NEW ZEALAND GEOTECHNICAL SOCIETY INC

A Collaborating Technical Society of The Institution of Professional Engineers New Zealand

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Chartered Professional Engineer (Geotechnical) – Body of Knowledge and Skills

1. Introduction

This document defines the core knowledge and skills that a Chartered Professional Engineer (Geotechnical) (CPEng(Geotechnical)) is expected to have in order to competently investigate, design and supervise the construction of geotechnical works in New Zealand. This Body of Knowledge and Skills (BOKS) is intended to complement and inform the Chartered Professional Engineer assessment process.

The purpose of the BOKS is to:

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

The BOKS is not intended to be a competence assessment framework. However, it is expected that the BOKS will inform the competence assessment process used by the Registration Authority to assess a CPEng(Geotechnical).

The title 'CPEng(Geotechnical)' is not proposed by NZGS or the Registration Authority. It is simply used as a convenient descriptor in this document.

2. Background

The Chartered Professional Engineers Registration Authority expects all Chartered Professional Engineers to:

- Either have a Washington Accord-accredited qualification (a four-year Bachelor of Engineering, Honours degree) or be able to demonstrate equivalent knowledge
- Demonstrate that they can work from first principles
- Demonstrate that they can solve complex engineering problems that require the application of engineering knowledge.

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The Registration Authority gives these expectations in a competence standard[1], which requires every Chartered Professional Engineer to demonstrate competence in their Practice Area. The Practice Area in which an engineer is assessed is aligned with one or two broad fields of engineering practice, which are published on the Register to assist the public when looking to engage an engineer. One of those Practice Fields is 'Geotechnical'.

While an engineer's Practice Area might be quite narrowly defined, engineers wishing to align their practice with the specialist field of geotechnical engineering, and be recognised as a CPEng(Geotechnical), are expected to demonstrate a breadth of geotechnical knowledge and skills (refer Section 3) which they are able to apply in a range of situations (refer Section 4).

The competence standard has 12 elements.

1. Comprehend and apply knowledge of accepted principles underpinning widely applied good practice for professional engineering
2. Comprehend and apply knowledge of accepted principles underpinning good practice for professional engineering that is specific to New Zealand
3. Define, investigate and analyse complex engineering problems in accordance with good practice for professional engineering
4. Design or develop solutions for complex engineering problems in accordance with good practice for professional engineering
5. Be responsible for making decisions on part or all of one or more complex engineering activities
6. Manage part or all of one or more complex engineering activities in accordance with good engineering management practice
7. Identify, assess and manage engineering risk
8. Conduct his or her professional engineering activities to an ethical standard at least equivalent to the code of ethical conduct
9. Recognise the reasonably foreseeable social, cultural and environmental effects of professional engineering activities generally
10. Communicate clearly with other engineers and others that he or she is likely to deal with in the course of his or her professional engineering activities
11. Maintain the currency of his or her engineering knowledge and skills
12. Exercise sound professional engineering judgement.

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

(a) involve the use of diverse resources (resources includes people, money, equipment, materials, and technologies)

[1] https://www.registrationauthority.org.nz/registration/competence-standard

(b) require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering, and other issues

(c) have significant consequences in a range of contexts

(d) involve the use of new materials, techniques, or processes or the use of existing materials, techniques, or processes in innovative ways

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

(a) involve wide-ranging or conflicting technical, engineering, and other issues

(b) have no obvious solution and require originality in analysis

(c) involve infrequently encountered issues

(d) are outside problems encompassed by standards and codes of practice for professional engineering

(e) involve diverse groups of stakeholders with widely varying needs

(f) have significant consequences in a range of contexts

(g) cannot be resolved without in-depth engineering knowledge

Elements 1, 2, 3 and 4 focus on the technical knowledge and skills of a Chartered Professional Engineer. Thus those four 'technical' elements can be considered to distinguish the knowledge and skills specifically required of a CPEng(Geotechnical) from those of other Chartered Professional Engineers. Elements 3 and 4 deal with complex engineering problems while elements 5 and 6 deal with complex engineering activities.

