THE CIVIL ENGINEERING PROFESSION

"You see things; and you say "Why?"
But I dream things that never were; and I say "Why not?""
George Bernard Shaw

What is an engineer?

Engineers are problem solvers!

"Engineering is concerned with the implementation of a solution to a practical problem. A scientist may ask "why?" and proceed to research the answer to the question. By contrast, engineers want to know *how* to solve a problem and how to implement that solution.

In other words, scientists investigate phenomena, whereas engineers create solutions to problems or improve upon existing solutions.

A scientist builds in order to learn. An engineer learns in order to build." (http://www.wordiq.com/definition/Engineering)

One way to define engineering is: "how to do new things in new ways" (Win Phillips, 1997)

Another definition is: "Engineering is the application of math and science to create something of value from our natural resources." The difference between science and engineering was explained well by Theodore Von Karman, an aerospace engineer. As he stated: "Scientists discover the world that exists; engineers create the world that never was." (http://www.discoverengineering.org/aboutengineers.asp)

Even the etymology of the word "engineer" reveals their problem-solving nature: "It is a myth that *engineer* originated to describe those who built engines. In fact, the words *engine* and *engineer* (as well as *ingenious*) developed in parallel from the Latin root *ingeniosus*, meaning "skilled". An engineer is thus a clever, practical, problem solver." (http://www.wordiq.com/definition/Engineering)

What is Civil Engineering?

Civil Engineering is the oldest and quintessential engineering profession. It encompasses a variety of sub-disciplines and jobs. The civil engineering curriculum at the University of Colorado (CU) and most other U.S. universities emphasize the following major sub-disciplines:

- structural
- environmental
- water resources
- geotechnical
- construction
- transportation

Architectural engineering is often a related but separate degree (such as at CU). Surveying is a skill used by many civil engineers, but there is a separate professional licensure for land surveyors. Urban planning is an activity that uses skills from a variety of the civil engineering sub disciplines.

Some interesting thoughts on civil engineering by Bugliarello (1994) include:

> Civil engineering is "the modification of nature to create and improve human habitats." Civil engineers work toward an ideal that is "a standard of perfection, beauty, or moral and physical excellence, especially as an aim of attainment or realization." Civil engineers strive to "match deep functionality with aesthetics in every manifestation of the profession." Engineers should be mindful that there is a "moral compact between the engineer and world society."

"Professional engineers should work for the welfare of the public. They are responsible for observing societal needs, and often have the position and resources to improve society. As professionals, engineers are expected to set examples in the work field and to establish themselves as assets to society."
T.D. Oates, 1993

What is a profession?
A *PROFESSION* is defined by:

1. Knowledge = requires formal education, judgment and discretion that are not routine and cannot be mechanized; continuing education required

2. Organization = sets standards for admission to profession, enforces standards of conduct, establishes codes of ethics

3. Public Good = purpose of service and preservation of public welfare

"America's engineers have always played a vitally important role in developing America's way of life and standard of living. From constructing bridges and highways to exploring the vast earth beneath us, America's engineers are helping to keep America moving and safe."
George Bush, 1989

"The American engineering profession needs to reassert its leadership; to raise its eyes and voices, roll up its sleeves, and do again for the nation what it did a century ago: make it a winner in the world marketplace. If competing and winning -- rather than puttering and theorizing -- become the real stuff of an engineering career, our best men and women, our winners, will once again gravitate toward the profession, and the impending decline of American engineering will become a thing of the past."
John F. Welch, Jr. Competitiveness: The Real Stuff of American Engineering. 1989.

"History provides the big picture, why large-scale projects were built and what their benefits are to society...You can wake people up to the importance of infrastructure, the efforts of the

civil engineers who have improved the quality of life through its design and construction, why it needs to be repaired, and where tax dollars will be going. You can use history to educate...engineers ...about where our present problems came from."
James M. Fels, 1990; in Morley 1994.

