AC 2009-591: INTRODUCTION OF SUSTAINABILITY TO CIVIL AND CONSTRUCTION ENGINEERING STUDENTS

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Introduction of Sustainability to Civil/ Construction Engineering Students

Abstract:

Recently, numerous civil engineering articles involve the concept of going green and sustainable development. Various papers related to sustainable development have been written but few relate to how civil engineering students can apply these innovations in their academic curriculum and assist them in discovering green technologies and their applications during a professional career. This paper is an effort to highlight the importance of knowledge regarding sustainability in the academic curriculum. Education now-a-days is not just about knowing conventional technologies, but also to discover alternate technologies to save vanishing natural resources. In other words, it may be also defined as "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs".[12] The approach utilized to study sustainability at a specific institution is presented which may also be used in other institutions to present the concept of sustainability. Recently it has been estimated that the future sustainable (green) economy could create roughly four million jobs. This forecast should certainly be of interest to construction students and contractors.

Introduction:

"… the people who will succeed 15 years from now, the countries which will succeed, are those which are most based on a sustainable vision of the world. That is what we should be training people to do."[16]

The balancing of economic, social and environmental objectives, both now and into the future has become known as Sustainable Development and this is increasingly important for a range of organizational and spatial needs. Therefore, sustainable development has become an important issue on international, regional and national agendas concerning education policy during the past few years.[3]

It is anticipated that the next generation will be faced with an unprecedented challenge to redesign nearly every major natural resource based system on the planet. Specifically, they will inherit systems of industrial and technological growth that are simultaneously destroying or depleting much of nature and endangering human and non-human species, while offering the highest material standard of living and rate of consumption ever known.

Some believe that, "Education is critical for promoting sustainable development and improving the capacity of people to address environmental and developmental issues."[4] It is argued that Sustainable Development is now absolutely central to the practice of Civil Engineering and this needs to be reflected in the education and training of civil engineers.[2] The essence of education, formal or informal, primary or tertiary, is to explore the edges of possibility and probability needed to transform and improve upon the conditions of both the learner and the community.

Though basic education is essential in taking an individual to the "threshold of self-sufficiency" by providing literacy and a knowledge of how and why things happen, higher education, on the other hand, has a special responsibility to conduct scientific research necessary to generate the new knowledge needed, and to train the leaders and teachers of tomorrow, laying emphasis on integrative learning and the ability to apply knowledge and skills to realworld settings.[12]

Sustainability Seminar:

In order to introduce sustainability and the concept of green buildings to university students a seminar was recently developed which investigates the subject. Numerous papers were written as listed in the Table below. Students in the seminar were requested, at times, to present their findings in the Building Construction course. In addition, all the papers were presented at a meeting of the organization listed in tabulation below. A selection of the papers are described, in part, in the following sections.

PAPER	CO-AUTHOR	ORGANIZATION	DATE
1. Going Green Around The Globe	R. H. Choudhary et al.	Texas Section ASCE	2008
2. Mud and Straw Bale Construction	A. Pakalpati	Texas Section ASCE	2008
3. Green Building Materials and Techniques for Residential Buildings	R. M. L. Darisa et al.	Texas Section ASCE	2008
4. Consequence of Climate Change on the Infrastructure	R. H. Chaudhary	Texas Section ASCE	2008
5. Green Buildings – Sustainable Construction	Y. R. Kanapuram	ASEE Gulf Southwest	2008
6. Sustainable Building Design	S. R. Yardimalla	ASEE Gulf Southwest	2008
7. Overview of Adaptive Techniques and Materials used in Sustainable Buildings	A. P. Pakalpati	Texas Section ASCE	2007
8. Effective Municipal Solid Waste Management in Third World Cities	D. Siringi	Texas Section ASCE	2007
9. Sustainability: Use of Recycled Water	J. Dedhia and S. Patil	Texas Section ASCE	2007
10. Hurricane Waste Management	D. O. Siringi	ASEE Gulf Southwest	2007
11. Resisting Environmental Disasters Utilizing Adequate Construction	G. R. Reddy et al.	Texas Section ASCE	2006
12. Evacuation and Shelters Required for Severe Environmental	K. C. Ponnapali et al.	Texas Section ASCE	2006

