LEED-Based Mertz Redesign

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ABSTRACT

The goal of this project is to analyze and redesign Mertz Hall to meet LEED® Specifications. The motivation behind the project is to familiarize myself with an extremely relevant topic in today's civil and environmental engineering fields, and to learn some valuable skills in project management. The main components of the project will be (1) to investigate an existing structure in light of LEED® Specifications; (2) to determine and develop a design; and (3) to model this redesigned structure in CAD; (4) to complete a cost analysis of the revised structure and compare with the costs of the original structure. A suitable design will be selected for various environmental and energy-related reasons. The model will serve as a culmination of my study in an area recently introduced on the graduate studies level and rare in undergraduate engineering studies. The project will not involve machine shop work, but will require primarily research and some design via applicable software. The only costs associated with the project were those of time and for some measuring devices.

ACKNOWLEDGMENTS

First and foremost I would like to thank God for providing me with the strength to complete this project and for providing me with the right people to guide and support me through this process. I would like to thank my advisor Professor Faruq Siddiqui and Professor Nelson Macken for their suggestions and assistance during the procurement phase of my project. I would like to thank all of the people at the Swarthmore College Services Building for providing me with access to Mertz Residence Hall and its associated drawings. Lastly, I would like to thank the employees at the Scott Arboretum for their assistance in learning more about the environmental situation surrounding the dormitory.

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INTRODUCTION

Inspired by courses taken in environmental and ecological engineering while on Study Abroad in Poland in Spring 2008, I have decided to couple my newfound interests in these areas of engineering with my existing interest in structural engineering concepts. As my primary interest lies in building design, I envision a project which emphasizes the importance of environmental considerations in development of structures.

I propose to develop a retrofit design on an existing small structure in the Philadelphia area. This structure should be no more than four stories so that the main focus of my work is determining an optimal design in light of Leadership in Energy and Environmental Design (LEED®) specifications. This project will require me to conduct a site analysis, and to gain a deep understanding of the architectural drawings and overall purpose of the structure. In addition to covering all of the LEED® specifications in my analysis and design development, I will prepare a cost analysis and construction documents.

This proposal elucidates how this project meets all LEED® constraints for design. Highlighted, are the specific LEED® considerations of sustainability, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation and design process. Subsequently, the plans, my qualifications in conducting the project, and the budget for the project are presented. In accordance with the criteria for E90 projects, an oral presentation of the final report will be presented in May, 2009.

Include information about a model for this project

BACKGROUND OF LEED

LEED certification emerged out of the development of the United States Green Building Council (USGBC), which formed in 1993. The council was established out of a concern for creation of some standard for sustainable building in the United States. Recognizing the significance of this issue across many markets and sectors, the group started a committee which was initially composed of architects, real estate agents, a building owner, a lawyer, an environmentalist, and other industry representatives.

Out of the Council's research and the contributions of the Committee came the first version of LEED Green Building Rating System in 1998, known as LEED Version 1.0. Subsequent versions arrived in 2000, 2002, and 2005, the last known as Version 2.2. Of course, more modifications are expected in coming years and the most recent is that released on April 27, 2009 – Version 3.0.

Over the years the modifications have incorporated various considerations of new developments in environmental and energy consciousness as well as known areas which had not been thoroughly analyzed by the Council and Committee at the time of submittal of the newest version. Since the first version the specifications have been organized to address particular building types, sectors, and project spaces. Thus, owners and project managers can look to such specifics as LEED for Core & Shell, LEED for New Construction, LEED for Schools, LEED for Neighborhood Development, LEED for Retail, LEED for Healthcare, LEED for Homes, and LEED for Commercial Interiors.

For the purposes of project registration and certification the Green Building Certification Institute (GBCI) was established in 2008. It is a separately incorporated body supported by the USGBC that manages programs to increase and measure the performance of buildings in conjunction with industry systems like LEED.

LEED, like other green building certification methods is constantly evolving due to the rapid changes in our understanding of our impact on the environment and in how we can more efficiently use energy. Thus, as the certifications are modified so too must our communities evolve to meet the new challenges of the day.

LEED for EXISTING BUILDINGS

LEED for Existing Buildings is the Rating System observed during the process of this project. Mertz Residence Hall is the subject of the project and having been constructed in 1981, qualifies as an existing building—one which was not certified under LEED before its construction.

LEED 2009 for Existing Buildings: Operations & Maintenance Rating System concentrates on 7 areas:

- Sustainable Sites (SS)
- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Materials and Resources (MR)
- Indoor Environmental Quality (IEQ)
- Innovation in Operations (IO)
- Regional Priority (RP)

A brief explanation of each of these areas follows and a more detailed explanation of each can be found in materials from the USGBC website included in Appendix A.