3. Knowledge and Skills

In looking to establish a finite set of knowledge and skills for a CPEng(Geotechnical), NZGS has defined the knowledge and skills required in order to deliver engineering outcomes for the different phases of a typical engineering project. A broad mapping back to the four 'technical' elements of the CPEng competence standard is then provided.

The knowledge and skills of a Chartered Professional Engineer (Geotechnical) are applied to the typical phases for investigation, design and construction of a project, namely:

a) Options and alternatives identification and evaluation
b) Site or project route selection
c) Assessment of the geotechnical issues that need to be addressed in a project
d) Development of programmes of geotechnical investigation focussed on addressing these issues
e) Performance of geotechnical field and laboratory studies
f) Analysis of geotechnical data and the performance of engineering computations
g) Performance and engineering evaluation of construction, post-construction and site monitoring

h) Preparation and engineering evaluation of geotechnical reports, design, and health and safety documentation

i) Monitoring the construction of the projects listed above

j) Inspection of the construction of geotechnical elements of the projects listed above

k) Awareness and use of key technical documentation, guidance and standards

l) Understanding of key building and health and safety regulations

It is recognised that there is overlap with the engineering geology profession and the PEngGeol registration administered by IPENZ and with the structural engineering BOKS (for example aspects of foundations and retaining walls).

KNOWLEDGE AND SKILLS		
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**	**Element of CPEng competence standard**
a) Options and alternatives identification and evaluation	i. Understand and describe the need for the project ii. Identify constraints and potential significant geotechnical issues iii. Identify range of potential solutions iv. Evaluate potential options and alternatives considering their relative feasibility, benefits and limitations	3
b) Site and route selection c) Assessment of geotechnical issues	i. Perform literature searches and site history analyses (including geology/geomorphology maps, hazard maps, aerial photographs, council files etc.) related to surface and subsurface conditions ii. Undertake a walk over survey, demonstrate a good understanding of geology and geomorphology, and how these provide evidence of the geotechnical issues that need to be considered in the design process. iii. Develop a preliminary ground model and possible hazards and documentation of the results iv. Screen sites based on this evidence	3
d) Development of programmes of geotechnical investigations	i. Communicate with other design consultants to determine the geotechnical input and the scope of the information needs ii. Formulate or evaluate the engineering aspects of ground investigation and laboratory testing programmes with appropriate consideration of the benefits and limitations of each investigation and laboratory test method. The investigations should	3

KNOWLEDGE AND SKILLS		
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**	**Element of CPEng competence standard**
	include a variety of techniques, for example boreholes, test pits, in-situ testing such as shear vane, CPTs, SPTs and shear wave testing, sample collection and a range of laboratory tests such as classification tests (Atterberg, PSD), strength tests (UCS, triaxial, CBR) and compaction/stiffness (MDD, oedometer) iii. Specify the scope and engagement of site investigation contractors, in consideration of the client's budget iv. Evaluate ground investigation and laboratory testing proposals v. Direct and/or modify ground investigation programmes, as required, upon evaluation of the conditions encountered with respect to the preliminary ground model	
e) Performance of geotechnical field and laboratory studies	i. Classify and evaluate subsurface conditions so as to further develop the ground model ii. Understand the purposes for and direct (and/or perform) routine field and laboratory tests for many of the following: a. soil and rock description in accordance with the NZGS guideline b. soil classification c. soil and rock strength d. bearing capacity e. expansion properties f. consolidation characteristics g. compaction characteristics and/or material acceptability for use in fill h. special properties such as soil collapse potential, erosion potential and acid sulphate conditions i. pavement sub-base qualities iii. Installation and monitoring of field instrumentation (e.g. groundwater, slope movements, settlement).	3