(Atmospheric) Conditions			
13. Interlinking of Rivers	A. Waghmare	Texas Section ASCE	2006
14. Biogas Technology and its Present Applications	V. Bhrambhatt	Texas Section ASCE	2006
15. Global Organizational Reporting on Environmental, Social Criteria	A. T. Johnson, R. T. Reddy and N. Naresh	Texas Section ASCE	2005
16. Environmentally and Economically Sustainable Residential Buildings	A. S. Phanse and A. Deshpande	Texas Section ASCE	2005
17. Effects of Construction on Communities	M. Vajjalla, K. Kumar and S. Ravikanth	ASEE Gulf Southwest	2005
18. Mold in Buildings	Nitin Paliwal and S. R. Aluguvelli	Texas Section ASCE	2004
19. Education in Sustainability: Design, Construction and Operation of Green Buildings	H. Easwaran	ASEE Gulf Southwest	2004
20. Impact of Air Quality – Including Ozone Formation in the Troposphere	G. Veeravel	ASEE Gulf Southwest	2004

Going Green around the Globe:

The expression “going green” generally refers to any practice which leads to the protection of the earth's environment. Today, environmentalism may in some sense be considered a process to save the earth from the effects of greenhouse gas emissions. Many countries have realized the importance of the harmful effects of global change. They have also started to implement some alternative green construction methods to reduce the use of nonrenewable resources. The objective of paper number one in the tabulation is to explain the manner in which countries around the globe are working to protect the environment and increase the use of renewable energy resources in construction.

Mud and Straw Bale Construction:

Energy efficiency has become one of the major items involved with sustainability in building construction. The conventional use of energy efficiency resources may be replaced by new techniques that promote natural and environmentally friendly facilities. In this context, the extensive internal heating and cooling costs of a building can be reduced by using mud and straw bale construction. Paper number two presents the advantages of mud and straw bale insulation as compared with conventional techniques.

Green Building Materials and Techniques for Residential Buildings:

Green building is the practice of increasing the efficiency with which facilities use energy, water, and materials, thereby reducing their negative impact on human health and the environment. Interest in the idea of building 'Green' sprang into the picture when people became aware that earth's atmospheric temperature was changing. Summers tended to become warmer and winters cooler than they had been in the past. The practice of 'Green' building can lead to benefits such as reduced operating costs and using less energy and water. The objective of this study is to develop a structure that has less negative impact on the environment by using renewable resources. In addition, 'Green' building can increase aesthetic harmony between structures and their surrounding natural habitat as illustrated in paper three.

Consequence of Climate Change on the Infrastructure:

The term climate change refers to any significant change in measures of climate for a certain period of time. Today, climate change tends to be used interchangeably with the term global warming. The earth's climate has varied from ice ages to periods of warmth as natural occurrences such as volcanic eruptions, energy releases from the sun, and shifts in the earth's orbit, have caused changes in the earth's climate. Human activities such as burning fossil fuels and deforestation may have also caused heat-trapping 'greenhouse gases' to increase significantly in the atmosphere. According to recent surveys, the earth's average temperature has increased by 1.2 to 1.4°F during the past century. Paper four addresses the significance of climate change and the possible dangers of human activities such as burning fossil fuels, deforestation, etc. It also recommends remedial measures that may be taken to minimize the effects of global warming.

