What is a Geotechnical Professional?

D.F. VanDine
VanDine, Geological Engineering Limited, Canada, vandine@islandnet.com, and
Canadian Geotechnical Society, Canada, President@cgs.ca

ABSTRACT
For the purpose of this paper, a 'geotechnical professional' is a 'geotechnical engineer' or an 'engineering geologist'. Such a professional likely has not graduated from an undergraduate or graduate degree program in 'geotechnical engineering' or 'engineering geology', and likely has not had to become registered as a 'geotechnical engineer' or 'engineering geologist' to be able to practice. The result is that geotechnical professionals are currently only self-regulated or, at best, regulated by peer opinion. In today's current global marketplace, in which many geotechnical professionals practice in a number of different jurisdictions, countries and even continents, these issues are becoming increasingly important for all stakeholders, clients and the geotechnical professionals themselves. This paper suggests two possible solutions to these issues:
1) Geotechnical professionals must come to some general world-wide consensus on the definitions of 'geotechnical engineering' and 'engineering geology'. I suggest that the ISSMGE and IAEG definitions are good starting points, but that these definitions should be revisited with input from all member countries.
2) Geotechnical professionals must come to some general world-wide consensus on the minimum standards, or competencies, required to practice 'geotechnical engineering' and 'engineering geology'. I suggest that the UK RoGEP and the draft FedIGS JTC-3's competencies are good starting points, but that they need to be adapted with input from all countries.

Keywords: geotechnical engineer, engineering geologist, competencies, professionalism

1 INTRODUCTION

'Geotechnical engineering' is a hybrid composed of soil mechanics, rock mechanics and geology, among others subjects. Most 'geotechnical engineers' have an undergraduate degree in Civil Engineering, Geological Engineering, Mining Engineering, or Petroleum Engineering. Similarly, 'engineering geology' is a hybrid of geology, geomorphology and at least an appreciation of engineering, among other subjects, and most 'engineering geologists' have an undergraduate degree in Geology, Earth Sciences, or perhaps even Physical Geography.

To my knowledge, there are no post-secondary institutions that offer undergraduate or graduate degrees in 'geotechnical engineering' or 'engineering geology'. There are specific programs, but no specific degrees. Therefore, there are no minimum standards or competencies for 'geotechnical engineers' or 'engineering geologists' (collectively referred to as 'geotechnical professionals'), and, as far as I am aware, there is nowhere in the world that requires a geotechnical professional to be registered as a 'geotechnical engineer' or 'engineering geologist' to be able to practice.

In addition, even though the phrases, 'geotechnical engineer' 'geotechnical specialist', 'geotechnical consultant' or something similar, often appear in various jurisdictional acts, regulations, bylaws, ordinances, guidelines and/or policies, the term 'geotechnical' is seldom, if ever, defined. Each jurisdiction likely has a different idea of what 'geotechnical' means and what qualifications geotechnical professionals have, or should have.

Geotechnical professionals themselves likely have different ideas of what qualifications they should have. The result is that geotechnical professionals are currently only self-regulated or, at best, regulated by peer opinion. In today's current global marketplace, in which many geotechnical professionals now practice in a number of different jurisdictions, countries and even continents, these issues are becoming increasingly important for all stakeholders, clients and the professionals themselves.

Most geotechnical professionals follow their respective professional engineering or professional geology code of ethics that states, for example, something similar to "a professional must undertake and accept responsibility for assignments only when qualified by training or experience". But how do geotechnical professionals know if they are qualified?

This paper suggests two possible solutions to these issues that, if followed, will help better protect the public, geotechnical professionals and the profession. First, there should be some general world-wide consensus on the definitions of 'geotechnical engineering' and 'engineering geology'. Second, there should be some general world-wide consensus on the minimum standards, or competencies, that geotechnical professionals should possess.

2 DEFINITIONS

2.1 Background

There is currently no world-wide consensus on the definitions of 'geotechnical engineering' and 'engineering geology'. Definitions, of course, depend on who is doing the defining and for what purpose.

