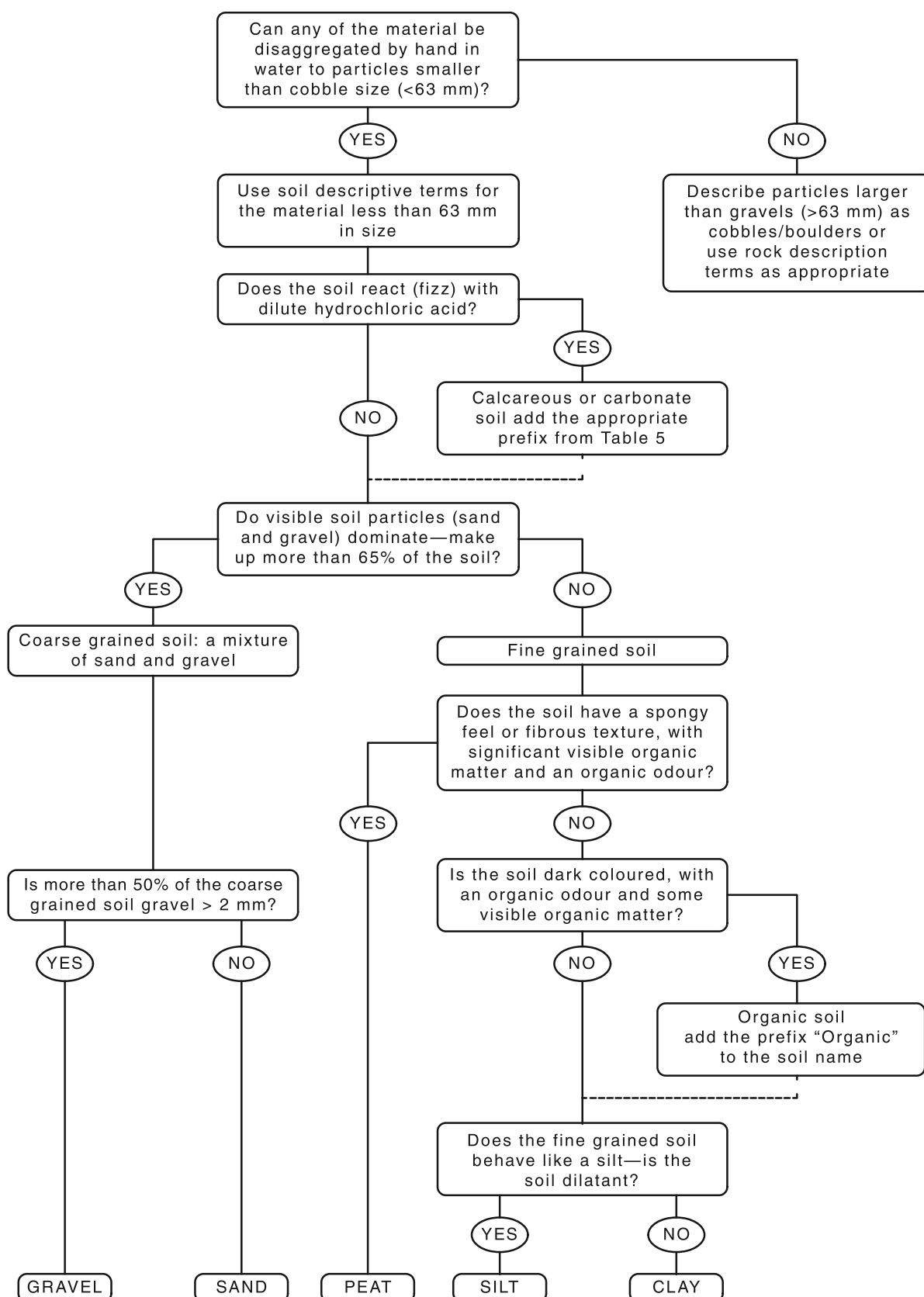
\* These sizes correspond approximately to standard sieve sizes.

As differentiation of grain sizes of fine particles between clay and silt is difficult, and as the grain size of fine particles is less important than their engineering behaviour, the sizes in Table 1 for silts and clays are taken as indicative only, and instead, fine soils shall be described as silts or clays on the basis of their behaviour as assessed by visual tactile techniques. Additional guidance for field assessment of fine grained soils is provided in Tables 7 and 8.

Soils that contain a significant organic content or a significant carbonate content shall be identified.

#### **6.1.4.3** *Identification of components*

The field process for identifying soil primary components is summarized in Figure 2.



## NOTES:

- 1 Gravel, sand, silt and clay are the major components of a soil. They are defined in Table 1.
- 2 Assessment of component proportions is by dry mass.
- 3 Dilatancy is assessed on the reaction of wet soil to shaking. Table 7 provides a method of assessment of dilatancy as well as other diagnostic characteristics of silt and clay.

