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Professional Engineering Geologist – Body of Knowledge and Skills

1. Introduction

This document defines the core knowledge and skills that a Professional Engineering Geologist (PEngGeol) is expected to have in order to competently investigate, analyse and communicate complex engineering geological issues which may arise as the result of the interaction between geology and the construction of engineering works, as well as to assess geological hazards and develop measures for mitigating them, in New Zealand. This Body of Knowledge and Skills (BOKS) is intended to complement and inform the Professional Engineering Geologist assessment process.

The purpose of this BOKS is to:

- Define the prerequisite skills and knowledge that are required of a PEngGeol;
- Provide a framework for Continuing Professional Development (CPD) and postgraduate training.

This BOKS has two key parts:

- The knowledge and skills are listed in the table in section 3. The list is comprehensive, but not exhaustive.
- The types of complex engineering geological problems and activities that a PEngGeol should be able to carry out are listed in section 4.

A PEngGeol is not expected to have all of the listed knowledge and skills. Rather they will have a broad range of them and in particular those relevant to their practice area. The knowledge and skills will be to a level sufficient to competently carry out the listed engineering geological problems and activities.

Care should be taken when comparing this BOKS to the BOKS for a Chartered Professional Engineer (Geotechnical). This BOKS relates to PEngGeol competence standard, whereas the CPEng (Geotechnical) BOKS relates to the specialist field of geotechnical engineering in the context of the CPEng competence standard, which applies to all areas and disciplines in engineering.

2. Background

Engineering New Zealand expects all Professional Engineering Geologists to:

- Have a geology degree at honours level or a postgraduate qualification in engineering geology, or be able to demonstrate equivalent knowledge
- Demonstrate they can assess the nature of the ground in activities requiring specialist and in-depth engineering geological knowledge
- Demonstrate they can work closely with other engineering professionals to solve (identify, investigate, assess and communicate) complex engineering geological problems.
- Demonstrate they can work closely with other engineering professionals to convey engineering geological context.

Engineering New Zealand gives sets out these expectations in a competence standard[1], which requires every Professional Engineering Geologist to demonstrate competence in their Practice Area. Competence for PEngGeol focuses on engineering geology practice and analysing complex engineering geological problems to inform land use policy, assessment and specific engineering solutions. The applicant needs to demonstrate that they have the ability, commitment, knowledge and skills to act effectively in each of these situations.

Engineering geologists wishing to register as PEngGeol are expected to demonstrate a breadth of knowledge and skills (refer Section 3) that they are able to apply in a range of situations and localities (refer Section 4). The PEngGeol competence standard comprises twelve elements grouped into four competence areas:

1. Engineering geological knowledge
2. Professional acumen
3. Managing engineering geological work
4. Analysing technical problems

Areas 1 and 4 can be considered the knowledge and skills required by a PEngGeol that distinguish them from those of other Chartered Professional Engineers, although it is acknowledged there is some overlap with CPEng (Geotechnical). Guidance on how Engineering New Zealand defines complexity is given below:

Complex engineering geological activities means activities or projects that have some or all of the following characteristics:

a. Diverse resources, e.g. people, money, equipment, materials and technologies;
b. Recognising, understanding and resolving significant problems when wide-ranging or conflicting engineering, engineering geology and/or other related issues defined by ground conditions interact;
c. New techniques or processes, or the innovative use of existing techniques or processes.

Complex engineering geological problems means problems that have some or all of the following characteristics:

a. Wide-ranging or conflicting technical or engineering issues;
b. Not easily recognised, understood or resolved without in-depth engineering geological knowledge;
c. Issues infrequently encountered, in an unfamiliar geological setting or requiring an original method of assessment;
d. Outside practice covered by guidelines, standards and codes of practice for professional engineering geology;
e. Involvement of diverse groups of stakeholders with a wide range of needs;
f. Significant consequences in a range of contexts.