The International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) defines 'geotechnical engineering' as "the story of the engineering relationship between humans and earth. The science that explores the mechanics of soils and rocks and its engineering application to the development of human kind" (ISSMGE, 2013). The International Association of Engineering Geology (IAEG) defines 'engineering geology' as "the science devoted to the investigation, study and solution of the engineering and environmental problems which may arise as the result of the interaction between geology and the works and activities of man as well as to the prediction and of the development of measures for prevention or remediation of geological hazards." (IAEG, 1992). But in the literature, and on the internet, one can find numerous other definitions, some of which vary considerably from the above.

In fact, there is not even agreement on the terms 'geotechnical engineering' and 'engineering geology'. The former is frequently referred to as 'geomechanics', 'ground engineering', and/or 'geo-engineering'[1], and the latter is frequently referred to as 'geotechnics', 'environmental geology' and/or 'applied geomorphology'.

Why are there no commonly accepted definitions of 'geotechnical engineering' and 'engineering geology'? One reason, as discussed above, is because 'geotechnical professionals' enter this profession from a wide range of educational backgrounds. Another reason could be that typical geotechnical activities and projects cover a very wide spectrum and, therefore, it's difficult to provide a 'definitive definition'.

2.2 Suggestion

It is my suggestion that geotechnical professionals must come to some general world-wide consensus on the definitions of 'geotechnical engineering' and 'engineering geology'. I suggest that the ISSMGE and IAEG definitions are good starting points, but the fact that they have not been universally adopted indicates that perhaps these definitions should be revisited, with input from all member countries.

3 COMPETENCIES

The following subsections describe a number of, at best, <u>voluntary</u> methods that various jurisdictions have established to help evaluate

[1] 'Geo-engineering' has relatively recently been adopted by some to mean the human intervention (at obviously a very large scale) of the Earth's climatic system to limit adverse effects of climate change.

the competencies of geotechnical professionals.

3.1 Canada

Engineers Canada is the national consortium of the country's 12 provincial and territorial professional engineering regulating bodies. Similarly, Geoscientists Canada is the national consortium of the country's nine provincial and territorial professional geosciences regulating bodies. These two organizations help to develop and maintain national standards for the engineering and geoscience undergraduate degree programs. This is done through the Canadian Engineering Accreditation Board of Engineers Canada and the Canadian Geoscience Standards Board of Geoscience Canada, respectively.

Because these boards only look at undergraduate degree programs, and as mentioned previously, there are no geotechnical-specific undergraduate degree programs in Canada, national competencies for 'geotechnical engineering' and 'engineering geology' have not been established.

However, one provincial regulating body, the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) has established ten geotechnical engineering-specific competencies, and within each competency there are between two and five 'indicators'. The competencies include the knowledge of: current and applicable acts, regulations, codes, permits, standards and guidelines; site and geotechnical characteristics; engineering principles to develop appropriate design solutions; safety; effective communication; and quality systems, and the ability to assess: that designs conform with actual site conditions; and the performance of the design solution over the design life of the project. The full document is available upon request from registrar@apeg.bc.ca.

These APEGBC competencies and indicators are intended to help new practitioners determine if they have suitable training and experience to practice 'geotechnical engineering'. Currently this is a voluntary self-evaluation process.

Therefore, in Canada, there are no nationally-defined geotechnical-specific competencies.

3.2 United States of America (US)

Within the broad discipline of Civil Engineering, the American Society of Civil Engineers (ASCE) has developed a 'Body of Knowledge' (BOK) (ASCE, 2008). Table 1[2] summarizes the BOK; the six levels of achievement and the 24 appropriate outcomes (competencies) for entry into to the practice Civil Engineering at the professional level. This BOK, however, is not geotechnical-specific.

In 2008, the (US) Academy of Geo-Professionals (AGP) was founded as an independent body, but is related to the Geo-Institute of the ASCE[3] among a number of other US geotechnical professional and trade organizations. The AGP provides a voluntary method for engineers who are already licensed to practice engineering in one or more US states (or elsewhere) to be recognized as having "a special knowledge and experience in the field of geotechnical engineering" (AGP, 2016).

