

Geo-environmental Engineering - An Integral Part of Civil Engineering

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Abstract

All sophomore students at Rowan University are introduced to engineering design and experiments through a series of integrated lectures and laboratories. The class described in the following paragraphs, is one in a series of engineering clinics offered in the freshmen to senior years. Sophomore students are exposed to a variety of engineering principles, experimental methods, and design tools not typically encountered in the sophomore level. The objective is to introduce them to an incrementally progressive design experience. In this particular sophomore clinic, students were introduced to the basic principles governing the design and construction of a landfill. This design experiment focussed on introducing the EPA regulations governing the siting of landfills, the importance of soil identification, the soils that would be ideal for locating a landfill on, design and construction of a landfill and the various geosynthetics that are used in landfill construction. The introduction of a design course early on in the engineering curriculum enable students to get an idea of the complexities involved in the design and construction of an engineered facility. They also get an early introduction to geo-environmental courses.

Introduction

Rowan University is developing an innovative engineering curriculum that will produce engineers that are suited to meet the needs of a challenging workplace in the 21st century. The students develop their technical knowledge, communication skills, awareness of social implications, life long learning ability and ethical judgment. This breadth of skills is needed by graduates who will become effective leaders in areas such as infrastructure enhancement, and environmental preservation. To best meet these needs, the engineering curriculum at Rowan University emphasizes: (i) "hands-on" and team oriented education; (ii) inter and multi-disciplinary education; (iii) use and incorporation of state-of-the-art technologies; (iv) and improving technical communication skills. To achieve these objectives, the four engineering programs of Civil, Chemical, Mechanical and Chemical Engineering include a common engineering clinic throughout their eight semesters of study.

The Sophomore Engineering Clinic has laboratory and design components in at least two of the major engineering disciplines. In addition, the students are expected to improve their technical presentation skills. The semester long sophomore clinic course taught in the spring focussed on design of landfills and wastewater treatment. The module dealing with the design of landfills introduces basic engineering principles governing the design of an engineered facility. Even though it is traditional practice to introduce students to this topic in the senior year, this course was structured towards introducing sophomore students to design of an engineered structure.

The use of case studies, especially for design problems are beginning to emerge in engineering education. Design problems are particularly suitable for a case study approach since the solutions are not singularities and must be viewed in the context of the individual problem.¹ Case studies also facilitate the introduction of multiple and often conflicting objectives faced by engineers in practice. Real engineering problems solved in the context of their environmental, societal, economic and ethical constraints as well as their technical context provide a much improved insight into the practice of engineering. The guidelines for ABET accreditation consistently require this broadened approach to engineering education.

The case study considered was the Lipari landfill located in Southern New Jersey. This site is in close proximity to Rowan University. The Lipari landfill is on the EPA National Priorities list. It has a dubious past, especially in the local community. The Volatile Organic Compounds (VOCs) and contaminated groundwater from the chemical compounds disposed of in the landfill indiscriminately, has been responsible for adverse health effects in the local population.

The course objective is to assess the suitability of the site on which the Lipari landfill is located. In addition, the students will redesign the landfill liner and cover of the Lipari landfill such that it meets the following requirements:

- Protect groundwater quality by limiting the discharge of leachate.
- Protect air quality.
- Minimize impact on adjacent wetlands by controlling and impounding surface runoff.
- Use the landfill area efficiently and extend site life as much as is practical.

Site selection

In the first two weeks, the students are introduced to a brief history of environmental regulations. In addition, they are introduced to site selection regulations as identified by the EPA.² The students then learn the additional criterion for a suitable landfill site. In this process, students are introduced to geology and soil identification.

In a laboratory component, the students learn about soil classification by performing particle size analysis as well as visual identification.³ These have been areas in which practitioners as well as renowned geotechnical engineers like Peck have voiced concern.⁴ By introducing the dilatancy, toughness, plasticity and dry strength tests early on, the students learn simple but practical information early on in their career. It also provides them with the "hands on" experience that will be valuable when they become practitioners.

