Undergraduate Geotechnical Education, 2004

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Abstract: The United States Universities Council on Geotechnical Education and Research (USUCGER) recently surveyed the state of practice in undergraduate geotechnical education. Information was gathered on course offerings, textbook usage, laboratory practices, typical class size, and methods of instruction. Particular attention was paid to the content of introductory courses to Geotechnical Engineering, identifying material that respondents considered essential at this level. A list of core course modules was developed. The content and conduct of laboratories that accompany introductory courses was similarly addressed. Information was also compiled on other course resources such as virtual laboratories, physical site visits, software, and web sites. Geotechnical course offerings beyond the introductory level were also surveyed and categorized as required or elective. Finally, respondents were questioned on the utility of posting course syllabi and modules to the web, with the purpose of providing background material to Junior Faculty and other first-time instructors.

The USUCGER Education Committee undertook a survey of undergraduate, introductory courses to Geotechnical Engineering during the spring of 2004. The intent of the survey was to ascertain the "state-of-practice" in undergraduate geotechnical education. A 16 point questionnaire that focused on undergraduate geotechnical courses was sent to the USUGCER mailing list, resulting in 22 completed responses. The summary of those responses is presented in this paper by the simple expedient of first stating the question, and then providing a summary of the results.

1. What is the present structure of your introductory Geotechnical course?
Semester or quarter system? (91% semester, 9% quarter)
Academic standing of students (junior, senior)?
Number of classroom credit hours?
Number of lab credit hours?

The most common format for delivering the undergraduate geotechnical course was three hours of lecture per week over the period of one semester, accompanied by a one credit hour weekly laboratory session. Juniors were the primary introductory geotechnical students at 86% of the schools that responded. The (3,1) format was used by 55% of the schools. The second most popular choice was a (2,1) format, which was used by 23% of the schools. Alternate formats of (4,1), (3,2), (3,0.5), and (3,0) were used by the remaining 22% of schools.

Would you change this arrangement?
Preferred arrangement?

The preferred arrangement was the (3,1) course format. The only respondents indicating a desire to change the format of the course were those using a different format. In all cases, a desire to change to the (3,1) format, from an alternate format, was expressed.

2. What is your typical class size?
What is your typical lab size?

The average size of the class lecture sections was 30 students, with a maximum reported class size of 65 students and a minimum reported size of 10. The typical lab section held 14 students, with a maximum of 35 and a minimum of 4. Only one institution reported that they did not have a laboratory associated with the classroom lectures.

3. Do you have Teaching Assistants to help with the class?
If so, how are they funded?

Teaching assistants were provided for the introductory geotechnical class by 68% of the institutions reporting. In all but one case teaching assistants were funded from departmental level funds. In the single exception, funding was provided at the university level.

4. What text book(s) do you use/recommend?

By far, the most commonly used text was Principles of Geotechnical Engineering by Braja M. Das. Only three respondents listed a required manual for the laboratory work. However, three additional respondents stated that they had developed "in-house" notes that were equivalent to a required manual. Table 1 presents a compilation of responses to this survey question.

Table 1. Text Book and Laboratory Manual Usage

Primary Text	Secondary Text	Lab	Author and Title
11	2		Das, Braja M., Principles of Geotechnical Engineering, 5/E, Brooks Cole, 2002, ISBN: 0-534-38742-X
4	1		Coduto, Donald P., Geotechnical Engineering: Principles and Practices, 1/E, Prentice Hall, 1999, ISBN: 0-13-576380-0
4	1		Holtz, Robert D. and Kovacs, William D., An Introduction to Geotechnical Engineering, 1/E, Prentice Hall 1981, ISBN: 0-13-484394-0
2	1		McCarthy, David F. PE, Essentials of Soil Mechanics and Foundations: Basic Geotechnics, 6/E, Prentice Hall, 2002, ISBN: 0-13-030383-6
2			Budhu, Muni, Soil Mechanics and Foundations, John Wiley & Son, 1999, ISBN: 0-471-25231-X
		2	Das, Braja M., Soil Mechanics Laboratory Manual, Engineering Press, 1986, ISBN: 0-910554-75-7
		1	Bardet, Jean-Pierre, Experimental Soil Mechanics, Prentice Hall, 1997, ISBN: 0-13-374935-5
		1	Liu, Cheng and Evett, Jack, Soil Properties: Testing, Measurement, and Evaluation, 5/E, Prentice Hall, 2003, ISBN: 0-13-093005-9

5. What do you think are the essential course modules as included in your syllabus?

The responses to this survey question are summarized in Table 2. As noted, the majority of respondents believe that the first eight categories are essential course modules in an introductory course on Geotechnical Engineering.

6. What do you think are essential laboratories?

Table 3 summarizes the responses to this survey question. In this case, the first ten categories were considered essential laboratory modules by the majority of respondents.

