2006-2285: INTEGRATING ETHICS INTO A CIVIL ENGINEERING COURSE

Christy Jeon, Georgia Institute of Technology

Adjo Amekudzi, Georgia Institute of Technology

Integrating Ethics into a Civil Engineering Course

Abstract

Ethics is a critical component of Civil Engineering education and practice. This paper discusses a case study to integrate ethics into a required undergraduate Civil Engineering course -- Civil Engineering Systems -- at Georgia Institute of Technology. The course introduces systems and sustainability concepts in Civil Engineering planning, design, operations, and renewal, and thus presents an appropriate context for integrating ethical issues in the curriculum. The case reviews the ASCE and NSPE Codes of Ethics and presents a real-life account of the failed Manhattan Westway project development owing to a breach of ethics in the development of the Environmental Impact Statement. With the ethical context of the project, students are then asked to develop a relative ranking of the project alternatives using a simple multi-attribute decision making framework to instill an appreciation of the subjectivity involved in identifying the optimal project, the ethical dilemmas that could arise in such situations, and the ethical responsibilities and pressures that civil engineers may face during project development. Such cases may be integrated into appropriate course material to introduce ethics into the civil and environmental engineering curriculum.

1. Introduction

This paper presents a case study to introduce ethics into a required undergraduate course, Civil Engineering Systems (CEE 3000), at Georgia Institute of Technology. The case study was developed to formally introduce ethical considerations by including ethics alongside with technical, economic, environmental, and social equity considerations. The case consists of an overview of Civil Engineering ethics, a discussion of the ethical issues associated with the Manhattan Westway Project, and a simple exercise to introduce students to ethical issues associated with evaluating project alternatives. Through this case study, students are forced to confront the uncertainties sometimes present when planning for civil engineering projects, understand the impacts of a range of plausible decisions, and appreciate the responsibilities of civil engineers in the resulting ethical dilemmas that can arise in such situations. The case can be presented as a class lecture and exercise in a Civil Engineering course that addresses sustainability and systems concepts.

1.1 The Civil Engineering Systems Course (CEE 3000)

The Civil Engineering Systems course (CEE 3000) is a required course in the undergraduate curriculum at the School of Civil and Environmental Engineering at the Georgia Institute of Technology. CEE 3000 focuses on applying systems and sustainability concepts and analytical tools in planning, design, operations, maintenance and renewal of civil infrastructure facilities. These concepts are introduced in three modules. The first module exposes the students to systems and sustainability concepts through directed readings and discussions of global trends in population growth, composition and urbanization, human resource consumption and wastes generation; environmental impact assessments, social equity analyses, and infrastructure asset management tools. The second module presents mathematical optimization methods for evaluating system performance and a third module introduces engineering economic analysis tools. A term project requires students in teams of 4-6 to select a large-scale civil infrastructure facility, evaluate it with the integrated systems/sustainability framework presented in the course, develop recommendations to enhance the sustainability of the system, and evaluate the associated costs and benefits. CEE 3000 satisfies the ABET 2000 requirements in the curriculum and enrolls about 150-200 students each year [1]. The course offers an ideal area in the curriculum to formerly integrate ethical issues. Other institutions with similar courses may find it helpful to incorporate similar case studies that extend the criteria for alternatives analysis to include ethical issues alongside with technical, economic, environmental, and social criteria.

2. Introduction to Civil Engineering Ethics

Ethics and morality are studies of what we ought to do and how we ought to behave from a moral viewpoint, as opposed to an economic, political, religious, or prudential viewpoint [2]. Thus, engineering ethics can be defined as (1) the study of the moral issues and decisions confronting individuals and organizations involved in engineering and (2) the study of related questions about moral conduct, character, ideals, and relationships of people and organizations involved in technological development [3].

Engineers are expected to employ their engineering knowledge as much as possible to improve the well-being of the public. Thus they have important responsibilities relative to preserving or improving the quality of life of the communities in which they practice. In their professional capacity, they can face various ethical dilemmas whenever what they feel compelled to do is very different from what they ought to do from a moral perspective. Engineering education, however, had not adequately emphasized the importance of incorporating ethics as a part of the engineering curriculum until the 1985 Accreditation Board for Engineering and Technology (ABET) Guidelines were issued [4]. ABET 1985 made serious efforts to foster in their students "an understanding of the ethical characteristics of the engineering profession and practice" [5]. Moreover, ABET 2000 requires that engineering programs demonstrate that their graduates also understand the impact of engineering in a global and societal context and have a knowledge of contemporary issues related to engineering. It also indicates that students are to have a "major design experience" that includes a consideration of ethical factors as well as economic, environmental, social, and political factors [4]. Thus, ethics has become a more critical component of Civil Engineering education and practice as in other engineering fields.