Overview of Adaptive Techniques and Materials used in Sustainable Buildings:

In the past few decades, the excessive consumption of natural resources has raised questions about their use in building construction and for daily activities. This over consumption of land, water, wood as well as nonrenewable resources like natural gas, coal, and petroleum might result in a shortage or absence of resources for future generations. In this context, the idea of sustainability may be considered. Sustainability is the effective use of land, sunlight, and ventilation, for instance, to reduce the superfluous use of nonrenewable energy resources. Paper number seven presents some of the methods and materials used for the construction of buildings that follow sustainable practices and, therefore, utilize less energy and act as a part of the eco-system.

Effective Municipal Solid Waste Management in Third World Cities:

Municipal Solid Waste Management (MSWM) constitutes a serious problem in many Third World cities. The current system of collection and disposal of solid wastes pollutes the environment and compromises human health. Paper number eight examines the conventional approaches to MSWM used by development agencies and organizations. This paper argues that conventional approaches, which often fail, use imported technology and involve centralized bureaucratic solutions that ignore the informal sectors' contributions and solicit little public participation. This paper, which proposes a policy framework for improving waste management, argues that a decentralized model for MSWM may be more appropriate to conditions in developing world cities. The proposed model would promote community participation and

incorporate informal refuse collectors and scavengers into public-private partnerships, micro-enterprises, or cooperatives. The proposed approach could help collection and disposal problems associated with solid wastes in a socially, economically, and environmentally sound manner.

Sustainability: Use of Recycled Water:

Paper number nine summarizes the current urban use of reclaimed water for drinking, gardening and toilets. It compares water quality standards for reclaimed water, the volumes of water required for toilets and the quality of grey water and domestic sewage that can be utilized for reuse. Worldwide examples of reuse schemes are presented. The interest in water reclamation is growing steadily, not only in water deficient areas, but also in countries that have not historically appeared to have a water supply problem. Tunisia, Jordan, Australia and USA are cases in point. This situation affords great opportunities for the creation of urban water recycling schemes.

Interlinking of Rivers:

In a developing country such as India, interlinking of rivers seems to be an acceptable solution to many of its water problems. Paper number thirteen discusses a highly ambitious and massive project that would integrate most of the major rivers in the nation. The present population is roughly one billion, and is expected to rise to between 1.5 to 1.8 billion by 2050. Due to the high variability of rainfall patterns, some parts of the country receive large amounts of rain, while others have desert-like conditions. Therefore, the interlinking of rivers is of great importance for future development. The estimated cost of this largest project in the world is $112 billion. Interlinking of the rivers will augment irrigation, provide a solution to the growing need for industrial and domestic water, generate electricity, and improve inland navigation. The project should protect the country against water shortages and create a greener India. Successful implementation of the program will result in the creation of a large number of jobs and will be an initial step towards providing irrigation for the entire nation.

Biogas Technology and its Present Applications:

Biogas is the mixture of gas produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition, and is a part of the natural circle as explained in paper number fourteen. In nature, biogas is produced in bogs. It can also be manufactured from biological material in an environment free from air, which is an excellent fuel for heat, electricity, and cars, that doesn't drain the earth's fossil resources. The raw-material in biogas production has traditionally been waste from the food industries, and communal sewage treatment works. Biogas technology is a complete system in itself with a specific set of objectives (cost effective production of energy and soil nutrients). Factors such as microbes, plant design, construction materials, climate, chemical and microbial characteristics of inputs, and the inter-relationships among these items are important design considerations. There are two common man-made technologies for obtaining biogas: the fermentation of human and/or animal waste in specially designed digesters, and capturing methane from municipal waste landfill sites.

Global Organizational Reporting on Environmental, Social Criteria:

There has been a great deal of activity in the business community since the definition of "sustainable development" was coined almost 20 years ago. In just under two decades, the business world has been subjected to increasingly greater scrutiny. The trend for better corporate governance and accountability has focused attention on the responsibilities an organization has towards all its stakeholder groups and to the environment and society in which it operates. Along with this emerging trend for greater organizational accountability has been the growing demand for more public information concerning how organizations conduct their business in the context of sustainable development. This can include policies, value statements, impact data, target setting, governance, management systems, and stakeholder engagement processes. What has grown out of this search for greater organization transparency is the practice of sustainability reporting. This revolution in reporting has not been consistent throughout the world. In some countries, sustainability reporting has yet to emerge, although in others the pioneering reports began 15 years ago. For those who do report, there is also much inconsistency in the quality and scope of reporting. Paper number fifteen investigates the use of environmental and sustainable reporting by U.S. and global corporations.