Table 2. Essential Course Modules

Percentage Cited	Course Modules
82%	Consolidation/settlement
82%	Flow net construction and use
82%	Shear strength
73%	Soil classification
64%	Permeability/hydraulic conductivity
55%	Effective stress
55%	Phase relations/phase diagrams
50%	Stresses at depth/subsurface stresses
45%	Compaction
32%	Atterberg limits
32%	Site investigation
32%	Soil formation
27%	Components of soil
27%	Lateral pressure/retaining wall design overview
27%	Slope stability
23%	Foundation design/ bearing capacity overview
18%	Grain size
18%	Mohr's circle
14%	Geology
14%	Soil consistency
9%	Soil suction
5%	Deep foundations
5%	Geosynthetics
5%	Landfills
5%	Shrink swell behavior
5%	Surcharging

Table 3. Essential Laboratory Modules

Percent Cited	Laboratory Modules
82%	Compaction/Proctor
82%	Consolidation
73%	Direct shear
68%	Mechanical grain size distribution
68%	Permeability/hydraulic conductivity
64%	Atterberg limits
64%	Unconfined compression test
59%	Soil identification
55%	Hydrometer analysis
55%	Triaxial shear
45%	Field density
23%	Specific gravity
18%	Moisture content
14%	Phase relations
14%	Relative density
14%	Rock identification
9%	Geologic map reading
9%	Lab final
9%	“Soil Magic” show
9%	Site investigation
5%	CBR
5%	Effective stress/quicksand tank
5%	Flow nets
5%	Instrumentation/data acquisition
5%	Shrinkage test
5%	Swell test

Could any of these be virtual laboratories?

The split over the possible use of virtual labs was 50% of respondents for and 45% against. The consolidation, flow nets, permeability, hydrometer analysis, and triaxial shear testing labs were cited as those most likely to be conducted virtually. Although 50% of the respondents thought that the use of virtual labs was a possibility, most of the accompanying comments were of the “Yes, but….” variety. There was strong sentiment that actual, hands-on experiences in the laboratory were essential for teaching basic geotechnical engineering.

Are lab reports required?

Lab reports were required by 77% of those responding, with 9% not requiring lab reports and 14% not providing a response to the question.

7. What case histories (if any) do you present?

Thirty-two percent of respondents stated that they did not present case histories in the introductory class. Table 4 summarizes responses received from the 68% who do present case histories.

Table 4. Case Histories Presented

Percent Cited	**Case History**
18%	Local interest
18%	Tower of Pisa
14%	Rissa landslide
14%	Settlement
14%	Teton Dam failure
9%	Chosen and presented by student
9%	Slope failure
5%	Aberfan, Wales coal waste dump failure
5%	Experience from consulting practice
5%	Kettleman Hills landfill failure
5%	Mississippi levee failure
5%	Niigata earthquake
5%	Settlement from Federal Highway Administration (FHWA) and Conference Proceedings
5%	Shrinking and swelling soils
5%	Transconia Elevator

8. Do you undertake any "design" exercises?
If so, what?

Fifty percent of respondents have the students undertake design exercises in the introductory class. A summary of these exercises is provided in Table 5.

Table 5. Design Exercises

Percent Cited	Design Exercise
23%	Foundation design (shallow foundations)
23%	Settlement from FHWA
9%	Retaining walls
9%	Seepage cutoff systems for a dam
5%	Dam or levee design
5%	Pile design
5%	Preloading to reduce settlement
5%	Seepage
5%	Sheet pile penetration

9. What software do you think should be introduced (if any)?

The predominant sentiment expressed in the answers to this question was that hand calculations were the most appropriate method to introduce geotechnical calculations. However, the use of spread-sheets and/ or word processing programs to aid calculations and presentations was considered fitting. Only 18% of the respondents replied that it was appropriate to introduce geotechnical specific software at the undergraduate level. A summary of software introduced into class by the respondents is given in Table 6.

Table 6. Software Introduced

Percent Cited	Software Introduced
23%	Flow nets; Geo-Slope (SEEP/w); Spires
14%	Excel spreadsheets
5%	Consol
5%	Finite Elements/ PLAXIS
5%	Slope stability
5%	Stress as a function of depth

10. What site visits should be undertaken (if any)?

Half of the professors responding thought that site visits required too much time in comparison to the benefit that they provided the students. The site visits described in Table 7 were a part of the class for 27% of the respondents.

Table 7. Site Visits Made

Percent Cited	Site Visits
18%	Large scale project
18%	Site investigation
9%	Excavation
9%	Shallow foundation construction
5%	Construction dewatering
5%	Deep foundations
5%	National test site
5%	Preloaded embankment
5%	Retaining wall
5%	Slope stability
5%	Commercial lab

11. What web sites would you recommend?

Table 8 summarizes the response to this survey question.