2.1 Professional Codes of Ethics

Accordingly, every occupational group designates professional codes of ethics that represent their consensus about the standards that should govern their conduct. The Code of Ethics both for the National Society of Professional Engineers (NSPE) and the American Society of Civil

Engineers (ASCE) are the two dominant Codes that affect the civil engineering profession. More specifically applied to civil engineers, the ASCE Code begins with four fundamental principles adopted from the ABET Code of Ethics of Engineers, and enumerates seven fundamental canons followed by more detailed guidelines to practice under the fundamental canons of ethics [6]. In particular, Canon 1 of the ASCE Code emphasizes engineers' concern for public health and the environment by stating that engineers are required to hold paramount the safety, health, and welfare of the public and to comply with the principles of sustainable development in the performance of their professional duties [6]. The rest of the canons require engineers to: (1) perform services only in areas of their competence; (2) issue public statements only in an objective and truthful manner; (3) act in professional matters for each employer or client as faithful agents or trustees who shall avoid conflicts of interest; (4) build their professional reputation on the merit of their services and not compete unfairly with others; (5) act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession; and (6) continue their professional development throughout their careers, and provide opportunities for the professional development of those engineers under their supervision [6].

3. Environmental Ethics Issues in Civil Engineering

The ASCE Code marks a distinct advance over the codes of other engineering societies with respect to the environment, because it has incorporated the concept of sustainable development to mandate engineers' environmental responsibility [4]. Sustainable development is most commonly defined as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs* [7]. While this concept can be tailored to various engineering disciplines, an important principle of sustainable development is the integration of economic, social, and environmental concerns into engineering decision-making process in a manner that captures the full environmental impacts and benefits and costs over the lifecycle of the project. For example, a sustainable transportation system can be defined as a system that is effective and efficient in providing its users with equitable and safe access to basic social and economic services, promotes economic development, and is not harmful to the environment [8].

The National Environmental Policy Act of 1969 (NEPA) established a national policy to promote the protection of the environment in the actions and programs of federal agencies such as the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) [9]. Under NEPA, environmental impact statements (EIS) are required for major transportation projects that have a significant impact on the human and natural environment. Draft EIS (DEIS) and Final EIS (FEIS) documents should provide a full description of the proposed project, the existing environment, and the analysis of the possible beneficial and adverse impacts of all reasonable alternatives, including input from the public [9]. These EIS documents are prepared by or commissioned by the proponent of a project or development whose employer or client is eager to get approval for the project. Several such projects may have adverse impacts on the environment. It is natural that project proponents would emphasize the advantages of the project to the community and downplay the disadvantages through the EIS, a public document that will be scrutinized by local residents, bureaucrats, politicians, and environmentalists [10]. Here, there is a difference between what the engineers ought to do morally and what they feel compelled to do to further some non-moral goal such as loyalty on their employers or clients in this case [2]. Such an ethical dilemma exists whenever moral reasons or considerations conflict with other rational perspectives, including economic, political, religious, or prudential viewpoints. With this overview as an appropriate context for ethical considerations in Civil Engineering, the real-life case of the Manhattan Westway Project is discussed.

4. The Manhattan Westway Project: Real-life Case Study Addressing Ethical Issues in Civil Engineering

Research has shown that a study of ethics cases and dilemmas is one of the most effective methods for improving students' ethical judgment. In addition, actual education experiences reveal that engineering students are involved not so much in fictional case studies, even though they are quite realistic, as in realistic stories. Through real-life case studies students can learn to recognize the presence of ethical problems in their profession and to develop the analytical skills necessary for solving them. They can understand that there may be some irresolvable uncertainties in ethical analysis and that in some situations rational and responsible professionals may disagree about what is right [4]. Below, we discuss the New York Manhattan Westway

Project, a withdrawn megaproject due to engineers' lack of complete disclosure in preparing the EIS document. The case draws out ethical issues underlying the EIS, and gives students an opportunity make value judgments on environmental and social impacts of the project employing a simple multi-attribute decision making framework. The intent of this exercise is to force the students to recognize how subjective such an evaluation process can be, especially in the light of incomplete data, and the resulting ethical implications.