Sustainable Sites are those buildings that show significant concern for use of resources and its impact on the current environment as well as the effects those us of resources has on future generations abilities to meet their needs. Water Efficiency is the considerate use of water resources in recognition of the unequal distribution of potable water and the efforts and impacts associated with the treatment of wastewater and use of the municipal water supply. Energy and Atmosphere addresses the need to replace fossil fuel energy usage with renewable energy source consumption and the impact of emissions on the environment, especially in terms of global climate change. Materials and Resources recognizes the significant impact our material and resource choices have on the environment, air quality, and the importance of waste reduction to minimize the use of landfills and incineration facilities. Indoor Environmental Quality focuses on the health and wellbeing of building occupants as related to indoor air quality, thermal comfort, acoustics, lighting, and the surrounding environment. Innovation in Operations affords project teams the opportunity to earn additional credits in areas not already specified by LEED. Finally, Regional Priority enables the group to earn additional credits for work that addresses environmental concerns specific to their geographical region.

The scale used in this rating system is as follows:

Certified	40-49 points
Silver	50-59 points
Gold	60-79 points
Platinum	80 points and above

All buildings that receive one of these certifications are acknowledged with a certification letter from the GBCI.

REDESIGN ASSESSMENT

SUSTAINABLE SITES (SS)

Credit 1: LEED Certified Design and Construction

This credit was not addressed as Mertz predates the establishment of LEED and has never been certified as an existing building. No points are earned for this credit.

Credit 2: Building Exterior and Hardscape Management Plan

This credit was not addressed as it is not engineering intensive. Points are not earned for this credit in Table X row 1, however this credit is assumed as achieved for row 2.

Credit 3: Integrated Pest Management, Erosion Control, and Landscape Management Plan

This credit was not addressed as it is not engineering intensive. Points are not earned for this credit in Table X row 1, however this credit is assumed as achieved for row 2.

Credit 4: Alternative Commuting Transportation

This credit is based on the goal of minimizing "pollution and land development impacts from automobile use for commuting." The primary requirement of this credit is to decrease the amount of trips to and from the site via "single occupant, conventionally powered and conventionally fueled vehicles." The term alternative commuting transportation as defined by USGBC includes but is not limited to telecommuting, compressed workweeks, mass transit, walking, bicycles or other manually-powered vehicles, carpools and vanpools, and fuel-efficient or alternative fuel vehicles with low emissions. According to USGBC, "Low-emitting vehicles and fuel-efficient vehicles are defined as vehicles that are classified as zero-emission vehicles (ZEVs) by the California Air Resources Board or that have achieved a minimum green score of 40 on the American Council for an Energy Efficient Economy annual vehicle-rating guide" (LEED 2009 EB: 4).

For calculations of the alternative commuting transportation performance for the site, a baseline assumption that "all regular occupants commute alone in conventional automobiles" is used. In the case of Mertz this calculation may look as follows:

$$Percentage\ reduction\ in\ conventional\ commuting\ trips$$

$$= \left(1 - \frac{number\ of\ occupants\ conventionally\ commuting}{total\ number\ of\ occupants}\right) \times 100\% \qquad [1]$$

$$= \left(1 - \frac{11}{139}\right) \times 100\%$$

$$= 92\%$$

This calculation is the most basic kind suggested by LEED for this credit. In the Reference Guide for Existing Buildings, which was not used for this report, a more detailed explanation of the nuances of this calculation is included. This includes how to calculate for changes in usage throughout different seasons, for example. While 92% appears to be a good result and suggests that no modifications need to be made to the current transportation system by Mertz, it must be noted that Mertz is a residence hall on a non-commuter college campus. Few students are offered permits in order to have a vehicle on campus and so assuming a baseline of all occupants commuting "conventionally" is unrealistic. At the same time it is commendable that the SEPTA commuter rail system, numerous SEPTA bus stops, campus shuttle service, and PhillyCar Share which uses hybrid vehicles are all located within 2 miles of Mertz dormitory. A map showing the locations of all forms of alternative transportation is shown in Figure X of Appendix X. Additionally, there is a outdoor bike rack provided for residents which has space for approximately 20 bicycles. According to the point distribution developed by USGBC shown below, Mertz earns 15 points for this credit without any modifications to the current system.

Demonstrated reduction in conventional commuting trips	Points
10%	3
13.75%	4
17.50%	5
21.25%	6
25.00%	7
31.25%	8
37.50%	9
43.75%	10
50.00%	11
56.25%	12
62.50%	13
68.75%	14
75.00%	15

Table 1. Point Distribution for SS Credit 4

Credit 5: Site Development – Protect or Restore Open Habitat

This credit is based on the goal of "[conserving] existing natural site areas and [restoring] damages site areas to provide habitat and promote biodiversity." The main requirement for this credit is to ensure that vegetation native to the region or at least adaptable to the region composes at least 25% of the entire site area (not including the building footprint) or at least 5% of the entire site area (including the building footprint). The greater of the two values is to be used. The credit allows for achievement by means of "improving and/or maintaining off-site areas with native or adapted plants" and by means of non-vegetation natural site systems, such as "water bodies, exposed rock, unvegetated ground, or other features that are part of the historic natural landscape within the region and provide habitat value" (LEED 2009 EB: 6). In the case of the former the alternative, every 2 square feet off-site are equivalent to 1 square foot on-site.