12. What is the current "equivalent course" at your university?

This question was badly worded and did not return any insightful answers.

13. What basic skills do you do want your students to have acquired by the end of the course?

The list of skills to be acquired closely mimicked the preferred content of the class and lab instructional modules, as seen in Table 9. However, perhaps the most eloquent responses addressed the overall practice of geotechnical engineering. In addition to understanding the fundamentals of soil mechanics, students should understand how geotechnical practice differs from other fields within civil engineering. Students need to develop the analytical and creative thinking skills to solve the open ended problems typical of geotechnical engineering.

Table 8. Useful Web Sites

Web Site	Content
www.epa.gov/epaoswer/non-hw/muncpl/disposal.htm	EPA Landfill web site
www.ejge.com/GVL/	Virtual Library of Geotechnical Engineering
www.geotechnicaldirectory.com	Geotechnical Directory (maintained by Malek Smadi, at UIUC
www.icivilengineer.com/Geotechnical_Engineering/	The Internet for Civil Engineers
www.geoengineer.org	The Geoengineer web site
www.tagasoft.com/TAGAsoft/Calculators/	Free spreadsheets for common geotechnical calculations
www.dur.ac.uk/~des0www4/cal/slopes/#SLOPE	Slope design site
www.ggsd.com/	Geotechnical and Geoenvironmental Software Directory
fbe.uwe.ac.uk/public/geocal/geoweb.htm	Compilation of geotechnical educational materials from UK professors
www.usucger.org	The USUCGER site
www.ngi.no	Norwegian Geotechnical Institute
www.unh.edu/nges/	National Geotechnical Experimentation Sites
cee.engr.ucdavis.edu/faculty/boulanger/geo_photo_album	Geotechnical Engineering Photo Album
www.liquefaction.com	CPT and Liquefaction Web Site
www.usace.army.mil/inet/usace-docs/eng-manuals/em.htm	US Army Corp of Engineers Manuals
soils.ag.uidaho.edu/soilorders/	Soil taxonomy

Table 9. Desired Basic Skills

Percent Cited	Basic Skills to be Acquired
64%	Consolidation/settlement
55%	Shear strength
55%	Soil classification
45%	Compaction
45%	Flown net construction and use
41%	Phase relations
36%	Soil behavior in general / unique behavior of soil
36%	Stresses in semi-infinite medium
32%	Effective stress
27%	Mohr's circle
27%	Permeability
23%	Field compaction
18%	Site investigation
18%	Soil formation
14%	Interpretation of soils data
14%	Lateral earth pressures
14%	Slope stability / factor of safety
14%	Soil profile from borings
14%	Business aspects of engineering
9%	Clay mineralogy
9%	Shallow foundation design
9%	Soil testing appropriate to conditions
5%	Geology
5%	Lab report writing / documentation
5%	Oral presentation of research topic

14. What alternatives do you see to classroom delivery?

Responses to this survey question are provided in Table 10.

15. What other geotechnical courses do you offer at the undergraduate level, and are any of the additional geotechnical courses required for graduation?

The results of this survey questions are given in Table 11. Almost 100% of respondents cited Foundation Engineering/Geotechnical Design as a further geotechnical course that was offered at the undergraduate level. Only 23% of respondents indicated that a second course in geotechnical engineering was required for graduation. Thus, it would appear that most universities consider that an introductory course in Geotechnical Engineering is sufficient for an undergraduate degree in Civil Engineering.

Table 10. Alternative Delivery Methods

Percent Cited	Alternative Delivery Methods
9%	Computer enhanced classroom/visual presentation
9%	Integrated lab and classroom
5%	Internship at geotechnical firm
5%	Distance learning
5%	Field trips
5%	Group exercises done in class
5%	Projects based course
5%	Self-guided computer tutorial
5%	Web lectures
5%	Web practice problems

Table 11. Additional Undergraduate Geotechnical Courses

Percent Cited	Additional Undergraduate Geotechnical Courses
95%	Foundation Engineering / Geotechnical Design
18%	Slopes, Dams, & Retaining Walls
14%	Ground Improvement
9%	Design with Geosynthetics
9%	Geoenvironmental Engineering
9%	Geology for Engineers
9%	Lab Class (senior level)
9%	Retaining Structures
5%	Advanced Foundation Design
5%	Advanced Soil Mechanics
5%	Contaminant Hydrogeology
5%	Field Methods
5%	Geophysical Methods
5%	Geotechnical Capstone Design

16. Would you agree to supply your "Intro to Geotech" course syllabus in electronic format for posting on the USUCGER web site?

All respondents graciously agreed to make their course syllabi available to USUCGER members.

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