Environmentally and Economically Sustainable Residential Buildings:

Today, numerous individuals have become more environmentally conscious and are therefore naturally concerned about their homes and workplaces, where they spend most of their time. Awareness about the ecological friendliness of surrounding structures is also increasing. This endeavor has led to various efforts to make design and construction more economical, as well as more environmentally sound and friendly. Different agencies and groups all over the world are devoting their valuable resources, such as time, money and manpower, to achieve high standards of ecological friendliness and economical construction. Any structure with these features is broadly classified as a "green building." Green buildings comprise all types of structures, including huge commercial buildings, individual residences, and large-scale housing projects. The main emphasis of paper number sixteen is the housing industry and measures that will qualify a residence as a green building. There is a growing trend in various parts of the world toward smaller, more sustainable, and environmentally responsible homes. Realizing that the current patterns of consumption probably cannot be maintained, many are seeking an environmentally healthier lifestyle. In this regard, green buildings are primarily designed to be environmentally and economically friendly homes.

Mold in Buildings:

Molds are microscopic fungi that are present everywhere—indoors and outdoors. Fungi are usually filamentous organisms and the production of spores is their principal characteristic. Buildings are perfect habitats for mold growth. Mold growth can be reduced by a number of factors, alone or in combination, during the design, construction, inspection, and maintenance of a facility. It has been found that molds may increase symptoms of allergies for individuals. Paper number eighteen contains a discussion of the origin of molds in buildings, the most common types of molds and the factors that expedite the growth of molds. It also focuses on the toxic

effects of molds, potential health effects on inhabitants, medical evaluations, environmental assessments, and remediation.

Sustainable Development:

The ASCE Board of Direction adopted the following definition of Sustainable Development: "Sustainable Development is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development."[16]

Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry, and fisheries sectors) conserves land, water, plant, and animal resources, is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable.

Sustainable development is omni disciplinary, that is, it cannot be limited to a number of disciplines or areas, but is applicable to the whole world and everyone and everything on it, now and in the future. Secondly, there is no set aim, but continuation of development is the aim of sustainability.

Sustainable Design:

Sustainable design is a reaction to the environmental crisis of rapid growth of economic activity and population, depletion of natural resources, damage to ecosystems and loss of biodiversity. Sustainable design is not an attachment or supplement to architectural design, but an integrated design process within civil/construction and architectural engineering. Sustainable design is the thoughtful integration of architecture with electrical, mechanical and structural engineering. In addition to the concern for the traditional aesthetics of massing, proportion, scale, texture, shadow and light, the facility design team needs to be concerned with long term costs: environmental, economic and human.[6]

What is a Green Building Material or Product?

Green building materials are composed of renewable, rather than non-renewable resources. Green materials are environmentally responsible because their impacts are considered over the life of the product. Green building materials also offer the following specific benefits to the building owner and building occupants: [7]

- Reduced maintenance/replacement costs over the life of the building.
- Energy conservation.
- Improved occupant health and productivity.
- Lower costs associated with changing space configurations.
- Greater design flexibility.