The criteria for an engineer to become an AGP 'Diplomate Geotechnical Engineering' (D.GE.) are:

- have a professional engineer's US state license (or foreign equivalent)
- have a minimum of eight years of progressively increasing responsibility after obtaining a US state licence (or foreign equivalent)
- have a master's degree in Civil Engineering with an emphasis on geotechnical engineering
- have satisfactory experience in at least one of the following areas:
  - site characterization
  - laboratory testing and analysis
  - foundation design
  - slope stability
  - excavations and retaining structures
  - tunnels and underground construction

[2] All tables are at the end of the paper.

[3] The Geo-Institute is the specialty institute within the ASCE that is most closely focused on 'geotechnical engineering'.

- embankments, earth and rockfill dams
- satisfactorily orally defend his / her application to a Board of Trustees.

Although national and geotechnical-specific, the AGP has not defined any geotechnical-specific competencies.

Therefore, in the US, although there is a voluntary program to become a Diplomate Geotechnical Engineer[4], there are no nationally-defined geotechnical-specific competencies.

3.3 United Kingdom (UK)

In the UK, nationally-defined geotechnical-specific competencies do exist.

In 2011, the voluntary UK Register of Ground Engineering Professionals (RoGEP) was established with the support of the Institution of Civil Engineers (ICE), the Geological Society of London (GSL), and the Institute of Materials, Minerals and Mining (IMMM), to identify members "who are suitably qualified and competent in ground engineering"[5] (ICE, 2014)

There are three grades of RoGEP registration: 'Ground Engineering Professional'; 'Ground Engineering Specialist'; and 'Ground Engineering Advisor', and progression from 'Professional' to 'Specialist' to 'Adviser' is encouraged. The RoGEP registration requirements common to all grades are:

- be a chartered engineer or geologist with ICE, GSL or IMMM
- possess a sound knowledge and understanding of scientific / engineering / technical principles together with experience of ground engineering
- by training and experience, meet the competence requirements set out in an appendix (Table 2)
- have a commitment to continuing professional development, particularly in the area of ground engineering.

The competencies in Table 2 are grouped into six areas: innovation; technical solutions; integration; risk management; sustainability; and management.

The emphasis of the 'Professional' is the ability to carry out certain tasks, the emphasis of the 'Specialist' is to manage certain tasks, and the emphasis of the 'Advisor' is to take responsibility for certain tasks.

Registrants also need to select one to four areas of expertise from:

- coastal / marine / offshore
- contaminated land / landfill engineering
- engineering geology / hydrogeology
- foundations / retaining structures
- ground investigation
- ground treatment
- materials and earthworks
- mining / quarrying
- soil and/or rock mechanics
- slopes, soil and/or rock
- underground works
- other

Competencies, requirements and typical responsibilities of each of the three grades, 'Professional'; 'Specialist' and 'Advisor', are summarized in Table 2 and 3.

Therefore, in the UK, there is a voluntary program to become designated as a 'Ground Engineering Professional', 'Ground Engineering Specialist' and 'Ground Engineering Advisor'[6], and there has been a start to broadly nationally-define geotechnical-specific competencies.

I understand that this UK geotechnical-specific voluntary professional registry program is being currently being evaluated for use by other European countries.

3.4 International

In 2002, the ISSMGE, the IAEG and the International Society of Rock Mechanics (ISRM) jointly began to look at the question of competencies of 'geotechnical engineers' and 'engineering geologists'. In 2006, the Joint Technical Committee on Education and Training (JTC-3) was established under the umbrella of the Federation of International Geo-engineering Societies (FedIGS). Its mandate was to prepare a "state-of-the-art report on education and training of

[4] Currently there are approximately 330 AGP members who are designated 'Diplomate Geotechnical Engineering' (D.GE.)

[5] I interpret 'ground engineering' to be closely related to 'geotechnical engineering' and 'engineering geology'.

[6] It is my understanding that the UK RoGEP hopes to have 400 members by the end of 2016.

engineering geologists, geological engineers, geotechnical engineers, and rock engineers". This committee produced its progress report in 2010 (Turner and Rengers, 2010).

