Developing a Civil Engineering Site Design
(Technical Topic)

History of Green Roofs
(STS Topic)

A Thesis Prospectus
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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Civil engineers have become creative in their problem solving techniques and have used ideas inspired from historical models to build the most successful infrastructure. There are two different topics within my prospectus, the technical problem and the STS research. The technical problem articulates the challenges with creating a civil engineering site design to best meet the needs of the user and the wants of the stakeholders while dealing with difficult terrain. The STS research focuses on green roofs and takes inspiration from the history of this sustainable infrastructure to create innovation in the future in civil engineering uses. The term "green roof" is used to describe any flat or sloped "roof with a layer of plant material" (EPA). The term is broad, as green roofs have taken many forms and materials throughout time.

Humans have used their environment to satisfy their needs. Green Roofs were first developed to increase heat retention or mitigate heat depending on the climates, but have further developed so the benefits include stormwater management, increased biodiversity, ecologic benefits, and cost benefits (Getter et al, 2006). Green roofs have taken many forms, from sod houses to stepped terraces, on a global scale through history, and used for a variety of purposes (Shafique et al,. 2018). For green roofs to have the biggest impact, identifying the most effective aspect of each design will allow for future developments to meet the needs of the civilization (Bevilacqua, 2021). The complexity and challenges of green roofs throughout history parallel those of creating a civil engineering site plan, where the designer is attempting to control the natural landscape. Additionally, green infrastructure is an essential part of civil engineering designs, and understanding green roofs and their strengths will allow the use of green design in projects to be more successful. The technical project will discuss the multifaceted challenges of designing a community building on rough terrain. Understanding how communities implemented

green roofs to mitigate different environmental and economic problems can be used when attempting to integrate the rigid ecosystem into the building design and terrain changes.

Technical Topic

Piedmont Virginia Community College (PVCC) is a comprehensive, public institution of higher education that awards associate degrees and certificates, and that "seeks to be a leader and innovator in post-secondary education" (*Mission and Goals | Piedmont Virginia Community College*, 2018). PVCC is looking to expand their campus with a new building and parking lot that will be developed on their empty land off of College Drive, shown in green in Figure 1.

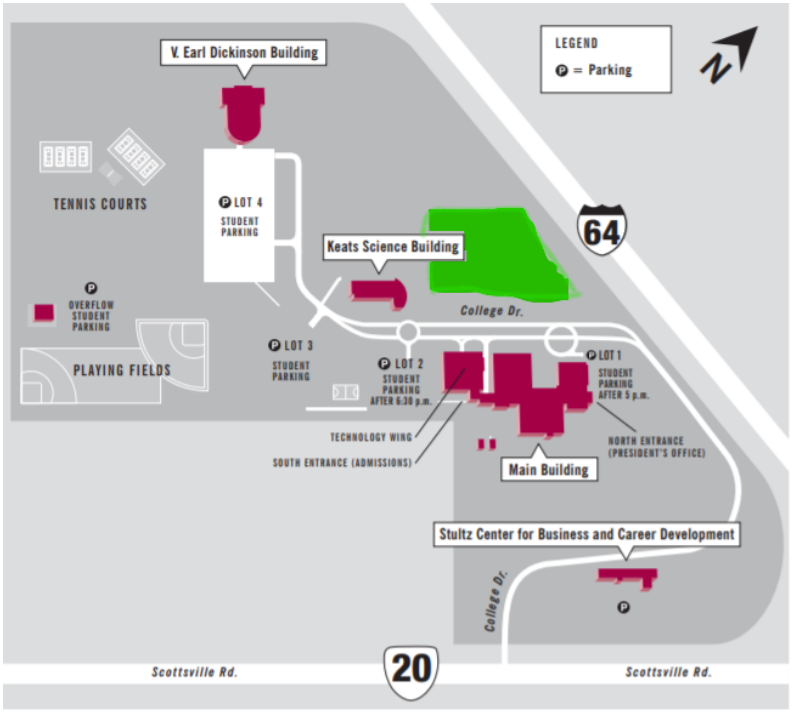

Figure 1: Campus Map (*Main Campus Map*, 2018).