Applicants for PEngGeol need to demonstrate their competence for independent practice against the competence standard for their area of expertise. An application typically includes five stages: preparation, validation, evaluation, recommendation and decision. The evidence that is submitted with the application includes their engineering geology qualification, work records, learning records (CPD), referees, Practice Field(s), a description of the Practice Area and a self-review demonstrating competence against the Assessment Criteria. The evaluation includes an

[1] https://www.engineeringnz.org/resources/rules-and-regulations/ refer to Election or Transfer to Membership Classes Regulations

interactive assessment including a Lead Assessor and a Practice Area Assessor. They make a recommendation to the Competency Assessment Board which makes a decision regarding the application. There may be a requirement for future reassessment at a pre-defined interval.

3. Knowledge and Skills

In looking to establish a set of knowledge and skills for a PEngGeol, NZGS has defined the knowledge and skills required in order to deliver engineering geology outcomes for the different phases of a project. For a typical engineering/engineering geological project this may be:

a. Scoping of Engineering Geological input to issues / problem / project;
b. Review of existing data;
c. Site or route selection;
d. Establishment of an initial geological and engineering ground model and assessment of the engineering geological issues that need to be addressed in a project;
e. Development of engineering geological investigation programmes focussed on addressing these issues;
f. Performance of engineering geological mapping, geotechnical field investigations and laboratory studies;
g. Interpretation of geological, geomorphological and hydrogeological conditions and hazards;
h. Refinement of initial ground model and clear communication of the significance of geological conditions and hazards to other engineering disciplines and related professionals involved in the project;
i. Development of recommendations related to design, mitigation and construction;
j. Preparation of engineering geological reports;
k. Documentation of the geological, geomorphological and hydrogeological conditions and hazards encountered during construction, and interpretation of the implications of those conditions for design or construction progression;
l. Supervision, inspection and sign-off of the geological, geomorphological and hydrogeological aspects of construction, post-construction and site monitoring;
m. Awareness and use of key technical documentation, guidance and standards;
n. Understanding of key building, environmental, resource management and health and safety regulations.

It is recognised that there is some capability overlap with other engineering professionals, in particular with geotechnical engineers. Many projects require the input of an experienced geotechnical engineer due to the type and complexity of the problem and the design issue being addressed.

The following table lists the core capabilities expected of a PEngGeol.

KNOWLEDGE AND SKILLS	
Project phase	**A PEngGeol should be able to :**
a) Scope engineering geological input b) Data review c) Site and route selection d) Establishment of initial ground model and assessment of	i. Understand the need for the project; ii. Perform literature searches and site history analyses (including geology/geomorphology maps, hazard maps, aerial photographs, satellite imagery, site usage, council files, New Zealand Geotechnical Database, etc.) related to regional and site surface and subsurface geological and hydrogeological conditions;

KNOWLEDGE AND SKILLS	
Project phase	**A PEngGeol should be able to :**
engineering geological issues	iii. Review preliminary project concept design plans to evaluate potential impacts from geological conditions; iv. Undertake or direct a walk over survey, conduct and clearly document field mapping; v. Demonstrate a good understanding of how geology and geomorphology provide evidence of the site conditions and help identify geological and geotechnical issues that need to be considered in the design process; vi. Identify constraints, gaps in understanding and potentially significant geotechnical issues and their associated risks; vii. Evaluate potential design options; iii. Develop and document a conceptual ground model showing existing subsurface conditions and hazards that have the potential to impact the proposed development; ix. Screen sites based on this evidence. x. Collaborate with other project stakeholders to integrate engineering geological elements into assessing the feasibility of the whole construction xi. Communicate potential engineering geological risks and options that may impact the design with clients and other stakeholders
e) Development of site investigation programmes	i. Communicate with other engineering professionals to determine the required engineering geological input and the scope of the information needs ii. Contribute to planning the scope and locations for ground investigation, field testing, instrumentation, sample collection and laboratory testing programmes with appropriate consideration of the benefits and limitations of each investigation, field test, sampling and laboratory test method and the site constraints, including buried/overhead services and existing structures/building. iii. Specify the scope and engagement of site investigation contractors, in consideration of the potential risks, the nature of the project and the client's budget iv. Consider regulatory and consent requirements for site investigation, monitoring and reporting; v. Direct and/or modify ground investigation programmes, as required, upon evaluation of the conditions encountered during investigation with respect to the conceptual ground model and changing design requirements.
f) Performance of geological mapping, geotechnical field and laboratory studies	i. Stereoscopic analysis and interpretation of remote sensing data (e.g. LIDAR, UAV, aerial photographs, satellite /imagery – including stereopairs); ii. Map geomorphology, lithology, geological structures (including defects, faults/shears and slope instability features), geohazards and hydrogeological features;