Turner and Rengers (2010) adapted the ASCE BOK (as discussed in Section 3.2 above) as the basis of their work. They used the same six levels of achievement as the ASCE BOK, but adapted the outcomes (competencies) that they felt were better suited to geotechnical professionals:

- foundational: mathematics; statistics, basic science, and geoscience
- technical-engineering science: statics, mechanics of materials, fluid mechanics, soil mechanics, and rock mechanics
- technical-engineering design: numerical modelling, engineering geology, hydrogeology, site investigation, foundations, and underground construction
- professional: communication, public policy, business and public administration, globalization, leadership, teamwork, attitudes, lifelong learning, and professional and ethical responsibility.

Turner and Rengers (2010) developed four conceptual competency profiles to provide examples how this approach could be used to assess education and training, one for each of 'geotechnical engineers', 'engineering geologists', 'geological engineers', and 'rock engineers'. The four conceptual competency profiles are shown in Tables 4 to 7. Because these tables are conceptual, education and training levels were not assigned, but are simply indicated with an 'X'. The common 'professional' competencies for all four sub-disciplines were taken directly from the ASCE BOK table and are shown in Table 8.

These conceptual competency profiles are useful in themselves, but are also useful to compare the relative competencies between the sub-disciplines of geotechnical professionals.

It is my understanding that since 2010, JTC-3 has not progressed further in the development of these tables.

3.5 Suggestion

It is my suggestion that geotechnical professionals must come to some general world-wide consensus on the minimum standards, or competencies, of 'geotechnical engineering' and 'engineering geology'. I suggest that the UK RoGEP and the draft FedIGS JTC-3's competencies are good starting points, but that they need to be adapted with input from all.

4 CONCLUSIONS AND SUGGESTIONS

So, what is a geotechnical professional? He or she is a professional that, as far as I know. has not graduated from an undergraduate or graduate degree program in 'geotechnical engineering' or 'engineering geology'. And as far as I know, does not have to become registered as a 'geotechnical engineer' or 'engineering geologist' to be able to practice. The result is that geotechnical professionals are currently only self-regulated or, at best, regulated by peer opinion. In today's current global marketplace, in which many geotechnical professionals now practice in a number of different jurisdictions, countries and even continents, these issues are becoming increasingly important for all stakeholders, clients and the professionals.

Most geotechnical professionals follow their respective professional engineering or professional geology code of ethics that requires them to be "qualified by training or experience". But how do geotechnical professionals know if they are qualified?

This paper suggests two possible solutions to these issues:

1) Geotechnical professionals must come to some general world-wide consensus on the definitions of 'geotechnical engineering' and 'engineering geology'.

2) Geotechnical professionals must come to some general world-wide consensus on the minimum standards, or competencies, of 'geotechnical engineering' and 'engineering geology'.

It is my opinion that, if followed, these suggestions will help better protect the public, geotechnical professionals and the profession.

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The opinions expressed herein are mine, and not necessarily those of the Canadian Geotechnical Society.

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Table 1 The ASCE Body of Knowledge (adapted from ASCE, 2008). 'B' indicates fulfilled through a bachelor's degree; 'M' through a master's degree or equivalent; and 'E' through pre-license experience.

OUTCOME NUMBER AND TITLE	LEVEL OF ACHIEVEMENT					
	Know-ledge	Compre-hension	Appli-cation	Analy-sis	Synthe-sis	Evalu-ation
Fundamental						
1. Mathematics	B	B	B			
2. Natural sciences	B	B	B			
3. Humanities	B	B	B			
4. Social sciences	B	B	B			
Technical						
5. Materials science	B	B	B			
6. Mechanics	B	B	B	B		
7. Experiments	B	B	B	B	M	
8. Problem recognition and solving	B	B	B	M		
9. Design	B	B	B	B	B	E
10. Sustainability	B	B	B	E		
11. Contemp. issues and hist. perspectives	B	B	B	E		
12. Risk and uncertainty	B	B	B	E		
13. Project management	B	B	B	E		
14. Breadth of civil engineering areas	B	B	B	B		
15. Technical specialization	B	M	M	M	M	E
Professional						
16. Communication	B	B	B	B	E	
17. Public policy	B	B	E			
18. Business and public administration	B	B	E			
19. Globalization	B	B	B	E		
20. Leadership	B	B	B	E		
21. Teamwork	B	B	B	E		
22. Attitudes	B	B	E			
23. Lifelong learning	B	B	B	E	E	
24. Professional and ethical responsibility	B	B	B	B	E	E