FIGURE 2 PROCESS FOR THE FIELD IDENTIFICATION OF SOIL PRIMARY COMPONENTS

#### 6.1.4.4 *Soil name*

The soil name shall be based on the identified components of a soil and their behavioural characteristics. The components of a soil are assessed to be primary, secondary, or minor, on the basis of their significance for the probable engineering characteristics of the soil at any particular moisture content.

The primary component of a soil is that component which dominates its engineering behaviour. A secondary component of a soil is any component of a soil which is not the primary component, but which is significant to the engineering properties of the soil. A minor component is present in the soil but is not significant to its engineering properties.

#### 6.1.4.5 *Assessment of primary component*

In the field, the size of grains in the coarse fraction is assessed from a representative portion of the soil, from which any boulders and cobbles have been removed. It may be helpful to examine the soil under air-dried and/or submerged conditions in order to achieve a clear separation between the coarse and fine fractions. In the laboratory, coarse and fine fractions can be separated by wet sieve analysis.

The primary component is chosen to reflect whether the soil is either fundamentally fine or coarse grained. This assessment is made according to whether the total dry mass of coarse fractions exceeds 65% (a coarse soil) or the total dry mass of fine fractions exceeds 35% (a fine soil).

If it is a coarse grained soil, the relative proportions of the sand and gravel can be estimated or measured and the primary component identified as SAND if sand exceeds gravel, or GRAVEL if gravel exceeds sand.

If it is identified as a fine grained soil, the behaviour shall be assessed to decide if the soil behaves as a silt or a clay and this will indicate primary component and soil name. Where assessed by visual tactile techniques (refer to Tables 7 and 8), a silt is indicated by low dry strength, low wet toughness and dilatancy, whereas a clay is indicated by high dry strength, high wet toughness and plasticity. Where assessed by laboratory testing, clay plots above the A-line and silt below the A-line on the Casagrande chart (refer to Clause 6.1.6 and Figure 5). In borderline cases, the terms silty CLAY or clayey SILT may be used at the discretion of the classifier, noting that there is no specifically defined criterion for their use, and that these descriptions imply only that the materials are borderline between behaving as silts or clays.

The presence of cobbles and boulders shall be specifically noted by beginning the description with 'MIXTURE OF SOIL AND COBBLES/BOULDERS' with the word order indicating the dominant proportion first and the proportions of cobbles and or boulders described together with an indication of whether they are supported by a matrix of soil or supported by themselves. The remaining soil shall then be described.

#### 6.1.4.6 *Assessment of secondary and minor components*

Any accessory soil components (i.e. those other than the primary component) are deemed to be either secondary or minor components, on the basis of their type and their amount, as determined by their presence on a percentage dry mass basis, according to Table 2.

A visual aid to assessing the proportions of coarse particles is provided in Figure 3.

**TABLE 2**  
**DESCRIPTIVE TERMS FOR ACCESSORY**  
**(SECONDARY AND MINOR) SOIL COMPONENTS**

| Designation of components | In coarse grained soils |                                                        |                             |                                                            | In fine grained soils |                                                            |
|---------------------------|-------------------------|--------------------------------------------------------|-----------------------------|------------------------------------------------------------|-----------------------|------------------------------------------------------------|
|                           | % Fines                 | Terminology                                            | % Accessory coarse fraction | Terminology                                                | % Sand/gravel         | Terminology                                                |
| Minor                     | ≤5                      | Add 'trace clay/silt' to description, as applicable    | ≤15                         | Add 'trace sand/gravel' to description, as applicable      | ≤15                   | Use 'trace'                                                |
|                           | >5, ≤12                 | Add 'with clay/silt' to description, as applicable     | >15, ≤30                    | Add 'with sand/gravel' to description, as applicable       | >15, ≤30              | Add 'with sand/gravel' to description, as applicable       |
| Secondary                 | >12                     | Prefix soil name as 'silty' or 'clayey', as applicable | >30                         | Prefix soil name with 'sandy' or 'gravelly', as applicable | >30                   | Prefix soil name with 'sandy' or 'gravelly', as applicable |