4.1. Project Background

Proposed in 1974, the intent of the Westway Project was to bury the West Side Highway in a tunnel underneath 181 acres of new landfill in the Hudson River in New York City. The project was to have been New York's version of Boston's Big Dig due to the expensive tunneling of much of the West Side Highway. The Federal government would fund the $2.3 billion dollar project. The project was highly controversial. Favoring construction were several state and federal "project agencies": the U.S. Army Corps of Engineers (ACOE), the Federal Highway Administration (FHWA), and the New York State Department of Transportation (DOT); urging caution were three federal "resource agencies": the Environmental Protection Agency (EPA), the Fish and Wildlife Service, and the National Marine Fisheries Service [11]. Supporters of Westway said it was the chance of a lifetime to create a substantial rivers edge park, rather than the narrow ribbon that snakes along the Hudson [12]. Critics countered that the federal funds should be "traded-in" and spent on that era's decaying transit system, not a new highway for cars [13].

Their differences crystallized around an environmental impact statement (EIS) commissioned by the FHWA that declared the proposed project area to be "biologically impoverished" and hence unlikely to be harmed by the proposed landfill. Even though 200 acres of the Hudson River was to be filled in, the EIS claimed there would be little impact on fisheries, as this part of the Hudson River was a "biological wasteland" almost devoid of fish. Between 1977 and 1981, the resource agencies repeatedly criticized the EIS, but the project agencies pushed ahead and, in March 1981, acquired a landfill permit for Westway [11]. However, a double-barreled review by a hostile federal court and the House Committee on Government Operations uncovered numerous methodological deficiencies in the FHWA's biological sampling methods. What began as an inquiry into the scientific integrity of the EIS turned into a probing critique of the moral and institutional integrity of the project agencies. Congressional investigators concluded that both the FHWA and the ACOE had violated basic canons of independent review and analysis. Their science was flawed because their methods had not been sufficiently virtuous. The House report accused the project agencies of having defied established norms of scientific peer review and independence [11].

The area actually was "a highly significant and productive habitat" for striped bass fish, and the presiding judge, Judge Griesa, stopped the project because this information was not included in the EIS. In 1985, the United States Court of Appeals Second Circuit decided that the Westway project would have an adverse impact on the Hudson River Striped Bass, and voided the Westway landfill permit. The proposed Westway landfill and highway development in and along the Hudson River in New York City were blocked because of the agency's failure to prepare an acceptable EIS. Under assault, and with rifts exposed between their ecology-minded and project-minded experts, the project agencies could defend neither their intellectual nor institutional superiority. Their scientific and moral authority crumbled simultaneously, and their opponents won the day without ever needing to prove their own scientific case definitively [14]. If the proponents had been honest and upfront about the impacts, Westway would have probably been built. Striped Bass were not an endangered species, and eliminating part of its habitat would not have stopped the project on its own. Proponents had withheld the facts and killed their project [13].

4.2. Environmental, Social, and Economic Impacts stated in EIS

The original EIS document, published in 1974, addresses probable impacts of five alternatives: (1) Maintenance, (2) Reconstruction, (3) Arterial, (4) Inboard, and (5) Outboard. Under the Maintenance alternative, the existing elevated West Side Highway would be repaired and reopened, and then served with continued periodic maintenance. The Reconstruction alternative provides for the rehabilitation and partial reconstruction of the existing elevated highway in order to correct major structural deficiencies, improve safety, and extend utilization of the facility to trucks and other commercial vehicles. The Arterial proposal contemplates the replacement of the existing West Side Highway with two new transportation facilities: (1) an at-grade arterial street and (2) a depressed and covered transitway. The Inboard alternative consists of three major transportation facilities: (1) a six lane interstate highway, (2) a new transitway, and (3) a rebuilt West Street. The Outboard alternative consists of three major transportation facilities: (1) a six lane interstate highway, (2) a new transitway, and (3) a reconstructed West Street-Twelfth Avenue.