What do engineers need to know?
Based on the 1995 Civil Engineering Education Conference of the American Society of Civil Engineers, the following areas were identified as fundamental elements which should be incorporated into Undergraduate engineering education (ASCE 1995):

1. A global vision and approach to problem identification and problem solving in areas such as infrastructure, environment, facilities, and systems

2. A basic management knowledge base in areas such as business, resources, personnel management, communication skills, costs and value judgments, and time management

3. A solid foundation in personal and inter-personal attributes ethics

4. An involvement with engineering practice as the formal education evolves

These elements were therefore chosen as emphasis areas for this course, and should provide a foundation for you as both professional engineers and in your future courses. What you learn here should help you identify areas where you will need to be strong in order to succeed as an engineer, and therefore in selecting courses which will allow you to build your skills in these areas.

What Emerging Engineers Need to Know

Industry survey by ASEE rank*, percent ASME/NSF** survey marked “very important” or “somewhat important” skills for new BS-level engineers, and skills in your career***.

Practices	Rank*	Percent**	Rank***
Communication writing	**1**	**89**	**1**
Professional Ethics	**2**	**85**	
Teams/Teamwork personal interaction	**3**	**94**	**4**
Creative Thinking	**3**	**85**	
Fundamentals	**5**	**85**	***2***
Application of Statistics	**5**	**73**	
Design *(for manufacture, performance, reliability, safety)*	**7**	**88, 85, 82, 80**	***2***
Business skills	**NR**	**74**	**3**
Computers	**NR**	**NR**	**5**

* American Society of Engineering Education

** Valenti, M. “Teaching Tomorrow’s Engineers”, July 1996, Mechanical Engineering.

*** “Engineering Education for a Changing World”; career skills needed; 2 = engineering

NR = not rated or ranked

Because every job in engineering is a little different, various skills (such as listed in the previous table and others) have varying levels of importance in different jobs. Thus, surveys of varying groups of employers always have slightly different rankings of various skills that are important for civil engineers. However, some of the skills appear near the top of almost every survey. These can be considered of major (or high) importance to all civil engineers. Other skills have widely ranging importance depending on the specific job that you do within civil engineering. Skills that were cited infrequently, not at all, or at the bottom of surveys can be considered of minor (or low) importance for the majority of civil engineers. Some examples of important skills for civil engineers were given in the table on the previous page and are listed and discussed below.

Desired Attributes of an Engineering Graduate
(American Society for Engineering Education: Engineering Education for a Changing World)

1 Good Communication Skills
2. Higher ethical standards
3. Ability to think critically and creatively; independently and cooperatively
4. Flexibility
5. Grasp of Engineering Science fundamentals
   (math, statistics, physics and life sciences, information technologies)
6. Good understanding of design and manufacturing processes
7. Basic understanding of the context in which engineering is practiced
   (economics, history, environment, customer and societal needs)
8. Possess a multi-disciplinary, system perspective

Skills in order of importance (in your career):

- writing
- engineering
- business/financial
- personal interaction
- computer

Civil engineering is moving somewhat away from the gold-standard of "design for function", and expanding to embrace "design to cost and environmental compatibility". It is important to recognize the revolution that has occurred in engineering since the 1960s. Computers and the web have changed many aspects of the job. Specifically, computers have replaced many things that engineers used to do. No longer are high-level skills with a slide rule and detailed manual computations needed, because computers have assumed much of this burden. This has resulted in significant time savings, freeing engineers to focus on broader integration issues of importance.

MORE is expected of engineers than any other profession! Civil engineers are responsible for the well-being of the entire population via water treatment, wastewater treatment, air pollution control, road design, and design of dams/buildings/bridges. Our work often goes unrecognized. The public tends to take the quality of our work for granted – until something goes wrong or performs below expectations.