KNOWLEDGE AND SKILLS		
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**	**Element of CPEng competence standard**
f) Analysis of geotechnical data and performance of engineering computations	Assess or calculate: i. Soil and rock strength ii. Bearing capacity, pile capacity (shallow and deep foundations) and allowable bearing pressures iii. Settlement and/or ground movement under static and seismic loads and over the design life, including expansion and consolidation properties iv. Slope stability and displacement under static and seismic actions v. Geotechnical aspects of retaining systems under static and seismic loads vi. Soil collapse and/or erosion potential vii. Control of groundwater viii. Earthworks including site preparation, cut/fill, compaction characteristics and material acceptability for use as fill ix. Pavement subgrade qualities and pavement design x. Understand and have competency in the use of most commonly used geotechnical analytical software (e.g. for retaining wall, foundation, pile and slope stability analysis and liquefaction assessment); and xi. Understand the limitations and assumptions behind this software.	2, 3, 4
g) Earthquake geotechnical engineering	Assess or calculate: i. Ground response to seismic action ii. Liquefaction susceptibility and vulnerability including assessment of secondary effect of settlement and lateral spread potential iii. Soil dynamic properties iv. Site subsoil class characterisation in terms of NZS1170.5 v. Seismic design parameters for geotechnical design vi. Engagement with structural engineers, for example soil-structure interaction vii. Understand the broad principles behind probabilistic seismic hazard analysis.	2, 3, 4

KNOWLEDGE AND SKILLS		
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**	**Element of CPEng competence standard**
h) Performance or engineering evaluation of construction, post-construction and site monitoring	Confirm encountered ground and groundwater conditions and structure response consistent with design assumptions, but not limited to: i. Perform or supervise geotechnical testing and observe site construction such as foundations, earthworks, retaining walls and excavation ii. Analyse, design and evaluate instrumentation programmes to evaluate or monitor various phenomena in the field, such as settlement, deformations, slope creep, porewater pressures, groundwater variations and the development of trigger criteria and response actions iii. Evaluate geotechnical performance during construction iv. Evaluate engineering aspects of ground related distress associated with for example slope, foundation, and/or retaining wall distress or failure	4
i) Preparation and engineering evaluation of geotechnical reports	i. Prepare appropriate plans, borelogs, in-situ and laboratory test results; ii. Document laboratory and field testing results and observations; iii. Prepare written factual and interpretive reports which present ground model and findings and present and interpret these reports to the clients; iv. Interpret and verify factual and interpretative geotechnical reports prepared by others; v. Quantify and document geotechnical uncertainties on a systematic basis and incorporate of these into the design and risk assessment process; vi. Demonstrate judgement as to the key risks and mitigation strategies and an awareness of current risk guidance and standards.	3, 4
j) Preparation of design and health and safety documentation	i. Prepare geotechnical design documentation, design features reports and relevant construction specifications; ii. Design and document construction sequence; iii. Provide the geotechnical aspects for “safety in design” reports prepared by others.	4

KNOWLEDGE AND SKILLS		
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**	**Element of CPEng competence standard**
k) Supervise construction	i. Oversee construction sequencing, managing the risk of instability throughout the construction sequence; ii. Review/update soil/rock exposures against the ground model and design assumptions; iii. Design and review temporary support system proposals; iv. Be familiar with geotechnical construction plant and machinery and their strengths and limitations; v. Supervise the construction to confirm it complies with the drawings and specifications and expected quality standards; vi. Design and issue any variations to the design as required to mitigate nonconforming work; vii. Keep records of all observations, contract variations and site instructions as they pertain to geotechnical matters; viii. Understand the management issues associated with contaminants in soils; ix. Understand the management issues with sediment run-off.	4
l) Awareness and use of key technical documentation, guidance and standards	Demonstrate general knowledge of the Building Act, Building Code, its core cited design actions and materials standards and other important guidelines and standards such as: i. AS/NZS1170 Structural Design Actions ii. NZS3604 Timber Framed Buildings iii. NZS4402 Methods of testing soils for civil engineering purposes iv. NZS4431 Code of Practice for Earth Fill for Residential Development v. AS2159 – 2009 Pile Design and Construction vi. AS4678 – 2002 Earth Retaining Structures vii. NZGS/MBIE Earthquake Geotechnical Engineering guidance modules viii. NZGS Field Description of Soil and Rock guideline ix. Awareness of international key standards for rock sample testing and in-situ testing etc x. MBIE guidance documents and practice advisories xi. NZTA Highways Structures Design Guide and	2