The EIS certainly recognized that environmental quality, social amenities, economic growth, and transportation benefits are all legitimate concerns of the public, and specified that attempts to maximize any one of them will often conflict with the achievement of others [15]. The document emphasized the fact that making choices in order to provide optimum future conditions within the Study Corridor will necessarily and properly reflect the balancing of various competing values [16]. Major possible impacts taken into account in the document are 1) social and economic impacts, 2) environmental impacts such as impacts on energy consumption, air and water quality impacts, and effects on noise levels, 3) changes in travel and traffic patterns, and 4) other impacts such as aesthetic and visual effects, parks and waterfront access, displacement and relocation, etc. [16].

In terms of social and economic impacts, the EIS considers long-term benefits from the provision of improved access to the CBD as well as indirect influences on population, employment, housing, and the provisions of public facilities and services. Not surprisingly, it indicates that no alternative would have a major adverse long-term impact on the air/water quality and noise levels with respect to environmental impacts. The EIS should have addressed here that the project might be harmful to the natural environment such as wetlands, floodplains, and threatened or endangered species. The document also highlights that alternatives would provide long-term beneficial impacts on traffic such as improved safety and capacity and decreased congestion in terms of changes in travel and traffic patterns. It details additional impacts such as (1) opportunities for improvement in the amount, quality, and distribution of open space, recreation facilities, and waterfront access on the West Side, (2) aesthetic enhancement of the waterfront, (3) adverse social and economic impacts from the relocation of private and public properties, and (4) temporary or short-term adverse environmental impacts from the actual construction [16].

4.3. Discussion on Ethical Issues

Several ethical issues can be identified for the project in terms of ASCE Code of Ethics. First and foremost, the project agencies were not forthright enough to acknowledge possible adverse impacts of the project on the environment. As mentioned earlier, the first Fundamental Canon of the ASCE Code of Ethics emphasizes engineers' commitment to improving the environment by adherence to the principles of sustainable development so as to enhance the quality of life of the general public [6]. Also, the third canon of the ASCE Code of Ethics states that engineers shall issue public statements only in an objective and truthful manner [6]. EIS is certainly a type of public document that will be scrutinized by various stakeholders such as local residents, bureaucrats, politicians, and environmentalists. The project proponents failed to objectively report the advantages and disadvantages of the project to the community; they tended to highlight the advantages and downplay the disadvantages through the EIS. Finally, the project agencies, both the FHWA and the ACOE, were accused of violating basic canons of independent review and analysis.

Cost-benefit analysis (CBA) has traditionally been used by governments as part of their decision-making processes. The sustainable development approach is to incorporate these environmental costs and benefits by pricing them and incorporating them into the calculations as much as possible [17]. In order to weigh costs against benefits, CBA usually attempts to put a monetary value on both costs and benefits so that they are expressed in the same units. Routinely, however, some costs and benefits are not easy to convert into monetary terms. These include environmental values such as the value of clean air and water, unspoilt wilderness areas, and ecological balance and diversity. Different people will put different valuations on these assets [9].

Valuations can include economic, ecological, aesthetic, and ethical components. The economic consultant who undertakes such a valuation must use judgment in deciding not only which methods to use to assess values but also whether and how to quantify them. If s/he decides to quantify environmental values, different methods will yield higher or lower figures and it will be tempting (especially if s/he wants future work) to use the method that suits the client's desired outcome [9]. Students will find out how subjective such an evaluation process can be through the following exercise in which they can make judgments to conduct simple relative valuations on social, economic, and environmental impacts, in order to rank the proposed alternatives.

