Notes on the 39th Congress, IAH, Niagara Falls, September 2012

Dick Jackson, January 15th, 2011

Proposed session:

Education and Core Competencies for Professional Hydrogeologists

Why?

Hydrogeologists may undergo initial education at the BS/BSc level as engineers, geoscientists or in another area of physical science. There is a need in the 21st Century to standardize the required competency profile of a professional hydrogeologist so that their professional certification is accepted internationally. This is particularly the case in free-trade areas such as North America and the European Union where cross border consulting is economically important. It is also important to foreign graduate students who will want to be assured that their academic qualification in hydrogeology will be accepted internationally.

Background

The Bologna process in Europe and the American Society of Civil Engineer's Body of Knowledge (BOK2) process in the US clearly indicate the growing acceptance of the BS/BSc degree as that of the engineer-in-training degree and that, in the words of the ASCE's Committee on Academic Prerequisites for Professional Practice:

The outcome regarding specialized technical knowledge is best accomplished in a post-graduate program of study. By not including technical specialization in the undergraduate program of study, necessary breadth can be achieved without increasing the size of the curriculum.

Thus, in the USA, the ASCE and the National Council of Examiners for Engineering and Surveying are implementing a plan so that by 2025 admission to an 8-hour written examination in the principles and practice of engineering will require that an engineering intern have:

1. A Master of Science degree in engineering from an accredited institution and 3 or more years of progressive experience, or
2. A minimum of 30 additional appropriate credits from approved course providers plus 4 or more years of progressive experience.

This is generally referred to as the B + M/30 & E requirement. Therefore the BS is the engineer-in-training degree and the MS is the professional engineer degree.

The Bologna process has moved the EU nations towards a similar policy position with a first cycle/second cycle university system of 3+2 years leading to an MEng or MSc(Eng) degree.

The Geo-Engineering community in the US and Europe have realized that they must respond to these developments in engineering education. The International Association of Engineering Geologists (IAEG), the International Society for Rock Mechanics (ISRM) and the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) has established a Joint Technical Committee JTC-3 on Education and Training to consider the competency profiles for these geo-engineering professions (see attached paper by Keith Turner, a Canadian retired from Colorado School of Mines).

What will be the response by the IAH and by hydrogeologists in general to these initiatives? A special session on this subject is warranted for the 39th Congress to get the debate underway.

Attachments:

1) Key Points About ASCE Policy Statement 465
2) Invited paper by Keith Turner, Emeritus Prof Geol Engineering, Colorado School of Mines at the IAEG Congress in Auckland NZ, August 2010

KEY POINTS ABOUT ASCE Policy Statement 465
Academic Prerequisites for Licensure & Professional Practice

From ASCE's Committee on Academic Prerequisites for Professional Practice (CAP^3)

1. Civil engineers face an increasingly complex world requiring more professional breadth and specialization. Policy Statement 465 (PS 465) outlines the preparation required for tomorrow's practice of civil engineering. PS465 advances the concept of a profession. A profession can be defined by a cooperative organization, an ethic of service, and a body of knowledge.
2. The CE Body of Knowledge (BOK) is the foundation—everything builds on it. The BOK defines the knowledge, skills, and attitudes necessary to enter the practice of civil engineering at the professional level -- and is described in Civil Engineering BOK for the 21st Century (2nd Ed.).
3. The "bottom-line" issue addressed by PS 465 is that "It is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four year baccalaureate degree" (Educating the Engineering of 2020, National Academy of Engineering 2005). PS 465 is in a ten to fifteen year implementation stage.
4. The BOK embraces the generally-accepted model of a professional's education that includes: (1) fundamentals in math and natural science, (2) breadth in the humanities and social sciences, (3) technical breadth, (4) professional practice breadth, and (5) technical depth or specialization.
5. According to the Body of Knowledge, those entering the profession should be able to:

Foundational Outcomes	
1 Mathematics	***Solve*** problems in mathematics through differential equations and ***apply*** this knowledge to the solution of engineering problems. **(L3)**
2 Natural sciences	***Solve*** problems in calculus-based physics, chemistry, and one additional area of natural science and ***apply*** this knowledge to the solution of engineering problems. **(L3)**
3 Humanities	***Demonstrate*** the importance of the humanities in the professional practice of engineering **(L3)**
4 Social sciences	***Demonstrate*** the incorporation of social sciences knowledge into the professional practice of engineering. **(L3)**
Technical Outcomes	
5 Materials science	***Use*** knowledge of materials science to ***solve*** problems appropriate to civil engineering. **(L3)**
6 Mechanics	***Analyze*** and solve problems in solid and fluid mechanics. **(L4)**
7 Experiments	***Specify*** an experiment to meet a need, conduct the experiment, and analyze and ***explain*** the resulting data. **(L5)**
8 Problem recognition and solving	***Formulate*** and solve an ill-defined engineering problem appropriate to civil engineering by ***selecting*** and applying appropriate techniques and tools. **(L4)**
9 Design	***Evaluate*** the design of a complex system, component, or process and ***assess*** compliance with customary standards of practice, user's and project's needs, and relevant constraints. **(L6)**
10 Sustainability	***Analyze*** systems of engineered works, whether traditional or emergent, for sustainable performance. **(L4)**