KNOWLEDGE AND SKILLS		
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**	**Element of CPEng competence standard**
	Bridge Manual xii. IPENZ Practice notes and guidelines xiii. NZS 3910 Conditions of contract for building and civil engineering construction xiv. NZSEE "Red Book" The Seismic Assessment of Existing Buildings xv. Construction Industry Council – Design Documentation Guidelines xvi. Design Features Report templates xvii. AGS "Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning viii. ISO 31001 Risk management — Risk assessment techniques xix. Ministry of Education Structural and Geotechnical Guidelines for School Design and Education Infrastructure Design Guidance and other documents	
m) Understanding of building and health and safety regulations	Demonstrate a good understanding of: i. Building Act, Regulations and Building Code ii. Demonstrate a good understanding of the Health and Safety at Work Act (2015) iii. Demonstrate a good understanding of the Chartered Professional Engineers of New Zealand Act (2002)	2

4. Examples of complex geotechnical engineering problems and activities

The CPEng competence standard requires an engineer to demonstrate an ability to analyse and develop solutions to complex engineering problems. The engineer uses his knowledge and skills to do these tasks. NZGS has identified a number of complex geotechnical engineering problems and activities for a CPEng(Geotechnical).

Engineers seeking specialist recognition as a CPEng(Geotechnical) are expected to demonstrate that they are capable of carrying out most of the following complex geotechnical engineering problems and activities:

A. Infrastructure route selection, land development, and/or sub-divisions

B. The assessment of the stability of natural, fill and cut slopes in soil and rock, in the order of 10m in height under static and seismic loadings with a medium to high risk to life (and/or property) if they fail

C. The geotechnical design of foundations and soil structure interaction analysis for IL 2 buildings (as defined by AS/NZS 1170.0) in the order of 3 storeys (about 10m) high, or bridges of comparable importance, founded on a range of ground conditions and a range of foundation types

D. Retaining structures in the order of 5m in height

E. Excavations in the order of 6m in depth (for example two levels of basement)

F. Assessment of situations with high risk to life or property where special precautions or expertise are or maybe required, for example:

   - During a response to an emergency events such as an earthquake or landslide
   - Significant potential of undermining or overwhelming of a nearby building or utility,
   - Obvious signs of distress of slope (natural, cut or fill) or retaining wall
   - Obvious signs of contaminated soils
   - Obvious signs of geothermal issues

The difficulty of the ground conditions shall also be considered when assessing complexity. For example, a simple structure on very difficult ground conditions such as thick peat may be considered complex geotechnical engineering problem.

Supplementary complex engineering problems and activities include:

- Low Potential Impact Classification (PIC) dams
- Route selection and design of tunnels
- Route selection and geotechnical design for pipelines
- Specialist ground improvement techniques such as underpinning or grouting
- Rockfall protection structures
- Erosion control structures
- Offshore structures

5. Comments on demonstrating competency

The complex engineering problems and activities in Section 4 represent the range of projects to which knowledge and skills would be applied by Geotechnical Engineers working within small, large or specialised organisations. Applicants would be expected to have at least five years of practical experience following graduation to cover the range of complex problems and activities, and to have been supervised by and have their work reviewed by a more experienced CPEng(Geotechnical).

Applicants should also be able to demonstrate that they understand the boundaries of their knowledge and skills, and will seek assistance when asked to work outside their competency or level of expertise, as per elements 10 and 12 of the competence standard. For example, a retaining wall design task may have a Structural Engineer design the structural elements while a Geotechnical Engineer will define appropriate earth loadings and bearing capacities, and assess overall stability.

It is acknowledged that applicants will have a range of both experience and competency for each complex problem and activity. They are likely to have worked as part of a team, in which case they will need to demonstrate they have taken responsibility for most of the problem and activity and/or when the problems and activities are spread over more than one project.

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

- presenting a portfolio of design calculations, drawings and reports;
- outlining the steps and judgment calls in the design process, and calculations for specific elements; and
- presenting case studies of project issues encountered and resolved, for example site inspections etc.

It is recognised that there are specialist fields or activities in geotechnical engineering that are not covered by the above BOKS. These include:

i. Tunnel engineering
ii. Mine design and mine slope engineering
iii. Offshore structure foundation design
iv. Water retaining structures and dams

These specialist activities will require much of the same knowledge and skills as listed in the table in Section 3 and may require working from first principles which are applicable across the broader aspects of geotechnical engineering. It may therefore be possible to meet the geotechnical CPEng(Geotechnical) BOKS requirements above even though the range of activities is quite different to that listed in Section 4.