On Boston College

The College of Arts and Science

Environmental Studies Program

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Abstract:

This research paper aims at reviewing the sustainability of the new recreational facility on lower Boston College campus, in order to determine if the building is a good candidate for a green roof. As the Boston College campus continues to grow, we believe it is imperative to explore sustainable development and implement energy saving, environmentally friendly infrastructure. A green roof system is an extension of an already existing roof. Green roofs are proven to provide natural heat and cooling insulation, support stormwater drainage and stormwater storage, increase air quality, stimulate biodiversity in urban areas, and most importantly provide opportunities for social gathering and environmental education. In this paper the researchers focused on three areas of sustainable development: potential economic incentives, whether or not green roofs will have a positive effect on the well being of the Boston College community, and what design will work best for the current infrastructure. In order to answer these questions, we collected data from case studies, conducted a survey in order to gather information on the Boston College community, and met with architects involved with the construction of the new Margot Connell Recreation Complex. Once the data was compiled, the researchers determined that a green roof would not have a significant effect on utility costs from heating and cooling. However, evidence suggested a green roof would reduce flooding in lower campus, provide natural fire retardation, increase local biodiversity, and provide a safe space for students and faculty to interact and socialize. It is recommended that the results of this study and the proposed green roof plan are considered by the Construction Managers and the Office of Sustainability.

Keywords: green roof, flooding, rainwater harvesting

Introduction

Figure 1: Boston College prior to 1957

Founded in 1863, Boston College has been a constantly changing and expanding university. Before 1957

requires the most amount of attention. The plants must be watered and fertilized until they are matured. After the first year the only maintenance required is a couple of visits a year to weed and perform safety inspections.

In a study conducted by H.F Castleton, a thorough investigation determined the potential benefits and risks of green roof infrastructure. The study discussed the potential benefits of green roofs with regards to reduction of energy use through better insulation, density and moisture content (Castleton 2010). The review begins by explaining how green roofs largely reduce the proportion of solar radiation that reaches the roof structure and offer increased insulation value. This feature is incredibly valuable as buildings account for around half of primary energy consumption, emphasizing their contribution of CO2 emissions (Castleton, 2010). The insulating effect was determined to be the most significant in both the summer and winter months, however, the article points out that these energy savings are most realized by older buildings that lack the density of modern infrastructure. As you can see from the figure below, modern, well-insulated roofs save around 2% annually from the implementation of a green roof. On the other hand, the older, non-insulated buildings saved from 31-44% a year (Castleton, 2010). This was particularly important for our study, as the Margot Connell Recreation Complex will be a state of the art facility. As a result, the energy savings from implementing a green roof should not be considered important to this study when compared to other social, environmental and economic benefits.

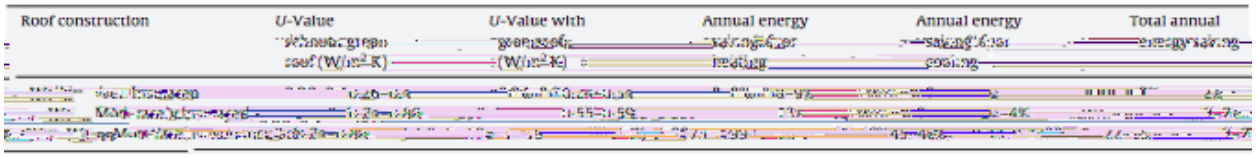

Figure 2: Energy savings with and without a green roof between well, moderately and non insulated buildings (Castleton, 2010).

A recent pap

spaces have shown to help adolescents escape stress and develop social capacities. They have also proven to be a great space to build positive emotions and self esteem (D. Li, 2018). They wanted to more closely examine this linkage. In order to examine the effect nature has on mood,

they first used satellite images and Google Street View to appropriately assess the concentration of nature in a certain area (D. Li, 2018). Further, to evaluate mood disturbances in the individuals

a global measure of feeli

While this study was conducted on adolescents, we believe its implications still apply at Boston College. Most college students are legal adults, however, mental health is still a big concern at Boston College and other universities. We believe that this study represents how a green roof can have an incredibly positive effect on the mood of our fellow classmates.

In addition to collecting data on the sociological and economic effects of green roofs, it was important we studied different types of green roof structures in order to determine what system would be best suited for the proposed area. We consulted Green Roofs For Healthy Cities, a non-profit professional industry organization, in order to understand the building standards and associated risks of green roof structures. The organization provided plans and insight as to how to specifically prevent wind damage, an impending threat to the new recreation facility, and provided us with design plans intended to optimize the efficiency of green roof structures.