11 Contemporary issues and historical perspectives	***Analyze*** the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and ***analyze*** the impact of engineering solutions on the economy, environment, political landscape, and society. **(L4)**
12 Risk and uncertainty	***Analyze*** the loading and capacity, and the effects of their respective uncertainties, for a well-defined design and ***illustrate*** the underlying probability of failure (or nonperformance) for a specified failure mode. **(L4)**
13 Project management	***Formulate*** documents to be incorporated into the project plan. **(L4)**
14 Breadth in civil engineering areas	***Analyze*** and solve well-defined engineering problems in at least four technical areas appropriate to civil engineering. **(L4)**
15 Technical specialization	***Evaluate*** the design of a complex system or process, or ***evaluate*** the validity of newly created knowledge or technologies in a traditional or emerging advanced specialized technical area appropriate to civil engineering. **(L6)**
Professional Outcomes	
16 Communication	***Plan, compose,*** and ***integrate*** the verbal, written, virtual, and graphical communication of a project to technical and non-technical audiences. **(L5)**
17 Public policy	***Apply*** public policy process techniques to simple public policy problems related to civil engineering works. **(L3)**
18 Business & public administration	***Apply*** business and public administration concepts and processes. **(L3)**

Professional Outcomes (continued)	
19 Globalization	***Analyze*** engineering works and services in order to function at a basic level in a global context. **(L4)**
20 Leadership	***Organize*** and ***direct*** the efforts of a group. **(L4)**
21 Teamwork	***Function*** effectively as a member of a multidisciplinary team. **(L4)**
22 Attitudes	***Demonstrate*** attitudes supportive of the professional practice of civil engineering. **(L3)**
23 Life-long learning	***Plan*** and ***execute*** the acquisition of required expertise appropriate for professional practice. **(L5)**
24 Professional and ethical responsibility	***Justify*** a solution to an engineering problem based on professional and ethical standards and ***assess*** personal professional and ethical development. **(L6)**

6. ASCE PS 465 states that the BOK should be fulfilled by obtaining (1) a Bachelor's degree in civil engineering, (2) a Master's degree or approximately 30 acceptable credits, and (3) experience. This is referred to as "B + M/30 & E." "B + M/30" represents several different, but related paths to fulfill the formal educational component of the BOK (see next section). The "E" refers to progressive, structured engineering experience which, when combined with the educational requirements, results in attainment of the requisite Civil Engineering Body of Knowledge.

7. One path for fulfilling the BOK in the near future can be symbolized as the following:

$$\mathbf{B^{ABET^{*}} \quad + \quad (M/30)^{Validated} \quad \& \quad E}$$

The "B" refers to an ABET/EAC accredited baccalaureate degree in civil engineering. The "M/30" refers to a master's degree or approximately 30 semester credits of acceptable graduate-level (or upper-level undergraduate) courses in a specialization area related to civil engineering. The "M" signifies a program leading to a master's degree; the "30" program does not have to lead to a master's degree. In either case, the "M/30" program will be validated by an approved outside entity.

8. Another path for fulfilling the BOK in the future can be symbolized as the following:

$$\mathbf{B \quad + \quad M^{ABET^{*}} \quad \& \quad E}$$

While it is not required that the baccalaureate degree associated with this path be an ABET/EAC accredited degree in civil engineering, the master's degree must be ABET/EAC accredited in civil engineering and must validate the attainment of the formal educational components of the BOK. ASCE has successfully pursued important modifications to ABET accreditation criteria and policies to make this a viable alternative path in the future.

9. There is consistency between ASCE's BOK fulfillment paths and the NCEES Model Law paths for the licensure of all engineers. The NCEES Model Law states that (as of January 1, 2020) admission to an 8-hour written examination in the principles/practice of engineering will require that an **engineer intern (EI)** have --

   (a) a master's degree in engineering from an institution that offers EAC/ABETaccredited programs, or the equivalent, and with a specific record of 3 years or more of progressive experience . . .

   (b) a master's degree in engineering from an EAC/M-ABET-accredited program and with a specific record of 3 years or more of progressive experience . . .