Many of the US Top 7 "Critical Technologies" identified by the National Government are related to Civil Engineering:
2. Environmental Quality
6. Materials
7. Transportation

"You must learn how to learn. This is part of your preparation for being an engineer; our profession will require that you keep up with new developments while you work: Life-long learning".
Dave DiLaura, "Being Smart is Not Enough."

What kinds of jobs are there for Civil Engineers?
Civil engineers held about 232,000 jobs in 2000 (US Department of Labor; http://www.bls.gov/oco/ocos030.htm). Civil engineering jobs tended to fall into a few main sectors. These job sectors and the approximate percentage of civil engineers employed within each are listed and described below.

Federal Government ~10%
- Transportation Bureau
- Environmental Protection Agency
- Department of Energy, Department of Defense, etc.....
- Military - Army Corps of Engineers, Air Force Center for Environ. Excellence

State or Local Government ~22%
- State Department of Transportation
- State Department of Natural Resources
- County or City Engineer
- Public Utilities
- Water or Wastewater Treatment Plant, Sanitation Department

Consulting Firms ~51%
- Consulting such as CH2M Hill, MWH, Earth Tech, etc…

Construction and Manufacturing ~12%
- Industry such as Exxon, Kiewit, etc...

Self Employed ~5%
- Ex: usually 1-person "consulting firm" such as Laube Engineering, Greeley CO

Other <1%
- Includes Peace Corps, Universities, research laboratories, etc…

During a career, many people change jobs and job type. For example, many Civil Engineers start in consulting and later move into government positions. Others move from consulting into self employment. In almost all cases, self employment comes after learning on-the-job under licensed professional engineers (PE's), gaining your own PE, and then significant world experience.

What do Civil Engineers do?
Every job and career path is different. The information below provides some examples and advice about a typical job path. However, every person, every employer, each job is different and there are no specific rules. Expect the unexpected. Variety and diversity are the key trait of civil engineering to remember. If you don't like one civil engineering job, don't despair. There is a fit for your skills, aspirations, and talents out there waiting for you.

First year engineer

Getting off to a strong start is the key to a successful career. Learn the way things are done, and figure out what you need to do to earn credibility and respect. Your first impression on your employers will determine the types of job assignments they give you.

Tips:

A **proper attitude** is vital

Have realistic expectations and be willing to earn your place in the organization.
Expect work to be different than college
Learn the "art of being new"

Demonstrate maturity by showing you know how much you DON'T know

Learn as much as you can about your company and the people in it by listening.
College only gives you part of what you need to be successful.
There will be on the job training, so don't believe you know everything when you start.
Recognize what you don't know, and make an effort to learn it quickly.
Don't be afraid to ask questions.

Learn the culture - each company has its own unique personality and culture

The culture is a unique set of rules and norms, often unspoken and informal, about how you should behave.
Watch how others behave, observe how people communicate and work together.

Be conscious of making a good impression

Everyone is trying to assess your abilities and strengths, so work hard to build a good reputation.
You want people to notice your maturity, good judgment, and ability to fit into a team.
Show that you want to fit into the corporate culture.
Make an extra effort, do whatever is asked no matter how trivial.

Learn what your boss wants and expects

Search for opportunities and projects on which you can contribute

Find a mentor to give you advice and help you adapt

A mentor can help you learn the culture, learn what you boss expects
A mentor can help you **build a network of colleagues**

What you might do:

write engineering reports (>50% of time)
call clients and vendors (~10-20%)
perform design calculations, or calculation checks
field work: construction oversight; inspection; surveying (~20%)
data analysis
special training: 40 hr HAZ; EDM, Nuclear gage
be given specific assignments to complete
work in a team => can be most rewarding and frustrating aspects of the job

"The feeling of being part of an effective team is the best feeling in the world. You WANT to go to work. You don't mind staying late and working on stuff if people have faith and trust in your abilities..."

Liz McMahon, during 2nd consulting job at V&K

"Most of my time went to data processing (inputting data into the computer, working with spreadsheets, etc.) and field work (groundwater sampling and well monitoring)."