The calculations for this credit are shown below and were determined from a determination of the approximate areas of the canopies of major plants at the site, shown on Figure X in Appendix X. What constitutes the Mertz site for the purposes of this report is clearly delineated in said figure. A ruler was used to measure the radii of the canopies as well as all sides of the building. The building area was determined to be 891 mm^2.

$$Percent\ of\ total\ area\ vegetated$$

$$=$$

= 11.05%

Or

$$Percent\ of\ total\ area\ vegetated$$

$$= \frac{total\ vegetated\ area}{total\ site\ area\ including\ building} \times 100\% \qquad [3]$$

$$= \frac{347.3\ mm^2}{4032\ mm^2}$$

$$= 8.614\%$$

From the above calculations it is clear that Equation 3 yields the better result as it satisfies the second option for fulfilling the requirement. Again no redesign is suggested for this credit as the original site design meets the necessary requirement. Mertz earns one credit for this credit.

Credit 6: Stormwater Quantity Control

This objective of this credit is to, as best as possible, maintain the natural hydrological processes of the site through such means as “reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff and eliminating contaminants.” In order to do meet this credit’s requirements, a stormwater management plan must be established that addresses runoff infiltration, collection and reuse. An alternative option is to evapotranspirate at least 15% of all precipitation that falls on-site for an average weather year as well as for the 2-year, 24-hour design storm. The credit also calls for subsequent periodic site inspection to ensure the efficacy of the management plan.

Suggestions offered by USGBC for achieving compliance with this credit’s requirements include collect and reusing stormwater for nonpotable purposes by means of alternative surfaces, including vegetated roofs and pervious pavements, or by means of nonstructural methods such as rain gardens and vegetated swales.

After a preliminary site inspection it was determined that a dry vegetated drainage swale might be a viable option for Mertz. The site’s main current stormwater control is composed of several drains on the site. In addition there a few significant mulched areas to help slow the flow of water and encourage infiltration. Unlike the drains, a drainage swale would provide the site with not only stormwater quantity control but also infiltration. Below the preliminary process for designing a drainage swale for the site is shown.

The first step in designing a drainage swale is determining the water quality treatment volume (*WQv*). This value is calculated as follows:

$$WQv = \frac{P \cdot Rv \cdot A}{12} \qquad [4]$$

where *P* is the rainfall in inches, *Rv* is the volumetric runoff coefficient and *A* is the area of the site in acres. The units of the water quality treatment volume are acre-feet. A common method for calculating *WQv* in Southeastern Pennsylvania assumes a rainfall depth of 1 inch for this formula. The area of this site as outlined in Figure X of Appendix X is calculated as approximately 1.216 acres. The volumetric runoff coefficient is determined from the following formula

$$Rv = 0.05 + 0.009(I) \qquad [5]$$

where *I* is the percentage of the site area that is impervious. The percent impervious was calculated as 22.1% using the same values for building footprint (891 mm^2) and overall site area (4032 mm^2). Plugging into Equation 5 for *I* it is determined that

$$Rv = .0520$$

Then plugging this value into Equation 5,

$$WQv = .00530 \quad acre - feet.$$

Subsequent to this initial calculation the parameters of the swale must be determined such that the *WQv* can be appropriately stored. Depending on the medium used for infiltration of the runoff and entrance of the runoff into the underdrain the drawdown time must also be determined. Finally, 2 – year and 10 – year frequencies, depths, and velocities are checked for capacity and erosive potential.

The drainage swale might be a good option for stormwater control at Mertz because it requires only a slight slope and gentle slopes can be found behind Mertz. Additionally, the drainage swale would be vegetated, thus, maintaining the beautified nature of the Mertz building surroundings. Additionally, the swale would help to manage polluted an heavily sedimented runoff from the surrounding sidewalks and driveway. The relative cheapness of construction and maintenance as well as the discouragement of long-standing water which enables soon-after rainfall mowing are added benefits.

Credit 7.1: Heat Island Reduction – Nonroof

Credit 7.2: Heat Island Reduction – Roof

Credit 8: Light Pollution Reduction

WATER EFFICIENCY

Prereq 1: Minimum Indoor Plumbing Fixture and Fitting Efficiency

Credit 1: Water Performance Measurement

Whole Building Metering

Submetering

Credit 2: Additional Indoor Plumbing Fixture and Fitting Efficiency

Credit 3: Water Efficient Landscaping

Credit 4: Cooling Tower Water Management

Chemical Management

Non-Potable Water Source Use

References:

Source for WQv -
http://www.co.berks.pa.us/planning/lib/planning/stormh2o/sacony/saconyv3-_vol_iii_appendixd_-_water_quality_analysis.pdf