   (c) a minimum of 30 additional credits from approved course providers and a specific record of 4 years or more of progressive experience . . . All 30 additional credits shall be equivalent in intellectual rigor to upper-level undergraduate and/or graduate courses offered at institutions that have a program accredited by EAC/ABET. Of the minimum required 30 additional credits, a minimum of 15 credits shall be in engineering. The remaining credits may include engineering-related science, mathematics, and/or professional practice topics such as business, communications, contract law, management, ethics, public policy, and quality control.

   The Model Law defines an **engineer intern (EI)** as a graduate of an engineering baccalaureate or masters program accredited by the EAC/ABET, or equivalent, who has passed the fundamentals of engineering (FE) exam. NCEES includes two additional paths for individuals with doctorates.

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* Within the context of this document, "ABET" degrees refer to programs accredited by the Engineering Accreditation Commission of ABET, Inc. – and programs considered to be equivalent. Typically, "equivalent" has included "Washington Accord" programs, "Substantially Equivalent" programs, and individual transcripts evaluated by services endorsed by NCEES.

Defining competencies for geo-engineering: implications for education and training

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ABSTRACT: The competency-oriented approach for evaluating education and training issues defines professionalism and establishes international standards. Over the past decade, the American Society of Civil Engineers (ASCE) have assessed professional competency for civil engineering by utilizing recognized terminology used by education professionals to quantify 24 "outcomes" and 6 "levels of achievement" (or "competencies") required for professional recognition. The ASCE process can be readily adapted to represent the geo-engineering field. A geo-engineering competency matrix can be developed to reflect principles and professional standards of the geo-engineering community. Competency profiles can define the relative roles of different specializations and show how competency can be achieved through education or by training/experience. Individuals can use them to evaluate their competencies, develop life-long-learning plans, or evaluate specialist training courses at the post-Masters level. They may also help promote appropriate international professional recognition of geo-engineering.

1 INTRODUCTION

Large civil engineering construction projects are increasingly undertaken by consortia composed of companies from different countries. This has resulted in a growing need for international cooperation and mutual understanding of design and construction codes and practices. It has also promoted mobility of geo-engineering experts, increasing the need to understand the qualifications and quality of geo-engineers from different educational and national backgrounds (Morgenstern 2000). Professional expertise of civil engineers and geologists often overlaps; competition, rather than cooperation, results when individuals seek opportunities to perform similar tasks and duties in site-investigation, design, and construction, as well as identification, evaluation, and mitigation of geo-hazards.

In response to these developments, the three principal international professional societies – the International Association of Engineering Geologists (IAEG), the International Society for Rock Mechanics (ISRM), and the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) – undertook studies of the educational aspects of their professional responsibilities.

In July 2002, a Joint European Working Group (JEWG) was formally established by the Presidents of ISRM, ISSMGE, and IAEG. In 2004 the JEWG issued a report which recommended further steps be undertaken to develop guidelines for the education of the different disciplines and that "competencies" be used to define their areas of expertise (Bock et al. 2004). This report was subsequently revised in 2008 (JEWG, 2008). The Joint Technical Committee on Education and Training (JTC-3) was established in 2006, under the umbrella of the Federation of International Geo-engineering Societies (FedIGS), with the specific request to develop and maintain a "State-of-the Art Report on Education and Training in Engineering Geology, Rock Mechanics, Soil Mechanics and Geotechnical Engineering." A progress report has been prepared by JTC-3 (Turner & Rengers 2010).

2 THE AMERICAN SOCIETY OF CIVIL ENGINEERS APPROACH

The American Society of Civil Engineers (ASCE) defines the domain of knowledge and experience that is considered to be essential for a qualified expert in civil engineering as “the ASCE Body of Knowledge (BOK).” The ASCE BOK is defined according to 24 outcomes; each outcome defines a certain part of the domain of knowledge and experience that is considered essential in civil engineering (ASCE 2008). The ASCE Report uses the term “outcome” with an almost identical meaning as “competency” in the JEWG Report (JEWG, 2008; Bock et al. 2004; Rengers & Bock 2008). However the ASCE has further defined how outcomes are mastered in terms of “level of achievement”, instead of defining each competency in terms of the number of educational credits, the approach used by Rengers & Bock (2008).

This difference appears to be a critically important improvement in providing a clear basis for international communications and comparisons. Experience with compilations of curricular tabulations from different universities demonstrates their limited utility as they merely show that apparently identical topics are taught in courses with different names, and two courses with the same name may contain dissimilar subject matter (Higgins & Williams, 1991; Rosenbaum 1997; Manoliu et al. 2000; Manoliu & Radulescu, 2008). In contrast, competencies define the knowledge, skills, and attitudes acquired by individuals through appropriate formal education and experience. A single competency may include topics that might appear in more than one course, or one course might contribute to many competencies, and many competencies can only be fulfilled with post-graduation experience. Thus, while conceivably one competency could encompass an entire course, in most cases the relationship between competency and educational credits is very complex.