Dr. Victor Magar, currently in the Environmental Restoration Dept. at Battelle

Some examples of civil engineering jobs, based on interviews with working civil engineers and listed job posting are given below. These have been grouped by number of years of work experience, as your activities and expectations of employers grow and evolve as engineers gain experience.

1-5 yrs

"Environmental Engineer II. Analyze and review air quality permit applications. Incorporate applicable state and federal regulations with review conclusions to develop draft air quality operating permits. Assist in the writing and review of air quality construction permits. Requirements: BS or higher degree in Civil, Mechanical, Chemical, or Environmental Engineering from an accredited engineering curriculum or registered as Engineer-In-Training. Two years environmentally related experience, including one year of experience specifically in air quality engineering. Excellent written and oral communication skills.: State Position, Aug 24, 1997 Post Ad

~5 years as engineer

business development - write proposals; talk with industry to develop a relationship
meet with clients
project engineer
    coordinate the activities of other junior engineers
    decide who will do what? delegate
    check their work
training: specialty workshops to develop new skills
present work at technical conferences

"Project Engineer, PE with minimum 4 yrs experience. Must be capable of providing coordination, scheduling, and supervision in the technical design of residential and commercial projects. Verifiable experience in design of utilities, grading and drainage. Ability to coordinate with clients and review agencies." Aug 24, '97 Post Ad

Water Resources - "...successful candidate will be highly energetic, motivated and a self-starter. We require a BSCE, PE, and 5 yrs WATER RESOURCES experience. Experience should include hydrologic and hydraulic analysis, watershed planning, and computer modelling. HEC1, HEC RAS, EPA NET, and other model proficiencies are desirable. Masters degree in Water Resources strongly preferred." Aug 24, '97 Post Ad

Structural engineer - "5 to 10 yrs experience in structural design of commercial or light industrial diverse building systems. Must be able to communicate well with other disciplines and construction personnel. PE required." Aug 24, '97 Post Ad

>10 years as engineer

project manager

select a project engineer
make sure project stays on budget and on time
interact closely with client to ensure they get what they want

"Project Manager: Architect/Engineer with minimum 7 yrs experience to coordinate design of major projects. Requires excellent organizational and communication skills, management of project information, maintenance of project schedules, budgets, and communication with internal technical, construction personnel, and clients. Professional registration required." Aug 24, '97 Post Ad

"Project Manager. National environmental remediation firm is seeking qualified candidates...minimum 5 yrs experience in remediation managing long-term or multi-task projects (health and safety, quality assurance/quality control, budget control, training and supervision, field crew management, interpreting specs/prints, etc) required. Requirements include operation of wastewater treatment processes, computer literacy, and willingness to be at remote sites for 6 to 8 months/yr. Current 40-hr OSHA certification desired." Aug 24, '97 Post Ad

"Project Manager, PE with 7-8 yrs experience. Must be capable of providing coordination scheduling, and supervision in the technical design of residential, commercial, and municipal projects. Ability to coordinate with clients, review agencies and attend public meetings." Aug 24, '97 Post Ad

Quality

"value engineering" = "accomplishing a required function at a lower cost, without any reduction in quality" David Berry, Bench Mark, Burns & McDonnell, Perspectives on Quality

1. identify basic and required functions
2. identify secondary and unnecessary functions
3. Determine the cost to worth ratio for each function
4. Look for alternatives in high cost-to-worth areas

Salaries

Salary numbers are somewhat hard to find and are highly variable. In particular, getting current numbers is challenging. This is important because salaries tend to increase over time due to inflation. Salaries vary by region due to the local cost of living. Salaries clearly tend to increase as employees have more years of work experience. Salaries are generally higher for people who have earned higher degrees (BS vs. MS vs. PhD). Frequently magazine or web-based surveys are based on people who chose to respond, so the data are not fully inclusive.

