International Association for Engineering Geology and the Environment

IAEG C4 – EDUCATION AND TRAINING

Engineering Geology Core Competencies

1 Introduction

An engineering geologist investigates, analyses, and communicates complex engineering geological problems that may arise as the result of the interaction between geology and the construction of geotechnical or resource extraction works, as well as to assess geological hazards and develop measures for mitigating them,

The competency areas that characterize an engineering geologist are detailed in the matrix. Six levels of achievement are indicated, based on the increasing order of thinking skills developed through education and training known as Bloom's Taxonomy. These are achieved through two different but complementary means:

- Achievement through education
- Achievement through practice

By education, we mean formalised post-secondary education, at undergraduate or graduate level, which will differ between institutions and education systems. By practice we mean engineering geology practice supervised, and preferably mentored, by senior practitioners, supplemented by continued professional development.

This document describes the way that these competencies are applied in practice for typical engineering geological activities. It is an expansion of the work of the FedIGS JTC3 recommendations for geo-engineering education and also takes into consideration core competencies required for registration/certification as geo-engineering professionals (e.g. Professional Engineering Geologist in New Zealand, Certified Engineering Geologist in California, Geotechnical Professionals in Germany).

The core competencies focus on engineering geology practice and analysing engineering geological problems to inform engineering solutions. The engineering geologist uses an understanding of geological features and processes and the genesis of geological formations to produce site-specific geological models (Turner and Rengers, 2010). While a individual engineering geologist's expertise might be quite narrowly defined, resulting from experience and training, engineering geologists should aim to have a breadth of knowledge and skills (refer Section 3) which they are able to apply in a range of situations and localities (refer Section 4).

In defining competencies a balance was sought which would make the matrix comprehensive enough to provide a framework for training and certifying engineering geologists, without making it so prescriptive that local and regional variability in education and practice could not be accommodated.

In particular, we recognise that around the world there are different types of institutions providing education for the same discipline (engineering geology) For example, depending on whether the university is technical or scientific, if the degree is awarded from a North American or European university or from elsewhere, the degree will have a different structure, level (i.e. undergraduate, postgraduate), and focus. We have established a list of competencies that, although it may not fit all programmes in all universities or countries, represents the broad education and training goals to be achieved by future engineering geologists. We have not differentiated between levels of education in the “level of achievement” columns in the matrix, focussing rather on what should be achieved through formal education (i.e. university) and what should be achieved through practice and work experience.

2 Examples of complex engineering geology problems and activities

In order to define the required core competencies for engineering geological practitioners (beginners) it is useful to identify the type of activities an engineering geologist should be able to undertake. An engineering geologist should have the ability to investigate, analyse, and communicate complex engineering geological problems. The engineering geologist uses his or her knowledge and skills to complete these tasks.

It is acknowledged that engineering geologists who have recently completed their education will have limited experience, knowledge skills in each competency area, depending on the local needs and capabilities of the educational institution. It is expected that continued professional development in these competency areas in practice will require supervision, support and training from senior colleagues upon entering the workforce. It is also expected that with experience an engineering geologist will develop the higher order thinking skills in the competency areas shown in the matrix and will be able to work on progressively more complex engineering geology problems activities.

Examples of complex engineering geology problems and activities are:

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, under static and seismic loadings with a medium to high risk to life (and/or property) if they fail
C. The assessment of landslides, slips and other forms of slope instability in soil and rock and assessment of mitigation measures
D. Importance Level 2 buildings, 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 maybe required, for example:
   - During a response to an emergency events such as an earthquake or landslide
   - Significant potential of undermining or overwhelming 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

H. Construction material selection for large earthworks

I. Debris barriers for buildings or infrastructure

3 Core Competencies

The core competencies of an engineering geologist may be related to the process steps for a typical design and construction project, grouped as follows:

Table 1: a) Review of existing data

b) Site or project route selection

c) Assessment of the engineering geological issues that need to be addressed in a project

Table 2: d) Development of engineering geological investigation programmes focussed on addressing these issues

e) Performance and interpretation of geological mapping, field investigations and laboratory studies

Table 3: f) Interpretation of geological and hydrogeological conditions and hazards from investigations

Table 4: g) Development of recommendations for design, mitigation and construction

Table 5: h) Preparation of engineering geology reports

Table 6: i) Documentation of the geological and hydrogeological conditions encountered during construction

j) Supervision and inspection of the geological and hydrogeological aspects of construction, post-construction and site monitoring

Table 7: k) Awareness and use of key technical documentation, guidance and standards

l) Understanding of key building, environmental, resource management and health and safety regulations

It is recognised that there is some overlap with the engineering profession and communication with other geo-professionals is, therefore, expected for each topic. It is also expected that engineering geologists will understand the requirement for review by senior engineering geologists and recognise when senior assistance is required.