Some competencies are more important than others; so a definition of the level at which each competency has to be mastered is required. The ASCE defines a “level of achievement” according to “Bloom’s Taxonomy” – an international standard used worldwide by educational specialists (Bloom, et al. 1956). Although more than 50 years old, Bloom’s taxonomy remains highly relevant. The current ASCE efforts focus on the cognitive domain because that domain addresses many conventional learning outcomes associated with engineering. Bloom’s taxonomy assesses the cognitive domain according to six levels of achievement, which are summarized in Table 1.

Table 1. Brief definitions of the Six Levels of Achievement in Bloom’s Taxonomy.
(ASCE, 2008, Appendix F)

Level 1: Knowledge Knowledge is defined as the remembering of previously learned material. This may involve the recall of a wide range of material, from specific facts to complete theories, but all that is required is the bringing to mind of the appropriate information.
Level 2: Comprehension Comprehension is defined as the ability to grasp the meaning of material. This may be shown by translating material from one form to another (words to numbers), by interpreting material (explaining or summarizing), and by estimating future trends (predicting consequences or effects).
Level 3: Application Application refers to the ability to use learned material in new and concrete situations. This may include the application of such things as rules, methods, concepts, principles, laws, and theories.
Level 4: Analysis Analysis refers to the ability to break down material into its component parts so that its organizational structure may be understood. This may include the identification of parts, analysis of the relationship between parts, and recognition of the organizational principles involved.
Level 5: Synthesis Synthesis refers to the ability to put together to form a new whole. This may involve the production of a unique communication, a plan of operation (research proposal), or a set of abstract relations (scheme for classifying information).
Level 6: Evaluation Evaluation concerns the ability to judge the value of material for a given purpose. The judgments are to be based on definite criteria. These may be internal criteria (organization) or external criteria (relevance to the purpose) and the individual may determine the criteria or be given them.

The ASCE BOK2 Committee developed a matrix composed of 24 rows - one for each competency - and 6 columns - one for each "level of achievement" in Bloom's taxonomy. The 24 competencies are categorized as foundational, technical, and professional and, within each category, are organized in approximate pedagogical order, and not relative importance. To complete the matrix, the ASCE BOK2 Committee first evaluated and defined each cell. Then the committee made decisions concerning the recommended level of achievement that an individual must demonstrate for each competency to practice civil engineering. With a third step, the committee identified the roles of bachelors, masters and experience in achieving each competency.

Figure 1 illustrates the resulting "Competency profile" for Civil Engineering which was developed by the ASCE following their prescribed analysis procedures. It shows the 24 outcomes, each with its necessary level of achievement and a code that explains when and how, through formal teaching and training or by experience, the competency may be developed.

