Sustainable water in Hydraulic Course for construction management students

Abstract:

Water is the source of the life for human use and maintains the health of local ecosystem. Water resources sustainability is the ability to use water in sufficient quantities and quality. Sustainable water use has been defined as "the use of water that support the ability of human society to endure and flourish into indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depends on it.[6]" There is need for adding the new section in the syllabus of hydraulic and hydrology that is been teaching to the colleges, especially technical colleges. As a part of this move to the greener environment in State College we are planning to add sustainable site and water efficiency to our current curriculum. The traditional hydraulic course has been teaching in state college did not include the sustainability. In this course we are implementing the Leadership in Energy and Environmental Design (LEED) criteria. There are six categories for LEED credit. We are including part of subcategory 6 from Sustainable Sites category. Subcategory 6 includes Stormwater design management both for quality and quantity control. Limit disruption of natural hydrology by reducing impervious cover, increasing on site infiltration and managing stormwater runoff moreover using rational method to estimate runoff will be covered from subcategory 6. In addition we will consider the strategies of project site design to maintain natural stormwater flows by promoting infiltration, minimize impervious surfaces. Moreover trying to reuse stormwater volumes generated for non potable uses such as landscape irrigation, toilets and urinal flushing. The new curriculum can be used to improve and Hydraulic/Hydrology related courses in several technical colleges.

Introduction:

Sustainability in the frame of water resources has changed through the time. At the beginning meeting water demand was the main concern. While later quality issue was more important and followed by water reuse, and today sustainability must include the whole aspect such as energy, efficiency, quality and quantity. The word sustainability involves the ability to support life, to comfort and to nourish. For all human history, the earth has sustained human being by providing food, water, air and shelter. On the other hand development means improving more advance situation to the current one[5]. As a result Sustainable Development implies working to improve human productive power without breaking society or the environment[4]. Society always involves the issues related to economy, environmental and equality around people. Water is a limited resource that is essential to all life. There is a demand for expanding freshwater resources to provide drinking water for increasing population, in the mean time preventing pollution and leaving enough water for natural ecosystem functions. These combined describe the need for sustainable waster resource management. The world's population, currently estimated at 6.7 billion, is growing by about 80 million people each year, which means demand for freshwater is increasing by 64 billion cubic meters a year[10]. Global per capita water supplies by 2001 were one –third lower than they were in 1970 due to population increase and water quality was turning down in many areas. According to UN, eighty percent of all illnesses in development countries are related to water. In addition by 2050 two-third of population or as many as 5 billion people

will face shortage of clean freshwater[10]. Water problem may become serious even in the wealthy countries, since some of the toxic organisms such as cryptosporidium are already resistant to chlorine which is the most widespread techniques used to purify drinking water.

Introduction to sustainable Development:

The most accepted worldwide definition of Sustainable Development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs[1]. Sustainable construction is any construction, while green building focuses on vertical construction. The horizontal construction is referring to green highways or sustainable streets. The Construction that focuses on energy efficiency and water efficiency is referred to as high performance building. Sustainable construction is an international concern. Green rating system in United States developed by the U.S. Green Building Council (USGBC). This system is referred to as LEED, which stands for Leadership in Energy and Environmental Design[7].

USGBC LEED-NC Rating System and its application in Hydraulic/Hydrology Course:

LEED-NC is subdivided into six groups for which there are prerequisites, subcategories, and credits in place of possible points[7]. The six categories are: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Material and Resources (MR), Indoor Environmental Quality (EQ) and Innovation and Design Processes (ID). These broad areas are assigned some specific points. Based on the satisfactory performance on those areas the project might score points. Cumulative score determine the level of certification based on the following scale.