4.4. Multiple Attribute Decision Making (MADM) Exercise

The exercise will first introduce the students to a simple multiattribute framework for decision making and then provide the EIS data on the five alternatives considered for the Manhattan Westway Project. An excerpt of the data is shown in Table 1. Multiple attribute decision making (MADM) here refers to making preference decisions (e.g., evaluation, prioritization, selection) over the available alternatives that are characterized by multiple, usually conflicting, attributes [18]. The class will be divided up into teams of three and asked to come up with a relative ranking for the project alternatives, using the simple multiattribute framework, based on both the quantitative and qualitative data provided on the costs, benefits, and negative impacts of the alternatives (Table 1). Students should begin with the generation of key attributes, which will become the criteria for determining the most preferred alternative. Then, the importance of each attribute relative to the others will be established by assigning weights. Qualitative attribute data should be quantified by assigning numerical values, generally using a five-point ordinal scale that scores 1, 2, 3, 4, or 5, indicating *very unfavorable*, *unfavorable*, *neutral*, *favorable*, and *very favorable*, respectively. After normalizing the attribute rating, the value of an alternative can be computed by multiplying the comparable rating for each attribute by the importance weight assigned to the attribute and then summing these products over all the attributes [18]. Teams will be randomly selected to present their rankings to the class and discuss and justify the assumptions they made to obtain these rankings. The rankings for all the alternatives will be collected and presented to the class to consider. Plausible ranking results are presented in Tables 2 and 3. From the nature of the uncertainty in the data, it is expected that there will be different rankings. In addition, attention will be focused on the important data that were not included in the analysis and how these could change the rankings of the alternatives. The different rankings will force the students to confront the subjectivity inherent in the process, and appreciate better the pressures that can be associated with choosing a preferred alternative. To reinforce the ethical implications of such choices, the instructor will lead a discussion that ties the findings of this exercise with the ethical issues experienced in the development of the Westway Project's EIS.

5. Summary

This paper develops a case study that can be used to introduce ethics in civil and environmental engineering curricula. The case reviews the concepts of ethics and morality and presents key principles from the ASCE Codes of Ethics. The case then develops an account of the failed Manhattan Westway Project pointing out the reasons for project failure and potential ethical dilemmas associated with developing Environmental Impact Statements. Understanding the context of this project, students are provided with realistic data from the project EIS and required to work in teams to discuss ethical issues in EIS procedures, develop a ranking of the five project alternatives using a multiattribute decision making framework, present this ranking to their peers, and defend the assumptions they have made in developing the rankings. This exercise forces students to confront the uncertainty and hence subjectivity in identifying the preferred project alternative in the face of limited data, and the potential ethical dilemmas that can arise in the process.

Table 1: Benefit and Cost Factors of the Westway Project Alternatives [16]

Project Alternatives	Maintenance	Reconstruction	Arterial	Inboard	Outboard
Costs ($ Million)	$ 86M	$ 227M	$ 1,104M	$ 1,285M	$ 1,585M
Social and Economic impacts					
Trends in the Study Corridor	Continuation of present Corridor trends in population, employment, and housing				
Community Facilities and Services	Continuation of present Corridor trends of needs for public facilities/services				
Land Use and Community Character	Few positive impacts on adjacent region	Few positive impacts on adjacent region	Positive redevelopment effect	Positive redevelopment effect	Extensive redevelopment effects
Parks and Waterfront Access					
Additional land acre of open space	0	0	2.81 acre	21.37 acre	80 acre
Length of the waterfront access	No change	No change	1.4 mile	1.9 mile	3.7 mile
Effects on the Visual Environment	No change	Slightly improved view	Moderately improved view	Significantly improved view	Entirely new visual environment
Changes in Travel and Traffic Patterns					
Traffic Flow Quality	Severe congestion, delays, and speeds of 3-5 mph	Congestion on the entire northbound roadway	Require the restriction of entering traffic	Adequate to handle all traffic demand without controls	Adequate to handle all traffic demand without controls
Evening Peak-hour Average Speed	5.7 mph	6.0 mph	5.7 mph	6.9 mph	6.8 mph
Public Transit	Double track rail transitway, bus transitway, and express bus systems are possible				
Impacts on Energy Consumption					
British Thermal Units (BTU) consumed	23.688 M	23.745 M	23.452 M	23.558 M	23.728 M
Air Quality Impacts (Carbon Monoxide Concentrations)	Meets all National Ambient Air Quality Standards	Peak 8 hour concentration exceed the standards	Both peak 1 and 8 hour concentration exceeds the standards	Meets all National Ambient Air Quality Standards	Meets all National Ambient Air Quality Standards
Impacts on Noise Levels	8 db decrease	5 db decrease	2 db decrease	10 db decrease	11 db decrease
Water Quality Impacts	No impact	No impact	No impact	Positive impact on water quality	Greatest improvement on water quality
Impacts on Public Facilities and Utilities	No major adverse impacts	Minor relocations needed	Minor relocations needed	Major relocations needed	Severe relocations needed
Displacement and Relocation					
Effects on Private Properties	No effect	No effect	4 buildings and 12 commercial enterprises	48 buildings, 89 families, 91 commercials	46 buildings, 118 families, 101 commercials
Effects on Public Properties	No effect	No effect	No effect	Moderate displacement	Severe displacement
Impacts during Construction	Adverse impacts on the environment (temporary, depending on the kind of construction)				