Once all the suitable characteristics of a landfill site are identified, the students are expected to assess the suitability of the Lipari landfill site. The students obtain information from the Soil Conservation Services and U.S. Geological Survey maps. They are also pointed to various information sources available on the World Wide Web, including the Code of Federal Regulations and the Environmental Protection Agency reports. This familiarizes the student with the information gathering process required to perform the preliminary design work.

By the end of the two 3-hour sessions, all the students, in teams of four, are expected to identify the soil type at the Lipari landfill site, get some geologic information about the site, identify the

water bodies in the area and the potential for ground water contamination. Based on the information, they are expected to assess the suitability of the site for a landfill.

Contaminant transport

The students are briefly introduced to contaminant transport. They are introduced to the equations governing ground water flow. In addition, they are introduced to a simple technique to model ground water flow using a computer spreadsheet based on the finite difference approach.⁵ The spreadsheet solution provides a very convenient way of tackling seepage and contaminant transport. It is a simple technique that is of particular use to practicing engineers. By introducing the sophomore engineering students to this technique, the students learn valuable computer skills that can be utilized in their more advanced courses and also when they go out into practice.

Design of the landfill liner and cover system

In the remaining lectures, the students undertake the design of the landfill liner and cover system. They are introduced to EPA regulations governing both municipal solid waste landfills and hazardous waste landfills. In addition, they are introduced to the various types of geosynthetics being currently used in practice. The introduction of new construction materials being used in practice is important to make them successful practicing engineers. They proceed then to redesign the landfill liner and cover system for the Lipari landfill so as to meet EPA regulations. The students also do realize that the design of a landfill cannot be done to completion without accounting for leachate collection systems and gas recovery systems.

Field trips and invited speakers

To provide the students with a complete design experience and to understand the complexity and importance of an engineering structure, the students visit an operational landfill. In a design project, the countless factors that interact could not possibly be imagined or described in paper to the extent that they are recognizable in real world situations. The visit to a landfill enables the students get a more complete view of the factors that they need to account for when designing a landfill. In addition, an invited speaker from the New Jersey Department of Environmental Protection explains the complexity of the application review and permitting process. The students were given some insight into the various agencies involved with the approval process as well as the legal implications.

The ultimate goal of the design experience is to provide the students with an opportunity to practice and hone their presentation skills. This opportunity is provided at the end of the module, whereby each team of students has to put together a poster and present it in class. The final design poster is largely a compilation of the individual design milestones. This gives the students an opportunity to be involved in a group activity and also to develop the vital communication skills that they will require when they graduate.

Summary and conclusions

This half semester design module shows the relevance of numerous technical areas that will be covered in much more depth in subsequent lecture courses. This provides the students with greater level of interest in advanced courses since they are familiar with the importance of the application of the subject matter. An appreciation of the relevance of material covered in future course work in fluid mechanics, soil mechanics, engineering economics and environmental engineering is obtained. In addition, the importance of geotechnical and geo-environmental engineering in the field of civil engineering becomes apparent. The students are introduced to concepts that they will experience in more detail in the senior engineering classes. The importance of ground water flow, contaminant transport, geology and soil characterization becomes obvious to the civil engineering student. The benefits of these activities include an increase in student confidence and appreciation for the role of engineers in solving complex design problems.

References

- 1) Dym, Clive L. (1994), "Teaching Design to Freshmen: Style and Content," *Journal of Engineering Education*, October 1994, pp. 303-316.
- 2) 40CFR258.10, "Criteria for Municipal Solid Waste Landfills, Location Restrictions."
- 3) ASTM D2488 (1984), "Standard Procedure for Description and Identification of Soils."
- 4) Peck, Ralph P. (1997), "Gaining Ground", *Civil Engineering*, December, 1997.
- 5) Williams, B.P., Smyrell, A.G., and Lewis, P.J. (1993), "Flownet Diagrams - the use of Finite Differences and a Spreadsheet to Determine Potential Heads," *Ground Engineering*, pp. 32-38.

Biographical Information

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