NEW ZEALAND GEOTECHNICAL SOCIETY INC

March 2019

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 monitor 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.
- 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'.

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

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 CPEng competence standard comprises twelve elements grouped into four competence areas:

1. Engineering knowledge
2. Professional acumen
3. Managing engineering work
4. Developing technical solutions.

Areas 1 and 4 can be considered the knowledge and skills that distinguish a CPEng(Geotechnical) from those of other Chartered Professional Engineers.

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)

(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.

Applicants for CPEng need to demonstrate competence for independent practice against the competence standard for their area of expertise. To remain registered, candidates undergo an ongoing reassessment at periodic intervals to prove continued competence. CPEng is the highest of the assessments that includes engineering professional (which includes engineering geologists), engineering technologist and engineering technician. An application typically

includes five stages: preparation, validation, evaluation, recommendation and decision. Evidence is submitted and includes engineering 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 interactive assessment including a Lead Assessor and a Practice Area Assessor. They make a recommendation to the Competency Assessment Board who make a decision regarding the application.

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. Some knowledge and skills are specific to civil structures or building structures but most are required by all CPEng(Geotechnical).

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) Concept design
c) Site or project route selection
d) Assessment of the geotechnical issues that need to be addressed in a project
e) Preliminary design
f) Development of programmes of geotechnical investigation focussed on addressing these issues
g) Performance of geotechnical field and laboratory studies
h) Preparation and engineering evaluation of geotechnical reports
i) Analysis of geotechnical data and the performance of engineering computations
j) Detailed design
k) Preparation of design and construction documents
l) Safety in design
m) Earthquake geotechnical engineering
n) Performance and engineering evaluation of construction, post-construction and site monitoring
o) Monitor construction
p) Awareness and use of key technical documentation, guidance and standards
q) 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 Engineering NZ 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:**
a) Options and alternatives identification and evaluation b) Concept design	i. Understand design processes, coordination and information required at each stage ii. Understand resource consent procedures and the level of information required for a resource consent iii. Understand peer review and building consent procedures and the level of information required for a building consent iv. Understand the general principles and terminology associated with geotechnical engineering as they relate to land development, building structures or civil structures v. Understand and describe the need for the project vi. Identify constraints and potential significant geotechnical issues vii. Identify range of potential solutions viii. Evaluate potential options and alternatives considering their relative feasibility, benefits and limitations ix. Collaborate with other project stakeholders to integrate geotechnical elements into the design of the whole construction, and x. Communicate design issues and options with clients and other stakeholders.
c) Site and route selection d) Assessment of geotechnical issues e) Preliminary design	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, and iv. Screen sites based on this evidence.
f) 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 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

KNOWLEDGE AND SKILLS	
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**
	contractors, in consideration of the client's budget iv. Evaluate ground investigation and laboratory testing proposals, and v. Direct and/or modify ground investigation programmes, as required, upon evaluation of the conditions encountered with respect to the preliminary ground model.
g) 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).
h) 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 review 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, and vi. Demonstrate judgement as to the key risks and mitigation strategies and an awareness of current risk guidance and standards.

KNOWLEDGE AND SKILLS	
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**
i) Analysis of geotechnical data and performance of engineering computations j) Detailed design k) Preparation of design and construction documents l) Safety in design	i. Understand the engineering properties of soil and rock ii. Understand the manufacture, principal engineering properties, durability, cost, availability and potential applications of construction materials iii. Understand quality control processes, certification and traceability of supply iv. Provide the geotechnical aspects for Safety in Design reports for the full project lifecycle including construction, operation, maintenance, modification and demolition. Design, assess and calculate: v. Soil and rock strength vi. Bearing capacity, pile capacity (shallow and deep foundations) and allowable bearing pressures vii. Settlement and/or ground movement under static and seismic loads and over the design life, including expansion and consolidation properties viii. Slope stability and displacement under static and seismic actions ix. Geotechnical aspects of retaining systems under static and seismic loads x. Soil collapse and/or erosion potential xi. Control of groundwater xii. Earthworks including site preparation, cut/fill, compaction characteristics and material acceptability for use as fill xiii. Pavement subgrade qualities and pavement design xiv. Understand and have competency in the use, and have competency in reviewing outputs prepared by others, of most commonly used geotechnical analytical software (e.g. for retaining wall, foundation, pile and slope stability analysis and liquefaction assessment) xv. Understand the limitations and assumptions behind this software xvi. Prepare geotechnical design documentation, design features reports and relevant construction specifications xvii. Design and document construction sequence, and xviii. Prepare specifications and construction monitoring requirements.
m) 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

KNOWLEDGE AND SKILLS	
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**
	vi. Engagement with structural engineers, for example soil-structure interaction, and vii. Understand the broad principles behind probabilistic seismic hazard analysis.
n) 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 monitor 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, and iv. Evaluate engineering aspects of ground related distress associated with for example slope, foundation, and/or retaining wall distress or failure.
o) Monitor construction	i. Be familiar with health and safety requirements and processes ii. Understand Building Code compliance processes and documentation including different construction monitoring levels iii. Understand construction contracts in accordance with relevant standards iv. Oversee construction sequencing, managing the risk of instability throughout the construction sequence v. Review/update soil/rock exposures against the ground model and design assumptions vi. Design and review temporary support system proposals vii. Be familiar with geotechnical construction plant and machinery and their strengths and limitations viii. Monitor the construction to confirm it complies with the drawings and specifications and expected quality standards ix. Know when to commission tests on the engineering properties of soil, rock and engineered materials, and evaluate test reports x. Design and issue any variations to the design as required to mitigate nonconforming work xi. Keep records of all observations, contract variations and site instructions as they pertain to geotechnical matters xii. Understand and implement quality control processes, certification and traceability of supply xiii. Understand the management issues associated with contaminants

KNOWLEDGE AND SKILLS	
Project phase	**A Chartered Professional Engineer (Geotechnical) should be able to:**
	in soils, and xiv. Understand the management issues with sediment run-off, and xv. Prepare maintenance schedules for the life of the structure.
p) 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 Bridge Manual xii. Engineering NZ Practice notes and guidelines xiii. NZS 3910 Conditions of contract for building and civil engineering construction xiv. NZSEE/SESOC/NZGS/MBIE/EQC, 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 xviii. ISO 31001 Risk management – Risk assessment techniques, and xix. Ministry of Education Structural and Geotechnical Guidelines for School Design and Education Infrastructure Design Guidance and other documents.
q) 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), and iii. The Chartered Professional Engineers of New Zealand Act (2002)

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/her 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 all of the following complex geotechnical engineering problems and activities.

A. Geotechnical engineering assessment for infrastructure route selection

B. Assessment and concept design of land for development or subdivision where the land has a range of ground conditions or is subject to natural hazards, and engineering works are required to enable development of the land

C. 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

D. 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

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

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

G. Assessment of situations with high risk to life or property where special precautions or expertise are or may be 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 a complex geotechnical engineering problem.

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. 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.