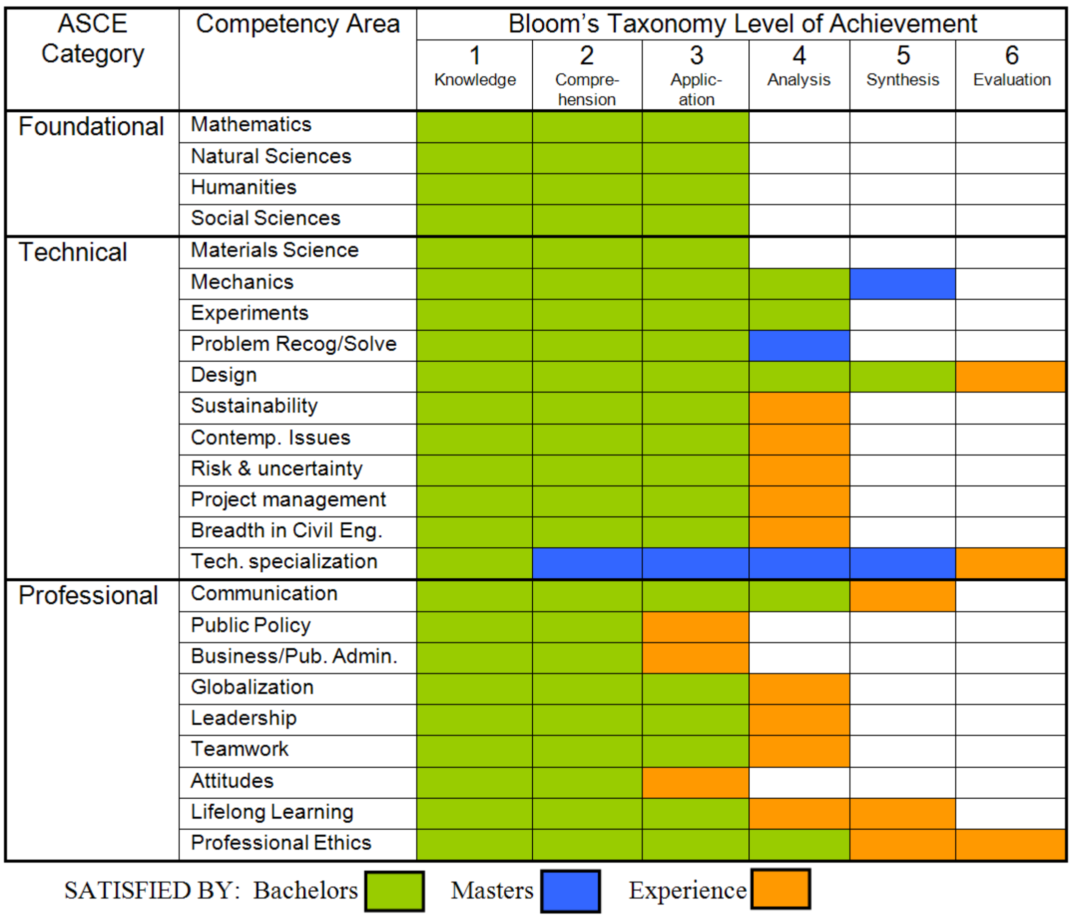

Figure 1. ASCE "Competency Profile" showing essential competencies for a qualified expert in civil engineering. (modified from ASCE, 2008)

The ASCE BOK2 Report (ASCE 2008) emphasizes that acquiring competencies with the appropriate levels of achievement is generally not a quick or simple process, and certainly is not a process that is restricted to formal education in a baccalaureate program of study. While some basic competencies are typically fulfilled through formal study in a baccalaureate program, other more advanced competencies require a master's degree or equivalent instruction, and some competencies can only be gained through practical field experience. The assumption is that experience is needed, in addition to formal education, to enter the practice of civil engineering at the professional level.

3 ADAPTING THE ASCE APPROACH TO GEO-ENGINEERING

The ASCE process can be adapted to represent the geo-engineering field. A geo-engineering competency matrix can be constructed with the same 6 levels of achievement, but with competency descriptions that reflect principles of geo-engineering (Fookes 1997; Morgenstern 2000; Knill 2002), plus additional relationships and professionalism characteristic of the geo-engineering community.

3.1 *Defining geo-engineering specializations*

In recent decades, engineering projects have become much more complex in response to enhanced environmental regulations, technological advances, and economic forces – bridges and tunnels are longer, high-speed transportation links have become common, and population growth has pushed developments into more complex geological locations where site conditions are less optimal and geohazards more likely. These trends naturally led to an increase in geo-engineering specializations, but four specializations are commonly recognized:

- The term "Engineering Geology" is widely used throughout the world in two contexts – to describe the application of geological principles relevant to engineering works, environmental concerns, and societal concerns, and to define specialist geologists ("Engineering Geologists") who are involved in such studies.
- "Geotechnical Engineering" is a specialty that applies earth sciences to the solution of civil, environmental, and mining engineering problems. Geotechnical engineers typically have competencies in soil mechanics and rock mechanics, but relatively little geological science knowledge. They are dominantly civil engineers and are capable of designing structures for foundations in soil or rock.
- "Rock Mechanics" is defined by the ISRM Statutes as including all studies relative to the physical and mechanical behaviour of rocks and rock masses and the applications of this knowledge for the better understanding of geological processes and in the fields of engineering.
- "Geological Engineering" developed as a specialty field within the broader engineering professions in the USA and Canada, where it first became established in response to a combination of existing legal and technological conditions (Turner 2004; 2008).

The terms "geological engineer" and "engineering geologist" may appear synonymous, both employ the words "geology" and "engineering," although in reverse order. The word choices may be unfortunate, but the two terms represent distinct, although related, concepts concerning educational and professional endeavors (Turner 2004; 2008).

Because geo-engineering practitioners are increasing likely to become involved in litigation, professional liability and professional recognition is becoming an important concern in many countries. The issues surrounding the professional recognition of geo-engineers are complex and often specific to each country, as the legal basis for professional recognition varies from country to country. Part of the complexity arises because aspects of geo-engineering practice frequently involve scientific studies and engineering design topics to varying degrees. In many countries, there are long-standing legal separations that divide engineering and scientific activities. Tepel (2009) provides views on the situation within the USA. The situation in other countries is often quite different. Bock (2009) provides some details of the contrasting situations in several European countries, including Germany, the Netherlands, and Austria. The recent report by the Joint Commission on Professional Practice (JTC4 2009) provides additional perspectives.