Table 1

Project phases: a) Data review and b) Site and route election and c) Assessment of geotechnical issues
Core competencies– **An engineering geologist should be able to** (including, but not limited to)**:**
i. Conduct a desk top study: perform literature searches and site history analyses (including geology/geomorphology maps, hazard maps, aerial photographs, site usage, council files etc.) related to surface and subsurface geological and hydrogeological conditions; ii. Develop a regional geological model of the project area on the basis of available geological data and field traverses; iii. Review preliminary project plans to identify potential impacts from adverse geological conditions; iv. Undertake or direct a site reconnaissance, and using a good understanding of geomorphology and geology, assess the geological and geotechnical issues that need to be considered in the design process; v. Develop and document a geological model showing existing subsurface conditions and possible hazards affecting the proposed development.

Table 2

Project phases: d) Development of site investigation programmes and e) Performance of geological mapping, geotechnical field and laboratory studies
Core competencies– **An engineering geologist should be able to** (including, but not limited to)**:**
i. Contribute to planning the scope and locations for ground investigation, sample collection and laboratory testing programmes with an appreciation of the benefits and limitations of each investigation and laboratory test method and the site constraints, including buried services; ii. Direct and/or modify ground investigation programmes, as required, upon evaluation of the conditions encountered with respect to the ground model; iii. Interpret remote sensing data; iv. Map geomorphology, lithology, hydrogeological features, geological structures

and geohazards; v. Log geological, hydrological and engineering properties of rock, soil and groundwater in exploratory borings, wells and excavations; vi. Direct and/or perform rock, soil and groundwater sampling for laboratory testing; vii. Direct and/or perform field geophysical techniques used to evaluate subsurface conditions and obtain geological and engineering properties of rock and soil; viii. Direct and/or perform routine field and laboratory tests for many of the following: a. soil and rock mass classification b. petrographic studies c. soil and rock strength and stiffness d. hydraulic conductivity e. groutability f. bearing capacity g. expansion/shrinkage properties h. consolidation characteristics i. compaction characteristics j. material acceptability for use in fill or armour k. slake durability l. In-situ stress m. Any other specialised studies like neotectonic studies, micro earthquake studies, karst analyses, liquefaction analysis, etc. if required as per site conditions. ix. Install and monitor field instrumentation (e.g. groundwater, slope movements, settlement); x. Identify constraints, gaps in understanding and uncertainties and their associated impacts on the design.

Table 3

Project Phase: f) Interpretation of investigation findings to refine the ground model
Core competencies– **An engineering geologist should be able to** (including, but not limited to)**:**
i. Prepare engineering geology maps and cross-sections, or 3-D models to depict surface and subsurface conditions (rock, soil and groundwater); ii. Evaluate geological structure, hazards, geomorphology, process rates and hydrogeology of the site from mapping, geophysics and subsurface investigations; iii. Interpret and compile the results of laboratory testing to determine engineering geological and chemical properties of rock, soil and water; iv. Calculate future ground response to natural and man-made processes (e.g. settlement, erosion, subsidence, slope or tunnel instability, rockfall, seismic action, fault rupture, dewatering, flooding) and its impact on the existing environment, including adjacent properties; v. Determine groundwater gradient and flow direction; vi. Identify materials or environments that may be detrimental to projects and/or

human health (e.g. asbestos, methane, sensitive soils).

Table 4

Project Phase: g) Recommendations for design, mitigation and construction
Core competencies– **An engineering geologist should be able to** (including, but not limited to)**:**
i. Operate slope stability and other software; ii. Carry out numerical modelling (FEM analysis); iii. Undertake basic engineering calculations; iv. Identify assumptions and limitations of calculations; v. Work with uncertainty and fragmented data; vi. Present results and data clearly and effectively for review and incorporation in the design; vii. Contribute to design components such as set backs, trigger criteria, monitoring, construction sequencing; viii. Contribute to design documentation and relevant construction specifications;

Table 5

Project Phase: h) Preparation of geotechnical reports
Core competencies– **An engineering geologist should be able to:**
Prepare written factual, interpretive and baseline reports which present geological model and findings and present and interpret these reports to the clients; i. Have reports approved by consenting agencies; ii. Prepare site visit reports/inspection reports/memos during construction and post construction stage. iii. Prepare bankable geological and geotechnical as-built documentation

Table 6

Project Phases: i) Documentation of encountered conditions and j) Construction and site monitoring
Core competencies– **An engineering geologist should be able to** (including, but not limited to)**:**
i. Monitor field instrumentation; ii. Prepare comprehensive notes on site observations; iii. Contextualise geological conditions encountered during construction to compare to the ground model; iv. Identify ground related distress associated with, for example, slope, foundation, and/or retaining wall distress or failure; v. Identify and report contaminants; vi. Recognise geotechnical construction plant and machinery and their strengths and limitations.

Table 7

Project Phases: k) Awareness and use of key technical documentation, guidance and standards and l) Understanding of building, environmental, resource and health and safety regulations
Core competencies– An engineering geologist should be able to:
Have an awareness of and work in accordance with: i. Applicable local building codes; ii. Technical guidance, guidelines, and standards published by the relevant Territorial Authority; iii. Health and safety regulations; iv. Professional registration; v. Professional societies (local, national, international)