This building will serve as the welcoming hub of the campus, as it houses many administrative offices and will be one of the first things that people see upon arrival. The addition of a welcome building will benefit new students by serving as an informational hub as they get oriented on campus and will be the first point of contact for any visitors. This building

will also serve as part of the technology center for PVCC and will house both labs and collaborative work spaces. In addition to indoor spaces, the design will allow outdoor, undeveloped spaces to be utilized as outdoor classrooms, recreational spaces, and connections to other parts of campus.

One challenge with the design is that the site has a large slope from College Drive down to the undeveloped site. Developing a building on a site that has steep grades, or abrupt changes in elevation over a short horizontal distance, means it must be properly graded to meet regulations for maximum slopes and accessibility, mandated by design codes and the Americans with Disabilities Act (ADA) respectively.

As the campus is currently laid out, there is no main welcoming building for PVCC. The main building that exists now is large and consists of a variety of classrooms, auditoriums, labs, libraries, lounges, etc. It is mostly an academic building and has little space for administrative and welcoming services (About PVCC | Piedmont Virginia Community College, 2018). The parking lots next to this building are only available to students after the standard work day is over (*Main Campus Map*, 2018). This means that the building is harder for students to access during normal working hours because there is no readily available parking close to the building. The new building that is being developed will include an accompanying parking lot with 100 parking spaces. This will make it easier for students, visitors, faculty, and staff to access and use the resources provided by this new building.

A challenging aspect of this project is the task of pleasing all of the stakeholders. There are many stakeholders involved with this project that include the owners of PVCC; the Commonwealth of Virginia, as most of the funding for this project is coming from the state; the Virginia Department of Transportation (VDOT), as they maintain the roads for this site and have

a say in what gets developed; the users at PVCC, which include current and future faculty, staff, and students; and environmentalists as well as other land-specific stakeholders for the site. For this particular project, we primarily have to please those who are funding it, but a main priority is to create a design that incorporates the needs and wants of the students to ensure that they feel comfortable using the new space. Most sites value cost over user experience, but for this project, we want to ensure that the user experience is the best it can be even if it is more costly.

In the as-built condition, there is no welcoming area for students, faculty, staff, or prospective students. There is no defined and easily-accessible area for students to inquire about resources available to them and more general information about the school. By creating a new building at the entrance of the PVCC campus, everyone entering the site will be guided directly to the information they need. Adding a new building on this undeveloped land also allows students to use new spaces on campus, especially as this new building has collaborative spaces, labs, and new academic resources for students.

My team will use land development engineering to design the site to make it suitable for a new building and parking lot. This will include the grading of the site, proper management of stormwater, routing of various utilities, and the implementation of accessibility to the rest of the campus through new infrastructure and sidewalks. This will be done by using information from the client to ensure their needs are met, as well as looking at all the other stakeholders and trying to please everyone involved. We will also work with a local engineering firm (Draper Aden and Associates), local architect (VMDO), and utilize our technical knowledge learned from previous internships and classes to aid with the site design for this project.

STS Topic

The earliest green roofs date back to 600 BCE and the designs have been changing and improving ever since. Though purposes were diverse, the fundamentals of using the environment to improve societies remained the same through place and time. A technical description of a green roof can be defined as a "human-made establishment product on the roof of a house, including erecting a structural framework with appropriate mechanical strength" with "naturalistic or self-established vegetation" (Abass et al., 2020). Studying the history of green roofs helps define the purpose of the design, economically, socially, and functionally, allowing future designs of green roofs to be most effective to meet the current needs.

Green roofs were originally created to help with temperature control. The first recorded green roofs were found in Mesopotamia where the religious buildings, known as the ziggurats, included trees and shrubs on terraces at 600 BCE. The ziggurats were large stone pyramids that stepped, and the vegetation served to decrease the amounts of the heat contained by the large objects (Osmundson, 1999). In places like France and Canada, with colder climates, the vegetation was used as a thermal layer in the walls or on the roof to trap the heat, which is where the first sod roof can be found.