Table 2 Assessment of Competence Level for UK RoGEP (adapted from UK RoGEP, 2014)

Attribute	Registered Ground Engineering Professional	Registered Ground Engineering Specialist	Registered Ground Engineering Adviser
Innovation	Ability to introduce and develop innovation in connection with ground engineering activities in respect of the challenges associated with research, design or construction	Manage the introduction and development of innovation in connection with ground engineering activities in respect of the challenges associated with research, design or construction	Take responsibility for the introduction and development of innovation in connection with ground engineering activities in respect of the challenges associated with research, design or construction
Technical Solutions	Ability to apply and implement technical solutions in connection with ground engineering activities in respect of problems associated with research, design or construction	Manage the application of technical solutions in connection with ground engineering activities in respect of problems associated with research, design or construction	Take responsibility for technical solutions in connection with ground engineering activities in respect of problems associated with research, design or construction
Integration	Ability to integrate ground engineering activities in a multidisciplinary environment associated with research, design or construction	Manage ground engineering activities in a multidisciplinary environment associated with research, design or construction	Take responsibility for ground engineering activities in a multi-disciplinary environment associated with research, design or construction
Risk Management	Ability to identify and assess risks in connection with ground engineering activities in respect of the challenges associated with research, design, construction, health, safety and welfare	Manage the identification and assessment of risks in connection with ground engineering activities in respect of the challenges associated with research, design, construction, health, safety and welfare	Take responsibility for the identification and assessment of risks in connection with ground engineering activities in respect of the challenges associated with research, design, construction, health, safety and welfare
Sustainability	Ability to investigate and promote sustainability in connection with ground engineering activities in respect of problems associated with research, design or construction	Manage the identification and promotion of sustainability in connection with ground engineering activities in respect of problems associated with research, design or construction	Take responsibility for the identification and promotion of sustainability in connection with ground engineering activities in respect of problems associated with research, design or construction
Management	Ability to plan and deliver ground engineering activities in respect of problems associated with research, design or construction	Manage the planning and delivery of ground engineering activities in respect of problems associated with research, design or construction	Take responsibility for the planning and delivery of ground engineering activities in respect of problems associated with research, design or construction

Table 3 UK RoGEP Grades (adapted from UK RoGEP, 2014)

Registered Ground Engineering Professionals will typically be competent to:
- carry out a range of routine ground engineering activities
- contribute within a team to the design and execution of a wider range of activities
- appreciate the role of their areas of ground engineering expertise within a project and in relation to other disciplines

Registered Ground Engineering Specialists will typically have eight years relevant post-graduate experience, or a relevant master's degree and six years relevant post-graduate experience, in ground engineering, and will typically be competent to:
- design and manage a range of ground engineering activities
- check the output documents from the same activities, when undertaken by others
- approve and/or authorise factual work and routine interpretative work by others

Registered Ground Engineering Adviser will typically have five years of practice as a Registered Ground Engineering Specialist, will be required to demonstrate sufficient additional post-chartership competence over and above the Specialist grade, and will typically be competent to:
- design, manage, check, approve, authorise and take responsibility for a wide range of ground engineering services
- act as a technical mentor to all other ground engineering professionals.

Tables 4-7 Four conceptual competency profiles demonstrating how the different specializations each have a distinct set of required competencies (adapted from Turner and Rengers, 2010.) 'X' indicates that the education and training levels are unassigned to either: 'B' fulfilled through a bachelor's degree; 'M' through a master's degree or equivalent; and 'E' through pre-license experience.

Table 8 is common to all four specializations, and should be attached to the bottom of each of Tables 4-7.