KNOWLEDGE AND SKILLS	
Project phase	**A PEngGeol should be able to :**
	iii. Log geological, hydrogeological and engineering properties of rock, soil and water in investigation borings, wells and excavations in accordance with New Zealand practice in a manner that considers the desired end use of the data; iv. Direct and/or employ field penetrometer techniques (SPT, CPT, DCPT) to investigate subsurface conditions and obtain geological and engineering properties of soil; v. Direct and/or perform rock, soil and groundwater sampling for laboratory testing; vi. Direct and/or employ field geophysical techniques to investigate subsurface conditions and obtain geological and engineering properties of rock and soil; vii. Direct and/or perform routine field and laboratory tests for many of the following: a. soil and rock mass classification b. soil and rock strength and stiffness c. clay mineralogy d. hydraulic conductivity e. expansion properties f. consolidation characteristics g. compaction characteristics h. material acceptability for use as aggregate, fill or armour i. special properties such as the potential for soil collapse or expansion, dispersion, slaking, erosion potential and liquefaction potential j. special conditions such as acid sulphate soils and acid rock drainage k. pavement sub-grade/aggregate qualities l. excavatability m. durability viii. Direct or perform the installation and monitoring of field instrumentation (e.g. groundwater, slope movements, settlement).
g) Interpretation of geological conditions and hazards h) Refinement and communication of ground model	i. Determine geomorphology, geological structure, hazards (such as landslide, earthquake/fault activity and active volcanism) and hydrogeology of the site from literature reviews, mapping, geophysics and/or subsurface investigations; ii. Prepare engineering geological maps, cross-sections and/or 3-D ground models to depict surface and subsurface conditions (rock, soil and groundwater) based on observations and interpretations from mapping, geophysics and subsurface investigations; iii. Determine geotechnical risk associated with geological hazards (in particular slope instability and earthquakes)

KNOWLEDGE AND SKILLS	
Project phase	**A PEngGeol should be able to :**
	iv. Interpret the results of laboratory testing to determine relevant physical, mechanical and chemical properties of rock, soil and water; v. Calculate geotechnical behaviour and associated risk, in response to natural and man-made processes (e.g. settlement, erosion, subsidence, liquefaction, slope failure, eruption blanket) specific to the geological conditions of the region; vi. Assess the impact of ground response on the existing environment, including adjacent properties; vii. Characterise site subsoil class in terms of seismic response; viii. Determine groundwater gradient and flow direction; ix. Identify materials that may be detrimental to projects and/or human health (e.g. asbestos, methane, contaminants); x. Estimate earthwork shrinkage and bulking factors. xi. Demonstrate an understanding of the consequences of hazards for other engineering disciplines. xii. Effectively and clearly communicate the significance of any hazards found to other engineering disciplines and/or the client on the project
i) Recommendations for design, mitigation and construction	Assess, develop or contribute to design, mitigation and construction solutions, ensuring the engineering geological factors are addressed over a range of designs such as:- i. Conceptual retaining wall design; ii. Remedial design for slope instability hazards; iii. Conceptual earthworks design; iv. Conceptual debris barrier/rockfall protection system design; v. Conceptual seawall design; vi. Infrastructure corridor assessments (e.g. pipeline, road, rail, etc.) vii. Subsurface drainage system design; viii. Design plans and mitigation of hazard associated with geothermal activity ix. Response plans for encountering contaminated soil and groundwater during construction; x. Ground response to seismic activity; xi. Setback distances of proposed structures from known active faults and cliff/slope crests and toes; xii. Mitigation plans for potentially soft, compressible and/or liquefiable soils; xiii. Selection or contribution to selection of trigger criteria and response actions for monitoring; xiv. Plans for sediment and erosion control; xv. Plans for pre-, during and post-construction monitoring (e.g. ground movement, groundwater, slope instability, settlement monitoring);