During the Renaissance and Middle ages, Europe became a center for improvements for green roofs, although not entirely on purpose. Germany experienced rapid industrialization in the 1880s, and flammable tar was used as roofing due to the inexpensive nature of the material. However, the fire hazard was recognized and sand and gravel were implemented on the roofs, where grass grew due to the natural process of plant colonization of the area (Köhler et al., 2002). In Tuscany, where the oldest urban green roofs still remains, the integrated gardens were made to mimic the natural environments for the aristocratic residents. The Guinigi Tower, with

the oldest roof garden, was built as a symbol of wealth and power by the Guingi family, with Holm Oak trees planted on top, as the highest point in the city for all to see (Jim, 2007). This use of plants as a privilege symbol contrasts the functional approach that is seen with most other green roofs. The most prominent historical use of green roofs in America was during the mast migration west, directly after the Homestead Act of 1862 (Jim, 2007). Due to the shortage of timber and stones, sod was matted together to mimic a brick, which was used for the roof and walls, to keep the inside of the structure warm and dry. While these early buildings were not seen as technologically advanced, the use of the environment in the design still created benefits for the users.

Modern green roofs are based on scientific testing and developed for stormwater management, heat mitigation, and aesthetics, intentionally designed to use vegetation to fit the desired needs on the building based on geographic location and setting. The modernization of the green roof occurred around the 1970s, although specific examples that meet that criteria were seen earlier, such as the green roof Rockefeller Center in New York City built in 1930. Additionally, guidelines for the support of green roofs have been implemented globally, such as LEED in the United States (Kilbert et al., 2002). Some notable examples of the most effective green roofs range from London to Chicago, where different strategies have been implemented, including relocation ecology, drainage systems, and noise barriers, to mitigate the negative effects caused in cities (Oberndorfer et al., 2007). In London, a combined vegetated and solar roofs, called biosolar roofs, were installed in Queen Olympic park in attempts to enhance biodiversity within urban areas and increase energy efficiency in the building. The roof included native plant species and used biomimicry in the design, which attempts to mimic regionally important habitats (Nash et al., 2016). Chicago used a method of diversifying plant species on

the green roofs in Millennium Park, to mitigate heat and prevent urban heat islands in the city (McConnell et al., 2021). The technology created today uses these historical models as inspiration for current society.

The history of green roofs will be explored in relation to the needs of society at the time and how the creativity from the past can improve the innovation for the future. Richard White's *The Organic Machine* demonstrates the complex relationship between humans and their environment through civilizations's manipulation of the Columbia River throughout history, to fit the demands of the community. White's analysis of the environment as a source of energy creates a framework for understanding and assessing the historical interaction between people and their environment, which will be used to evaluate green roofs. A specific use of the environment on green roofs is the reduction of stormwater runoff which will reduce the fluctuation of flooding in urban areas (Mentens et al,. 2006). The plant's "power" is harnessed and used for the needs of the community within the city. The purpose of this paper is to understand how sustainable infrastructure developed throughout time and impacted cultures laying the groundwork for the innovations used today. The influence of green roofs will be analyzed through the lens created by Richard White, in *The Organic Machine,* to view the relationship between humans and their use of the environment.

Conclusion

Civil engineering designs take creativity and inspiration from history to improve the community in which the design is implemented. The technical proposal will focus on the challenges of creating a design that both serves the needs of the community and faces difficult technical challenges in the design process, using a land development perspective. The STS prospectus will analyze the significance of green roofs in society throughout history through the

framework laid out in White's *The Organic Machine*. Green roofs have evolved through time, changing in size and ability, creating opportunities for future innovations to help combat future challenges. By understanding the past, the issues faced by civil engineers will be solved more efficiently and effectively to improve society.

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