Table 4

GEOTECHNICAL ENGINEER

OUTCOME	LEVEL OF ACHIEVEMENT					
	Know-ledge	Compre-hension	Appli-cation	Analy-sis	Sythe-sis	Evalu-ation
Foundational						
Mathematics	X	X	X			
Statistics	X	X	X			
Basic science	X	X	X			
Geoscience	X	X				
Technical-Engineering Science						
Statics	X	X	X	X		
Mechanics of materials	X	X	X	X		
Fluid mechanics	X	X	X	X		
Soil mechanics	X	X	X	X		
Rock mechanics	X	X	X			
Technical-Engineering Design						
Numerical modelling	X	X				
Engineering geology	X					
Hydrogeology	X					
Site investigation	X	X	X			
Foundations	X	X	X	X	X	X
Underground construction	X	X				

Table 5 Refer to note above Table 4

ENGINEERING GEOLOGIST

OUTCOME	LEVEL OF ACHIEVEMENT					
	Know-ledge	Compre-hension	Appli-cation	Analy-sis	Systhe-sis	Evalu-ation
Foundational						
Mathematics	X	X				
Statistics	X	X	X			
Basic science	X	X	X			
Geoscience	X	X	X	X	X	X
Technical-Engineering Science						
Statics	X					
Mechanics of materials	X					
Fluid mechanics	X					
Soil mechanics	X	X				
Rock mechanics	X	X				
Technical-Engineering Design						
Numerical modelling	X					
Engineering geology	X	X	X	X	X	X
Hydrogeology	X	X	X	X	X	
Site investigation	X	X	X	X	X	X
Foundations	X	X				
Underground construction	X					

Table 6 Refer to note above Table 4

GEOLOGICAL ENGINEER

OUTCOME	LEVEL OF ACHIEVEMENT					
	Know-ledge	Compre-hension	Appli-cation	Analy-sis	Systhe-sis	Evalu-ation
Foundational						
Mathematics	X	X	X			
Statistics	X	X	X			
Basic science	X	X	X	X		
Geoscience	X	X	X	X	X	X
Technical-Engineering Science						
Statics	X	X	X	X		
Mechanics of materials	X	X	X	X		
Fluid mechanics	X	X	X	X		
Soil mechanics	X	X	X	X		
Rock mechanics	X	X	X	X		
Technical-Engineering Design						
Numerical modelling	X	X				
Engineering geology	X	X	X	X	X	X
Hydrogeology	X	X	X	X	X	X
Site investigation	X	X	X	X	X	X
Foundations	X	X	X			
Underground construction	X	X	X	X		

Table 7 Refer to note above Table 4

ROCK ENGINEER

OUTCOME	LEVEL OF ACHIEVEMENT					
	Know-ledge	Compre-hension	Appli-cation	Analy-sis	Synthe-sis	Evalu-ation
Foundational						
Mathematics	X	X	X			
Statistics	X	X	X			
Basic science	X	X	X			
Geoscience	X	X				
Technical-Engineering Science						
Statics	X	X	X	X		
Mechanics of materials	X	X	X	X		
Fluid mechanics	X	X	X	X		
Soil mechanics	X	X				
Rock mechanics	X	X	X	X	X	X
Technical-Engineering Design						
Numerical modelling	X	X	X	X	X	
Engineering geology	X	X	X			
Hydrogeology	X	X				
Site investigation	X	X	X			
Foundations	X	X				
Underground construction	X	X	X	X	X	X

Table 8 Common outcomes to all four specializations shown in Table 4 to 7. Refer to note above Table 4

COMMON OUTCOMES

OUTCOME	LEVEL OF ACHIEVEMENT					
	Know-ledge	Compre-hension	Appli-cation	Analy-sis	Synthe-sis	Evalu-ation
Professional						
Communication	B	B	B	B	E	
Public policy	B	B	E			
Business and Public administration	B	B	E			
Globalization	B	B	B	E		
Leadership	B	B	B	E		
Teamwork	B	B	B	E		
Attitudes	B	B	E			
Lifelong learning	B	B	B	E	E	
Professional and ethical responsibility	B	B	B	B	E	E