3.2 *Defining geo-engineering competencies*

The JEWG prepared a list of competencies for Soil Mechanics Engineers, Rock Mechanics Engineers, and Engineering Geologists in 2008 (JEWG, 2008). Rengers & Bock (2008) and Bock (2009) discuss the concepts developed by the JEWG. Subsequently, Dr. J.D. Higgins, a professor at the Colorado School of Mines, created a draft competency model for Geological Engineers that tends to bridge the competencies for the Engineering Geologists and the Soil Mechanics Engineers and Rock Mechanics Engineers defined by Rengers & Bock (2008). The recent

JTC-3 progress report provides comparisons of the competencies proposed for all four specializations (Turner & Rengers 2010).

3.3 *Demonstrating the concept*

A sequence of four conceptual competency profiles have been developed to provide an example of how the competency-based approach can provide benefits to the assessment of educational and training needs for sub-disciplines within geo-engineering. Figure 2 shows four profiles – Engineering Geology, Geological Engineering, Geotechnical Engineering, and Rock Engineering. These profiles are conceptual only. They should not be construed as representing definitive descriptions of these sub-disciplines, nor of providing answers to educational and training issues that must still be resolved in the future after a fully-developed geo-engineering assessment matrix has been developed.

These conceptual competency profiles were developed by faculty at the Colorado School of Mines, based on their extensive experience and interactions with Engineering Geologists, Geotechnical Engineers, and Rock Engineers (rock mechanics specialists) within North America (Higgins 1991; Turner 2008). Thus the four profiles shown in Figure 2 represent this collective experience. The profiles were developed in the following manner:

1. A representative, but temporary, set of competency categories had to be developed because competencies defined for civil engineering by the ASCE BOK2 Report were not considered entirely appropriate for assessing the competencies of geo-engineering sub-disciplines, and a full set of such competencies has yet to be established,
2. Thus, a series of 15 competency classes was established that approximated the ASCE Foundational and Technical categories. “Engineering Science” and “Engineering Design” classifications, formerly used to assess engineering curricula in the USA, were used to define the Technical category.
3. The resulting sequence of competencies thus neither entirely conforms to existing assessment criteria, nor is expected to be the selection developed in the future.
4. The 6 levels of achievement defined by Bloom’s taxonomy were used to form the columns of the matrix.
5. Guidance in establishing the profiles was obtained by using the competency profile for civil engineering developed by ASCE (Fig. 1) as a base case against which the levels of achievement for each geo-engineering sub-discipline could be raised or lowered.

In spite of the limitations imposed by the fact that these are preliminary conceptual representations, the four profiles show distinct patterns of strength and specialization for each sub-discipline. Accordingly, they demonstrate, on a conceptual level, some of the advantages of a competency-based assessment approach applied to geo-engineering with its several sub-disciplines.

4 CONCLUSIONS

Competency profiles for the specialties within geo-engineering can provide a basis for defining the relative roles of the different specializations. Competency can be achieved through education, or by training/experience; individuals can use them to evaluate their own competencies. Competency profiles may also allow for:

- Developing individual life-long-learning plans,
- Establishing the relevance of specialist training courses at the post-Masters level, or
- Evaluating professional qualifications of individuals wanting to work at certain levels within the Eurocode structures, or seeking professional licensure.

Competency profiles should be produced by analyzing a single matrix of competency topics and levels of achievement – the development of this matrix for geo-engineering is currently the major task remaining to be undertaken cooperatively by the geo-engineering community. The size and complexity of this matrix, the number of columns and rows comprising it, should be similar to the existing matrix (or rubic) developed by the ASCE for civil engineering.