- Certified Level: 26-32 points
- Silver Level: 33-38 points
- Gold Level: 39-51 points
- Platinum Level: 51-69 points

Based on LEED certificated for new building Sustainable Site (SS) can obtain up to 14 credits for all its subcategories[11]. Water Efficiency (WE), can attain up to 5 credits. From these groups the Sustainable Sites (SS) and Water Efficiency (WE) can be part of the sustainable water in the Hydraulic/ Hydrology syllabus in construction technology management program. From Sustainable Sites (SS) the credits 6.1 stormwater Design, Quantity and Quality Control and from Water Efficiency (WE) the subcategories of Innovative Wastewater Technologies and Water Use Reduction (by 20-30% Reduction) are included in the syllabus.

<u>Effect of Sustainable Site Subcategory 6, Stormwater Management in Hydraulic/Hydrology course:</u>

Stormwater management is a term that is used to describe all measures to control runoff in areas affected by development. Typically structures used in stromwater managements such as storm sewers, culverts, swales and detention basin. These structures are used to help convey runoff safety and efficiently away from development. This is the general definition and usage of

Stormwater management. In current syllabus of Hydraulic/Hydrology in most technical colleges the students are learning to find the runoff and design of the structures for stormwater management. In current outline for the course of Hydraulic/Hydrology in State college, CON303, we are covering the required topics such as fundamental of Hydrostatics and Hydrodynamics, Hydraulic devices, open channel Hydraulic, uniform and varied flow in channels and in the Hydrology section, the fundamental of Hydrology and runoff calculation. Due to the need of sustainability in water resources worldwide we are including the bridge between the current curriculums with a new view to reach to sustainable water resources. Since there is a chance that too many different perspectives will interfere with the overall goal of developing a strategy we will follow the rating system developed by the U.S. Green Building Council (USGBC). We are offering students introduction of some major concepts that are being accepted in methodologies to introduce sustainability into construction practices in the United States. The system is entitles LEED and has grown out of energy saving efforts in the United States. Intention of the sustainable site credit 6.1 which is stormwater management- quantity control is to limit disruption of natural hydrology by reducing impervious cover, increasing on site infiltration and managing stormwater runoff. For reaching to this goal two options are required. The first choice is for the situation that existing imperviousness is less than or equal 50%. It means that the stromwater management should achieve a plan that avoids the post development peak discharge rate and quantity from exceeding the pre development peak discharge rate and the quantity for the one and two years , 24 hour design storms. The second option if for existing imperviousness is greater than 50%. In this case the stromwater management plan implements that effect in a 25% decrease in the volume of stormwater runoff from the two year, 24 hour design storm. In general design the project sites to retain natural stormwater run by maintaining infiltration. To minimize the impervious surfaces using the vegetated roof, pervious paving and reuse stormwater generated for non potable uses such as landscape, irrigation and toilet flushing. To imply this credit we have to first determine some terms, in general in land development and watershed analysis the land is divided to pervious and impervious surfaces. Impervious surfaces are such as roofed and paved areas where the material used in theses surfaces doesn't allow any major infiltration of water into the ground. Pervious surfaces are everything else. Normally it is necessary to determine the percent pervious or percent impervious areas for a project. The percent of impervious is the percent of impervious of the land areas covered by impervious surfaces, divided by the total project area A_T.

$$\%Impervious = \frac{A_{imp}}{A_T} \times 100 \quad \text{(Equation 1)}$$

However some surfaces may not be completely impervious, for example an asphalt shingle roof may be considered as a impervious surface by definition but in reality it doesn't shed all the rain fall as a runoff and some will absorbed in the cracks on the surface and later on evaporated. It means all the rainfall in the impervious surface won't be as a way of infiltration, some of it might be evaporated or evapotranspated. There is a method that estimates the amount of runoff based on the characteristics of the surface areas. This method is rational method which is already in the current syllabus of Hydraulic/Hydrology outlines. In version 2.1 of LEED-NC, the adopting equation of imperviousness is given as a rational method coefficient on percent.