In addition, the yearly salary number ignores bonuses. There has recently been a trend for companies to give more bonuses, as incentives for hard work, rather than simply set raises. In a survey, 55% of all engineers surveyed received bonuses. So if the company does well, the engineers will be rewarded. This tends to make up for the "dragging" state of pay raises, which failed to keep pace with inflation in 1995.

The US department of Labor provides the following data on Civil Engineering salaries:

"Median annual earnings of civil engineers were $60,070 in 2002. The middle 50 percent earned between $48,360 and $74,700. The lowest 10 percent earned less than $39,960, and the highest 10 percent earned more than $91,010. Median annual earnings in the industries employing the largest numbers of civil engineers in 2002 were:

Federal government	$67,410
Local government	62,210
Architectural, engineering, and related services	59,060
State government	58,350
Nonresidential building construction	54,190

According to a 2003 salary survey by the National Association of Colleges and Employers, bachelor's degree candidates in civil engineering received starting offers averaging $41,669 a year; master's degree candidates received an average offer of $47,245, and Ph.D. candidates were offered $69,079, on average, as an initial salary"
(http://www.bls.gov/oco/ocos030.htm#earnings)

It's important to realize that the average salary increases based on the level of education you've received. Salaries also increase based on the number of years you've worked as an engineer.

2003 web data (http://www.payscale.com/salary-survey/vid-3268/fid-6886) shows how salaries tend to increase with more experience:

Years experience	**Salary range**	**Average**
<1	$35,000-$47,500	$40,000

1-4	$39,000-$49,000	$42,000
5-9	$48,000 -$56,000	$52,000
10-19	$59,000-$82,000	$65,000
>20	$45,000-$120,000	$70,000

(note: includes all levels of degrees)

For a fun salary calculator, check out: http://www.collegegrad.com/salaries/salaries.shtml. This website lets you see how different salaries vary for different disciplines in various parts of the country.

Thoughts for the Future....

Consider getting an advanced degree at some point in your career. The American Society of Civil Engineers (ASCE) now considers the Master's degree to be the basic preparation for professional practice. This is driven largely by the ever expanding breadth and depth of technical knowledge that is relevant to a practicing civil engineer.

> "On October 9, 2001, the ASCE Board of Direction unanimously approved revised Policy 465: Academic Prerequisites for Licensure and Professional Practice. The policy states, "ASCE supports the concept of the Master's degree or Equivalent as a prerequisite for licensure and the practice of civil engineering at a professional level."" http://www.asce.org/professional/educ/report100901.cfm

"Today, engineering is becoming increasingly specialized. Students should plan to pursue their masters degree, regardless of their engineering discipline. Working between the bachelor's and master's is encouraged, but the masters degree should not be neglected. With a masters degree, engineers will be given noticeably more responsibility, more important tasks, more technical tasks, they will move up the corporate ladder more rapidly, and they will have greater self-confidence and better technical skills. ...a masters degree will pay off with higher salaries and more rapid advancement." Victor S. Magar, PE, PhD, Aug. 1997

Therefore, you may want to consider the CU combined BS/MS degree. If you want to know more, talk to your advisor.

References

Bugliarello, G. 1994. "Ideal of Civil Engineering." Journal of Professional Issues in Engineering Education and Practice. Vol 120(3): 290-294.

DiLaura, Dave. 1996. "Being Smart is Not Enough: Chautauquas for First Year Engineering Students."
Notes.

Holton, Ed. 1992/93. "The Critical First Year on the Job." CPC Annual, Vol. 1, p. 72-75.

Magar, Victor S. Personal Interview in 1997. PE. PhD in Civil Engineering at the University of Washington.

T.D. Oates. 1993. “Practice of Professionalism” Journal of Professional Issues in Engineering Education and Practice. 119(1): 44-45.

Phillips, Winfred M. “The Challenge of Change for Engineering Education.” Presentation at the 1997 NSF Engineering Education Scholars Workshop.

Welch, John F. Jr. 1989. Competitiveness: The Real Stuff of American Engineering.