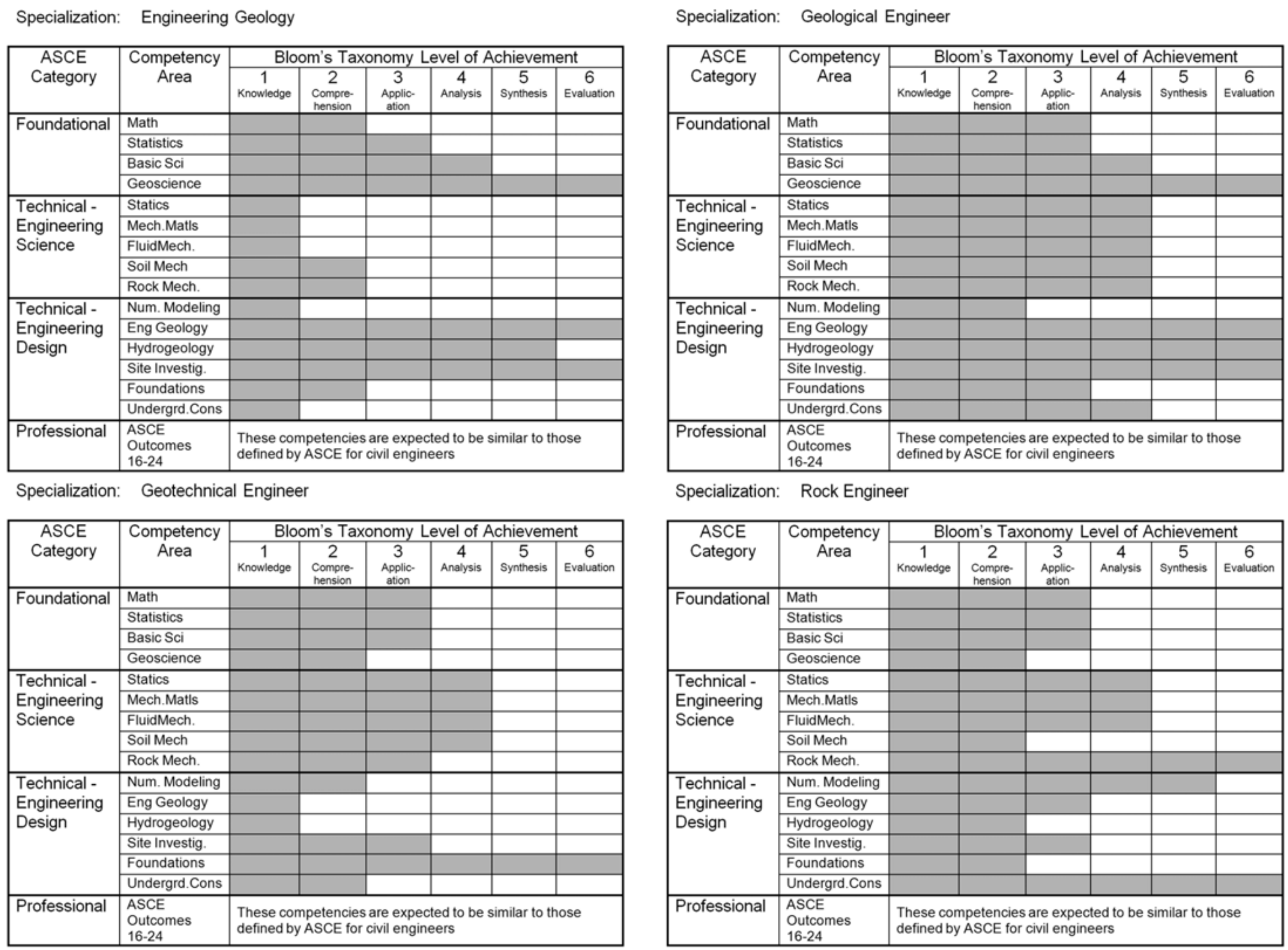

Figure 2. Four conceptual competency profiles for geo-engineering specializations demonstrate their distinctive required competencies.

Once such a matrix is agreed to, it can also form the basis for evaluating regional variations in the competency profiles of individual specializations, or of geo-engineering in its entirety. For instance, how do the desired competencies for Engineering Geologists in South America compare to those in Europe, or in Asia? Such competency profiles are likely to show differences among the various regions due to the presence/absence of geohazards, and the relative importance of several economic factors, such as large urban centers, groundwater resources or flooding, and mining or underground construction. The availability of such international comparisons will provide the basis for communicating and understanding the role and importance of education and training issues. They may also assist in promoting appropriate professional recognition of geo-engineering specializations within nations, regions, and internationally.

REFERENCES

ASCE Body of Knowledge Committee. 2008. *Civil Engineering Body of Knowledge for the 21st Century-2nd Edition (BOK2)*. American Society of Civil Engineers, Reston, Virginia, 181p. A free downloadable PDF version is available (size 1.1Mbytes) from: http://www.asce.org/professional/educ/

Bloom, B.S., Englehart, M.D., Furst, E.J., Hill, W.H. & Krathwohl, D. 1956. *Taxonomy of Educational Objectives, the Classification of Educational Goals, Handbook I: Cognitive Domain*. David McKay, New York, NY.

Bock, H. 2009. Core Values, Competences and Issues in Engineering Geology: A European Perspective, In Culshaw, M.G., Reeves, H.J., Jefferson, I. & Spink, T.W. (eds.), *Engineering Geology for Tomorrow's Cities Geological Society, London, Engineering Geology Special Publications* 22: 289-297.