Building Material/Product Selection Criteria:

- Resource efficiency
- Indoor air quality
- Energy efficiency
- Water conservation
- Affordability

Sustainability - Use of Recycled Water:

The availability of recycled water may be considered critical to maintain a sustainable potable water supply. Recycled water helps reduce dependence on an over-drafted groundwater supply and also helps reduce use of potable water for landscape irrigation. Recycled water could possibly be drought proof and its use allows establishing a balanced, sustainable water supply by reducing the use of groundwater and surface water. The use of recycled water for non-drinking purposes includes irrigation for agriculture, landscaping for public parks or golf courses and toilet flush water. Another major non-potable use is within industrial facilities, such as power plants and oil refineries, as well as commercial facilities that require significant volumes of water for cooling processes. Recently, the use of reclaimed water for commercial and private laundry operations is being considered in numerous locations.[8,9]

Resisting Environmental Disasters using Sustainable Design:

Awareness of the value of resilience in architecture and community design emerged through the application of criteria to sustainability during emergency management efforts. The three criteria for sustainability: equity in the present and future, economy and ecology, were used to assess weather-related emergency management activities typically conducted as a contingency before an emergency, the reaction during the emergency and recovery activities conducted after the event. Planning sustainable communities is a concept that is growing in importance in today's world. Sustainable communities are disaster resistant and vice versa. Sustainable community development and disaster resistant communities are natural partners, and therefore bridges must be built between them to help optimize the goals of each. By the nature of their missions, they must be concerned both with the workings of nature and the relationship between the built environment and the natural environment, as well as the associated social and economic implications. This must be the foundation and essential first step for creating sustainable communities as well as disaster resistant communities.[5]

The United States has developed several sustainable design organizations and programs in green building. The U.S. Green Building Council (USGBC) is a non-profit trade organization that promotes sustainability in how buildings are designed, built and operated. The USGBC is best known for the development of the Leadership in Energy and Environmental Design (LEED) rating system and Greenbuild, a green building conference that promotes the green building industry. As of September 2008, USGBC has more than 17,000 member organizations from every sector of the building industry and works to promote buildings that are environmentally responsible, profitable and healthy places in which to live and work. To achieve this it has developed a variety of programs and services, and works closely with key industry and research

organizations and federal, state and local government agencies. USGBC also offers a host of educational opportunities, including workshops and Web-based seminars to educate the public and industry professionals on different elements of the green building industry, from the basics to more technical information. Through its Green Building Certification Institute, USGBC offers industry professionals the chance to develop expertise in the field of green building and to receive accreditation as green building professionals.[14]

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC), provides numerous standards for environmentally sustainable construction. Since its inception in 1998, LEED has grown to encompass more than 14,000 projects in 50 US States and 30 countries covering 1.062 billion square feet (99 km²) of development area. The hallmark of LEED is that it is an open and transparent process where the technical criteria proposed by the LEED committees are publicly reviewed for approval by the more than 10,000 membership organizations that currently constitute the USGBC. Individuals recognized for their knowledge of the LEED rating system are permitted to use the LEED Accredited Professional (AP) acronym after their name, indicating they have passed the accreditation exam given by the Green Building Certification Institute (a 3rd party organization that handles accreditation for the USGBC).[15]

Sustainability in Universities:

Teaching sustainability is far different compared to some of the other subjects taught at an university. Achieving sustainability in the postmodern world will require an active and competent citizenry, demonstrating civic virtue, a high degree of ecological literacy, and ecological competence. The goal is to encourage a world view, one in which students will become activists for sustainability after they graduate, whether in a civic sphere or by bringing sustainability criteria to bear in their work.[1,13]

The goal of a particular course is to give students a chance to investigate methods to integrate sustainability into the structure of the built environment, and introduce ways to undertake community development that is an alternative to market driven economic development.

Summary and Conclusion:

Educating today's students about sustainability would hopefully increase future interest in and concern for the environment. Students in universities should be considered the base for teaching sustainability. In fact, they are at the level where this knowledge may assist them in their professional career. Proper care should be taken to make sustainability interesting and just not another course needed to be taken to graduate.

Specifically, this paper describes the type of course a university may adopt for the civil and construction engineering students. It presents methods which may be considered to incorporate the concepts of sustainability into a civil or construction engineering curriculum.

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