$$\%Impervious = 100 \times C \quad \text{(Equation 2)}$$

In equation 2 the C is defined as the rational method runoff coefficient. This coefficient shows the fractional percentage of a rainfall volume from a 2 to 10 year frequency storm which estimated to result in runoff from that particular surface. Equation 3 shows the overall runoff coefficient:

$$C = \frac{\Sigma C_i \, A_i}{\Sigma A_i} \qquad \text{(Equation 3)}$$

From Equation 3 the overall runoff coefficient C is calculated as the land-area-weighted average of the individual area coefficient C_i for each individual land area A_i. There are different references to obtain the C value. The values of typical runoff coefficient for two years storms are shown in table 1 in Appendix A. Table 1 is from LEED-NC 2.1 with the pervious pavement grids. In addition the pervious concrete values determine din the laboratory study at the University of South Carolina.[12] based on this study the imperviousness of the existing site is determined and then for the new design the proposed site must meet with any of the two options for the situation that existing imperviousness is less than or equal 50%. Objective of the sustainable site credit 6.2 which is stormwater management- quality control is by reducing impervious cover, increasing on site infiltration, eliminating sources of contamination, and removing impurity from stormwater runoff reduce or eliminate water pollution. Limit disruption of natural hydrology by reducing impervious cover, increasing on site infiltration and managing stormwater runoff. For reaching this goal two options are required. For obtaining this purpose apply a stormwater management plan that reduces impervious cover, increase infiltration, and detains and treats the stromwater runoff from 90% of the average annual rainfall using acceptable best management practices(BMPs). BMPs used to treat runoff must be capable of removing 80% of the average annual post development total suspended solids (TSS) load based on existing monitoring reports. Strategies for reaching this objective is to design a site to capture, slow and treat stromwater runoff by dropping impervious surfaces, produce rainwater and directing remaining stormwater runoff to soil and vegetation based water treatment methods like vegetated bioretention facilities, rain gardens, wetlands, green roofs and bioswales. are to use substitute surface such as vegetated roof, grid paver or pervious pavement and nonstructural techniques like rain gardens, rain water recycling and disconnected imperviousness to reduce imperviousness and promote filtration in that way reducing pollutant loadings. Use sustainable design policies such as low impact development and environmentally sensitive designs to intend included natural and mechanical treatment systems like constructed wetlands, vegetated filter and open channel to treat stormwater runoff.

Effect of LEED Water Efficiency category of water use reduction in Hydraulic/Hydrology course:

The Water Efficiency (WE) portion deals with issues that reduce the use of potable water at the site and discharge of wastewater from the site. The subcategory of reduction in water use can be cover in the Hydraulic/Hydrology syllabus in the technology colleges. The total credits from this category are 5 which 2 of it is belongs to the water used reduction. The objective of water use reduction is maximizing waster efficiency within buildings to reduce the burden on municipal water supply and wastewater systems. There are two requirements to achieve this goal, the first one is to use 20% less water than the water use baseline calculated for the building which is not

included irrigation and the other one is utilize strategies to use 30% less water than the water use baseline calculated for the building which is not included irrigation. We can obtain this aim by using high efficiency fixtures, dry fixture such as composting toilet systems and non water using urinals, and occupant sensors to reduce the potable water demand. The average US household uses about 50 gallons per person per day a rate more than seven times the per capita average in the rest of the world[3] yet the World Health Organization declares good health and cleanliness require a total daily supply of about 8 gallon per person per day[2].Two third of residential interior water is used for toilet flushing (4gal/flush) and bathing (15-50 gal/ shower or bath) while a dishwasher uses 8-12 gallon and a top loading clothes washer 4055 gallon[3].Consider reuse stormwater and greywater for non-potable applications such a toilets and urinal flushing as custodial uses.