KNOWLEDGE AND SKILLS	
Project phase	**A PEngGeol should be able to :**
	xvi. Different engineering geological aspects of design solutions with recommendations for a preferred option; vii. Design of construction sequencing and inspection schedule; iii. Design documentation, design features reports, including for "safety in design" and relevant construction specifications;
j) Preparation of engineering geological reports	Be able to demonstrate experience in most of the following: i. Prepare appropriate maps, plans, drillhole logs, in-situ and laboratory test results; ii. Prepare 3D ground models appropriate to the engineering task; iii. Document laboratory and field testing results, instrumentation and observations; iv. Prepare written factual, baseline and interpretive reports which present ground model and findings v. Present to and interpret these reports for the clients; vi. Interpret and verify the engineering geological aspects of factual and interpretative geotechnical reports prepared by others; vii. Quantify and document geotechnical and geological uncertainties on a systematic basis and incorporate these into the design and risk assessment process; iii. Demonstrate judgement as to the key risks and mitigation strategies and an awareness of current risk guidance and standards.
k) Documentation of encountered conditions and implications l) Supervision and inspection of construction, post construction and site monitoring	Be able to demonstrate experience of most of the following: i. Monitor field instrumentation and assess against trigger criteria; ii. Perform or supervise geotechnical testing and observe site construction such as for foundations, earthworks, retaining walls and trench excavation; iii. Document geological and groundwater conditions encountered during construction and refine the ground model; iv. Assess, record and communicate unforeseen geological and groundwater conditions during construction; v. Evaluate geotechnical performance during construction, based on observations and field instrumentation; vi. Evaluate ground related distress associated with, for example, slope, foundation and/or retaining wall distress or failure; vii. Be familiar with geotechnical construction plant and machinery and its strengths and limitations; iii. Guide engineering geological aspects of the construction to confirm it complies with the drawings and specifications and expected quality standards, and alert designers if it does not;

KNOWLEDGE AND SKILLS	
Project phase	**A PEngGeol should be able to :**
	ix. Draft any variations to engineering geological aspects of the design as required to mitigate non-conforming work; x. Keep records of all observations, contract variations and site instructions as they pertain to geological matters; xi. Identify and/or respond identification of presence of contaminants in soils; xii. Respond to sediment run-off and erosion; xiii. Prepare post-construction reports in accordance with regulatory and contractual requirements.
m) Awareness and use of key technical documentation, guidance and standards	Demonstrate detailed knowledge of NZGS Field Description of Soil and Rock Description guideline. Demonstrate a broad familiarity with the Building Act, the New Zealand Building Code, its core cited design actions and materials standards and other important guidelines and standards such as (but not limited to): i. AS/NZS 1170 Structural Design Actions, in particular hazard criteria in 1170.5; ii. NZS 3604 Timber Framed Buildings (i.e. 'good ground'); iii. NZS 4402 Methods of testing soils for civil engineering purposes; iv. Awareness of international key standards and guidelines for rock sample testing and in-situ testing etc; v. NZS 4431 Code of Practice for Earth Fill for Residential Development; vi. NZGS/MBIE Earthquake Geotechnical Engineering guidance modules; vii. NZGS guidelines such as NZ Ground Investigation Specification; viii. MBIE guidance documents and practice advisories; ix. NZTA Bridge Manual; x. NZTA Risk Management Process Manual; xi. Relevant IPENZ Practice notes and guidelines; xii. Design Features Report templates; xiii. AGS "Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning"; xiv. AS1726 Geotechnical Site Investigations; xv. ISO 31001 Risk management — Risk assessment techniques; xvi. TNZ M/04:2006 Specification for basecourse aggregate; xvii. Technical guidance published by the relevant Territorial Authority.
n) Understanding of building, environmental, resource and health and safety regulations	Demonstrate a good working knowledge and understanding of the: i. Building Act, Regulations and Building Code; ii. Health and Safety at Work Act (2015);