Bock, H., Broch, E., Chartres, R., Gambin, M., Maertens, J., Maertens, L., Norbury, D., Pinto, P., Schubert, W. & Stille, H. 2004. The Joint European Working Group of the ISSMGE, ISRM and IAEG for the Definition of Professional Tasks, Responsibilities and Co-operation in Ground Engineering, In: Hack, R., Azzam, R. & Charlier, R.(Eds.), *Engineering Geology for Infrastructure Planning in Europe: A European Perspective, Lecture Notes in Earth Sciences* 104:1-8, Springer-Verlag, Berlin.

Fookes, P.G. 1997. 1st Glossup Lecture: Geology for Engineers: The Geological Model, Prediction and Performance, *Quart Jour Eng Geol & Hydrogeology* 30: 293-424.

Higgins, J.D. 1991. Geological Engineering Programs as Academic Preparation for Careers in Engineering Geology and Hydrogeology. In Higgins J.D. & Williams J.W. (eds.) *Academic Preparation for Careers in Engineering Geology and Geological Engineering, Association of Engineering Geologists Special Publication* 2: 7-11.

Higgins, J.D. & Williams, J.W. 1991. *Academic Preparation for Careers in Engineering Geology and Geological Engineering*, AEG Special Publication 2.

Joint European Working Group (JEWG). 2008. *Professional Tasks, Responsibilities and Co-operation in Ground Engineering*, Report of the Joint European Working Group to the Presidents of the IAEG, ISRM and ISSMGE.

JTC4. 2009. *Risk, Recognition and Reward in Geotechnical Professional Practice*, Report by Joint Technical Committee JTC4 on Professional Practice, August 2009,109 p. [Available for download from: http://www.fedigs.org/sites/default/files/JTC4-FinalReport-Rev1.pdf]

Knill, Sir J. 2002. Core Values: The First Hans Cloos Lecture. *Proceedings, 9th Congress, IAEG, Durban, 16-20 Sept. 2002*: 1-45.

Manoliu, I., Antonescu, I. & Radulescu, N. (eds). 2000. *Proceedings, 1st International Conference on Geotechnical Engineering Education and Training, Sinaia, Romania, 12-14 June 2000*, Balkema, Rotterdam.

Manoliu, I. & Radulescu, N. (eds). 2008. *Proceedings, 1st International Conference on Education and Training in Geo-Engineering Sciences, Constantza, Romania, 2-4 June 2008*, CRC Press, Taylor & Francis Group, London.

Morgenstern, N.R. 2000. Common Ground, In *GeoEng2000, International Conference on Geotechnical & Geological Engineering, Melbourne, Australia, Invited Papers* 1: 1-30 Technomic Publishing Co., Lancaster, PA, USA.

Rengers, N. & Bock, H. 2008. Competency-oriented curricula development in Geo-engineering with particular reference to Engineering Geology, In: *Proceedings,1st International Conference on Education and Training in Geo-Engineering Sciences, Constantza, Romania, 2-4 June 2008*, (I. Manoliu & N. Radulescu, eds), CRC Press, Taylor & Francis Group, London, 2008: 101-110.

Rosenbaum, M.S. 1997. Environmental Geology Courses within University Education, In: P.G. Marinos, G.C. Koukis, G.C. Tsiambaos & G.C. Stournaras, (eds.), *Proceedings of the International Symposium on Engineering Geology in the Environment, Athens*, A.A. Balkema Publishers, 4: 3655-3666.

Tepel, R.E. 2009. The Core Attributes of Engineering Geology: A US Perspective, In: Culshaw, M.G., Reeves, H.J., Jefferson, I. & T.W. Spink (eds.), *Engineering Geology for Tomorrow's Cities Geological Society, London, Engineering Geology Special Publication* 22: 273–276.

Turner, A.K. 2004. Geological Engineering, (R. Selley, R. Cocks, and I. Plimer, eds.), *Encyclopedia of Geology* 3: 35-42, Academic Press.

Turner, A.K. 2008. Education and Professional Recognition of Engineering Geologists and Geological Engineers in Canada and the United States, In: *Proceedings,1st International Conference on Education and Training in Geo-Engineering Sciences, Constantza, Romania, 2-4 June 2008*, (I. Manoliu & N. Radulescu, Eds), CRC Press, Taylor & Francis Group, London, 2008: 111-118.

Turner, A.K. & Rengers, N. 2010. *A Report Proposing the Adaptation of the ASCE Body of Knowlege Competency-based Approach to the Assessment of Education and Training Needs in Geo-Engineering*. Report by Joint Technical Committee JTC3 on Education and Training, January 2010, 37 p.