Conclusion:

How much is the water value? We might think that diamonds are more valuable than water, but it really depends how thirsty we are. Most of natural resources have substitutes that we can use, such as natural gas for oil but there is no alternate for water. According to UNESCO half a billion people in Africa lack access to adequate sanitation, and that 5,000 children die daily from diarrhea, a disease that can be prevented with clean water. The agency said the number of people living on less than $1.25 a day is roughly the same as the number without access to safe drinking water. Freshwater and energy are two resources that are intricately connected. Energy is used to help clean and transport water and water is used to help produce energy. American public water supply and treatment facilities consume about 56 billion kilowatt-hours (kWh) per year enough to power more than 5 million homes for an entire year[9]. Sustainable construction research and applications are still in their early years. There is a great need for research, education and case studies from applications to further develop a more sustainable future in development and construction. Referring to US EPA, half of irrigation water can be wasted as a result of evaporation, wind and over watering, but weather based irrigation system can reduce irrigation water use by 20% or 24 billion gallons per year[8]. For reaching to water resources sustainability we must increase public awareness about the challenges the world is facing in relation to water. Introducing sustainable water resources to the technology colleges especially for construction management students can be a great step toward sustainability.

Appendix -1

Surface Type	Typical Runoff Coefficient
Pavement, asphalt	0.95
Pavement, concrete	0.95
Pavement, brick	0.85
Pervious pavement, plastic grid with grass	0.20
Pervious pavement, concrete grid with grass	0.60
Pervious pavement, concrete paver grid with gravel	0.85
Pervious concrete (0–1% slope)	~0
Turf, flat (0–1% slope)	0.25
Turf, average (1–3% slope)	0.35
Turf, hilly (3–10% slope)	0.40
Turf, steep (>10% slope)	0.45
Roofs, conventional	0.95
Roof, garden roof (<4-in substrate)	0.50
Roof, garden roof (4- to 8-in substrate)	0.30
Roof, garden roof (9- to 20-in substrate)	0.20
Roof, garden roof (>20-in substrate)	0.10
Vegetation, flat (0–1% slope)	0.10
Vegetation, average (1–3% slope)	0.20
Vegetation, hilly (3–10% slope)	0.25
Vegetation, steep (>10% slope)	0.30

Table 1- Typical Runoff Coefficents(Two Year Storm)[11,12]

Bibliography

1. Brundtland Commission, (1987), "*our common future*" reported by the Brundtland Commission, formally the World Commission on Environmental and Development (WCED), Oxford university Press.
2. Collier, C. (1999). "*Save some for Tomorrow*". Environmental News Service (ENS).
3. Environmental News Service (ENS). (1999b). "Growing population faces Shrinking Water Supply".
4. Flint,R.W., (2003). "*Sustainable Development: What does sustainability means to individual in conduct of their life and business*." In handbook of development Policy Strategies, edited by G.M. Mudacumura. New York: Marcel Dekker, Inc.
5. Flint,R.W., F.C.Frick, A.Duffy,J.Brittingham,K. Stephens, P.Graham and C.Borgmeyer. (2002). "*Characteristics of Sustainable Destination Resort Communities.*" Resort Municipality of Whistler, BC, Canada
6. Gleick, P., P. Loh, S. Gomez, and J. Morrison. (1995). "California Water 2020: A Sustainable Vision. Pacific Institute Report", Pacific Institute for Studies in Development, Environment, and Security. Oakland, California.
7. Haselbach L., (2008), "*The Engineering Guide to LEED-New Construction*".
8. U.S. Environmental Protection Agency. (2007). "Outdoor water use in the United States". (EPA Pub 832-F-06-005) Department of the Interior, Editor.
9. U.S. EPA (2007)," *Why Water Efficiency"*.
10. UNESCO, (2003). Water for People, Water for Life: the World Water Development Report. World Water Assessment Programme, United Nation, NY.
11. USGBC, (2003), LEED-NC for New Construction, Reference guide, Version 2.1, 2nd ed, May, U.S. Green Building Council, Washington, D.C.
12. Valavala, S., F.Montes, and L.M. Haselbach (2006), " Area Rated Rational Runoff Coefficient Values for Portland Cement Pervious Concrete Pavement", ASCE Journal of Hydrology Engineering, American Society of Civil Engineering, Reston, Va., May-June, 11(3): 257-260