Table 2 Ranking Example I

	X1: Costs	Benefits		
		X2: Air Quality Impacts	X3: Water Quality Impacts	X4: Traffic Flow Quality
	(Weight: 0.3)	(Weight: 0.2)	(Weight: 0.2)	(Weight: 0.3)
A1: Maintenance	$ 86M	5	3	1
A2: Reconstruction	$ 227M	4	3	2
A3: Arterial	$ 1,104M	3	3	3
A4: Inboard	$ 1,285M	5	4	5
A5: Outboard	$ 1,585M	5	5	5

Table 3 Ranking Example II

	X1: Costs	Benefits		
		X2: Water Quality Impacts	X3: Effects on Private Properties	X4: Effects on Visual Environment
	(Weight: 0.2)	(Weight: 0.3)	(Weight: 0.3)	(Weight: 0.2)
A1: Maintenance	$ 86M	3	3	3
A2: Reconstruction	$ 227M	3	3	4
A3: Arterial	$ 1,104M	3	2	4
A4: Inboard	$ 1,285M	4	1	5
A5: Outboard	$ 1,585M	5	1	5

References

[1] Adjo Amekudzi and Michael Meyer, "The Civil Engineering Systems Course at Georgia Institute of Technology," Presented at the *2004 Engineering Systems Symposium*, Massachusetts Institute of Technology, March 29-31, 2004.

[2] Kenneth K. Humphreys, "What every engineer should know about Ethics," Marcel Dekker, Inc., New York, 1999.

[3] Mike Martin and Roland Schinzinger, "Ethics in Engineering," Second Edition, McGraw-Hill, Inc., 1989.

[4] Charles Harris, Jr., Michael Pritchard, and Michael Rabins, "Engineering Ethics: Concepts and Cases," Second Edition, Wadsworth, Canada, 2000.

[5] Accreditation Board for Engineering and Technology (ABET), Fifty-third Annual Report, 1985.

[6] Code of Ethics (1996), American Society of Civil Engineers (ASCE) Homepage (www.asce.org).

[7] World Commission on Environment and Development (WCED), "Our Common Future," Oxford University Press, Oxford, England, 1987.

[8] Christy Jeon and Adjo Amekudzi, "Addressing Sustainability in Transportation Systems: Definitions, Indicators, and Metrics," *American Society of Civil Engineers (ASCE) Journal of Infrastructure Systems,* Volume 11, Number 1, pp. 31-50, 2005.

[9] http://www.planning.dot.gov/documents/BriefingBook/BBook.htm#9BB

[10] Sharon Beder, "Environmental Impact Assessment," *Ecodate*, pp. 3-8, July 1997.

[11] http://www.issues.org/issues/13.1/jasano.htm

[12] http://www.wnyc.org/news/articles/39284

[13] http://www.newyorkgames.org/news/archives/001918.html

[14] Sheila Jasanoff, "The dilemma of environmental democracy," Issues in Science and Technology, pp. 63-70, 1996. (http://www.issues.org/13.1/jasano.htm)

[15] Policy Statement of Steering Committee, West Side Highway Project Report No. 2.01, August 1972.

[16] Draft environmental impact statement and section 4 (f) statement for West Side Highway, interstate route 478, Brooklyn-Battery Tunnel to Lincoln Tunnel, New York County, U.S. Dept. of Transportation, 1974.

[17] Sharon Beder, "Engineers, Ethics, and Sustainable Development," Paper presented to the 10th International Congress of Logic, Methodology and Philosophy of Science, Florence, 1995.

[18] K. P. Yoon and C.-L. Hwang. (1995) "Multiple Attribute Decision Making: An Introduction." Sage University Paper series on Quantitative Applications in the Social Sciences, 07-104. Thousand Oaks, CA: Sage.