KNOWLEDGE AND SKILLS	
Project phase	**A PEngGeol should be able to :**
	iii.Historic Places Act 1993; iv.Resource Management Act 1991; v.Wildlife Act; vi.Local authority plans and guidance documents.

4. Examples of complex engineering geological problems and activities

The PEngGeol competence standard requires an engineering geologist to demonstrate an ability to scope, investigate, analyse and communicate complex engineering geological problems. The engineering geologist uses his or her knowledge and skills to complete these tasks. The NZGS has identified a number of examples of complex engineering geological problems and activities to assist a PEngGeol applicant.

A candidate applying for PEngGeol is expected to demonstrate that they are capable of carrying out all of the following complex engineering geological problems and activities. The candidate does not need to have actually carried out the following problems and activities. Rather the candidate can demonstrate that they are capable of carrying out the problems and activities by drawing on relevant evidence from other problems and activities.

A. Mapping and characterisation of difficult soils and/or rocks for either infrastructure route selection, land development, dams, tunnels or mines;
B. Mapping and characterisation of complex soil and rock masses for stability assessment of natural, fill and cut slopes, under static and seismic loadings, and to inform the design of potential mitigation measures;
C. Mapping and characterisation of a range of ground conditions to inform the design of either IL 2 buildings (as defined by AS/NZS 1170.0; as an example of typology), or bridges, dams and tunnels of comparable importance, on or in a range of foundation types;
D. Assessment of situations with high risk to life or property where special precautions or expertise are or may be required to identify and assess impacts from geological hazards, for example during a response to an emergency event such as an earthquake
E. Characterisation and selection of soil and rock construction material for earthworks requiring a range of characteristics and properties.

5. Comments on demonstrating competency

The complex engineering geological problems and activities listed in Section 4 represent a range of projects to which knowledge and skills would be applied by Professional Engineering Geologists working within small, large or specialised organisations.

Applicants are expected to have at least five years' of practical experience following graduation, with exposure to a range of complex problems and activities, and to have been supervised by and have their work reviewed by a more experienced PEngGeol or CPEng (Geotechnical).

Applicants should also be able to demonstrate that they understand the boundaries of their own knowledge and skills and will actively seek assistance when asked to work outside their competence or level of expertise.

It is acknowledged that applicants will have gained a range of both experience and competency for each complex problem and activity to which they have been exposed. They are likely to have

worked as part of a team, in which case they will need to demonstrate they have taken responsibility for a major part of the problem and activity and/or that their experience of complex problems and activities has been spread over more than one project.

Demonstration of competency is likely to be through a combination of:

- presenting a portfolio of geological models, assessments, reports and drawings;
- outlining the steps and judgement calls in the investigation, analysis, communication and reporting of specific elements;
- presenting case studies of project issues encountered, investigated and resolved;
- demonstrating their contributions, which may include use of referee support as to their roles and outcomes.

It is recognised that there are specialist fields or activities in engineering geology that are not specifically covered by the above BOKS (e.g. geothermal resource development). Engineering geological activities in these fields and activities require much of the same knowledge and skills as listed in the table in Section 3 and may also require working from first principles using their broader understanding of engineering geology and specialist knowledge of geological controls and impacts in their field of activity. It may therefore be possible to meet the PEngGeol BOKS requirements above even though the range of activities differs to a degree from that listed in Section 4.