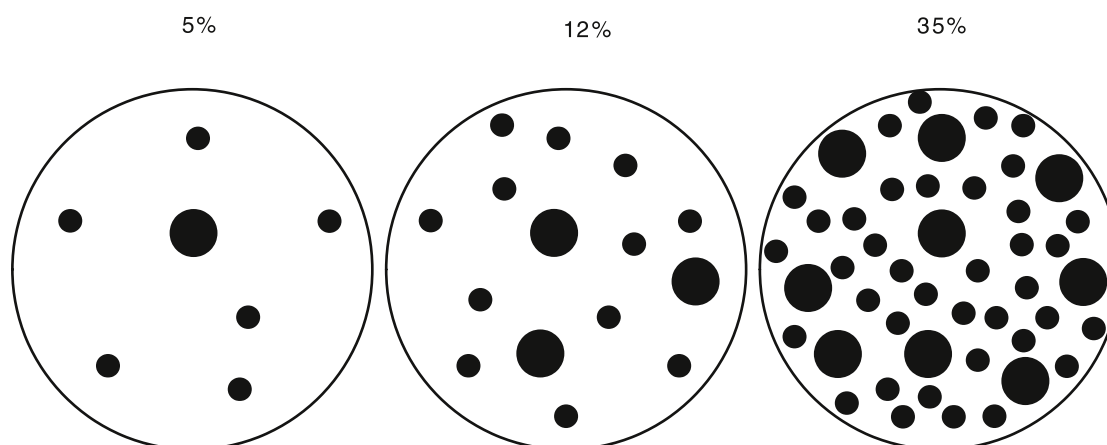


FIGURE 3 DIAGRAM OF VARIOUS PERCENTAGES OF GRAINS

#### 6.1.4.7 Assignment of a name

The name of a soil is made up of the primary and secondary components. The primary component is included as a noun, written in BLOCK LETTERS on logs, qualified by the secondary components (if present), included as adjectives.

Minor fractions are not included in the name, but are included in the description using phrases which include the words 'trace' or 'with', according to their relative importance, as indicated in Table 2.

As an example, consider a soil with 30% plastic fines and 70% coarse fractions, which comprise 10% gravel and 60% sand. The soil is coarse and sand is the primary component. Gravel is a minor component and does not appear in the name. The plastic fines exceed 12% and are a secondary component, so 'clayey' is added as an adjective to the word 'sand'. Hence it would be named 'Clayey SAND'.

#### 6.1.4.8 Peat soils

Organic content of soils can have a significant effect on their geotechnical properties. Colour and odour are the key properties for field identification of organic soils. Organic soils are usually either dark grey or black. Fresh, moist organic soils generally have a mouldy odour which can be intensified by heating. Putrefying, rotten organic components in soil can be recognized by their odour typical of hydrogen sulfide, which can be intensified by pouring dilute hydrochloric acid on the sample. Dry inorganic clays have an earthy odour after being moistened. Organic soils should be named with 'Organic' preceding the primary soil name. For example, 'Organic CLAY' or 'Organic SILT'.

Peat can be identified in the field by its spongy feel and fibrous texture.

Where laboratory tests are available, organic soils and peat may be identified using Table 3. Table 4 provides terms that may be used to describe the degree of decomposition of Peat.

**TABLE 3**  
**IDENTIFICATION OF ORGANIC SOILS**  
**USING LABORATORY TESTS**

| Material       | Organic content – % of dry mass |
|----------------|---------------------------------|
| Inorganic soil | <2                              |
| Organic soil   | 2 to 25                         |
| Peat           | >25                             |

**TABLE 4**  
**DESCRIPTIVE TERMS FOR THE DEGREE**  
**OF DECOMPOSITION OF PEAT**

| Term           | Decomposition  | Remains                                  | Squeeze                     |
|----------------|----------------|------------------------------------------|-----------------------------|
| Fibrous        | Little or none | Clearly recognizable                     | Only water<br>No solids     |
| Pseudo-fibrous | Moderate       | Mixture of fibres and<br>amorphous paste | Turbid water<br><50% solids |
| Amorphous      | Full           | Not recognizable                         | Paste<br>>50% solids        |

#### 6.1.4.9 Carbonate soils

The carbonate content of soils can have a significant effect on their geotechnical properties as soil particles composed of calcium carbonate can have high porosity and low crushing strengths. The carbonate content should be assessed by the application of droplets of dilute hydrochloric acid (10% HCl, see Note to Table 5). Table 5 gives an approximate carbonate content based on the reaction to acid, and provides descriptive terms for carbonate content.

**TABLE 5**  
**ASSESSMENT OF CARBONATE CONTENT**

| Term           | Reaction to acid                            | Approximate carbonate content |
|----------------|---------------------------------------------|-------------------------------|
| Non-calcareous | HCl produces no effervescence               | Negligible                    |
| Calcareous     | HCl produces weak or sporadic effervescence | <50%                          |
| Carbonate      | HCl produces clear sustained effervescence  | >50%                          |

NOTE: 10% hydrochloric acid is made by taking 10 mL of concentrated HCl acid solution (36% HCl) and making it up to 100 mL. This gives 3.6% HCl by mass which is about 1.2 molar.

#### 6.1.4.10 Plasticity and behaviour (fine grained soils)

When laboratory tests are available, clay and silt, both alone and in mixtures with coarser material, shall be described according to their plasticity as defined in Table 6.

**TABLE 6**  
**DESCRIPTIVE TERMS FOR PLASTICITY**

| Descriptive term  | Range of liquid limit for silt | Range of liquid limit for clay |
|-------------------|--------------------------------|--------------------------------|
| Non-plastic       | Not applicable                 | Not applicable                 |
| Low plasticity    | $\leq 50$                      | $\leq 35$                      |
| Medium plasticity | Not applicable                 | $>35$ and $\leq 50$            |
| High plasticity   | $>50$                          | $>50$                          |

When laboratory tests are not available, plasticity and soil behaviour are assessed in the field using the visual–tactile techniques described in Table 7. These procedures are to be performed on particles less than 0.2 mm in size. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Table 8 gives a guide to typical soil names and plasticity characteristics.