In order to determine what type of green roof structure, extensive or intensive, we consulted the journal, *Renewable and Sustainable Energy Reviews*. This journal provided us with general design considerations and system requirements. In the article, *Wind Design Standard for vegetative Roofing Systems*, the author argues all vegetative roofing systems shall comply with the following: roof structure, building height, slope, positive pressure building systems (HVAC equipment), roof top projections, membrane requirements, membrane perimeter and angle change attachment, parapet height, and threat of wind erosion (Green Roofs For Healthy Cities, 2016). Using the data they collected from their own studies, we were able to consider all the elements a proposed roof must have in order to withstand a green roof structure. This data drew brought us to our conclusion: the new recreation facility, with 80,000 sq/ft of available flat roof space, would be the best location for a low maintenance, high efficiency green roof.

The General Services Administration (GSA) published a report to compare costs of green roofs with the benefits they provide. This cost benefit analysis gave us information to ensure that implementing a green roof on the Boston College campus would be beneficial. It also gave insight into evaluating if a green roof would be a sound economic investment for Boston College. As previously mentioned green roofs on newer buildings have a very slim margin for cost saving when it comes to heating and cooling, because of technological advancements that have enhanced the quality of insulation. That being said, our main focus for examining economic benefits is measured through long term savings that a green roof provides. Green roofs are

typically $10.30 to $12.50 more expensive per square-foot than conventional black roofs, but the cost per square-foot decreases as the size of the roof increases (GSA, 2011). Although green roofs cost more to install than a traditional roof, they tend to have a longer lifespan and do need renovations as frequently. Another long term benefit of incorporating a green roof is its capacity to retain water. Having this design helps to manage the damage stormwater can cause, which will be effective in reducing the costs to fix infrastructure over time.

Figure 5

roofs, and domestic homes. We then focused our research on the cost benefit analysis of green roof systems, using the Net Present Value Model (NPV) (Castleton, 2010). This model takes in the Life Cycle Cost (LCC) and compares it to that of conventional flat roof systems, both black

project and is discounted back to a one single price relative to the present day using the present alculating the NPV we have to consider the following: roof age, area, total costs including watering, vegetation and other material costs, average maintenance cost per year, and technology repairs (mechanical repairs, plumbing repairs, and labor costs). The United States General Services Administration, determines the green roof NPV using a 4.4% interest rate over a period of 50 years (Castleton, 2010). In addition to the NPV model, we then focused on our attention on the potential for long term investments like municipal uses such as stormwater management and stormwater storage.

In order to determine the feasibility of this project we spoke with architects, construction site managers, and botanists. The lead project manager of the upcoming Margot Connell Recreation Facility gave us a tour of the construction site, which we concluded would be the best building on campus to implement a green roof structure. In addition, he shared construction blueprints, which allowed us to analyze the slope of the roof, the space and access points (See Figure 12 &13). With the blue prints we were able to determine what type of green roof, intensive or extensive, would work best for the existing building. Lastly, we spoke with architects and botanists, in addition to collecting online research, in order to understand what vegetative species would work best for the given environment, and how to make the proposed green roof low maintenance and cost effective.

Results

Economic Conclusions

Through extensive research, and consideration to the Net Present Value Model and the Life Cost Cycle, we concluded that green roof systems have significantly larger upfront costs than a conventional roof. However, this conclusion was expected. When considering the energy saving benefits of green roofs, our data was less conclusive. For example, energy saving benefits are dependent on the climate, substrate thickness, location in accordance to the sun, vegetation type, building age, and local utility rates (Kantor, 2017). Because the Margot Connell Recreation

facility is still under construction we were unable to determine whether or not a green roof would have a significant impact on overall energy consumption. In addition, because the building is brand new, it is built to the best standards, and already has energy efficient heating and cooling systems in place. Therefore, we have reached the conclusion that a green roof would not cause a significant reduction in energy for heating and cooling.

Despite reaching the conclusion that a green roof on the new recreation facility will not reduce utility costs, we did discover there are significant municipal incentives associated with green roof systems. We elaborate more on this theory in the discussion section.

Green Roof Design Conclusions

We have concluded that an extensive green roof, rather than an intensive green roof, is recommended for the new recreation facility on lower campus. An extensive green roof has a

our recommendation due to the fact that extensive green roof structures are lightweight and low maintenance. In comparison, an intensive green roof structure has a deeper substrate layer in order to allow deep rooting plants like trees and shrubs. Figure 6 illustrates the required elements of an extensive green roof. In our proposal we recommend sedum vegetation and native grasses. Sedum are low maintenance, low lying plants, that offer coverages and roof membrane protection (Castleton, 2010). It is imperative that the vegetation we propose is able to withstand the elements, specifically wind exposure. There are reported cases of green roofs falling apart when exposed to extreme weather. However, Sedum landscaping will help avoid these complications.

According to the Green Roof Center, an extensive green roof system costs between $67.29 and $112 per m^2

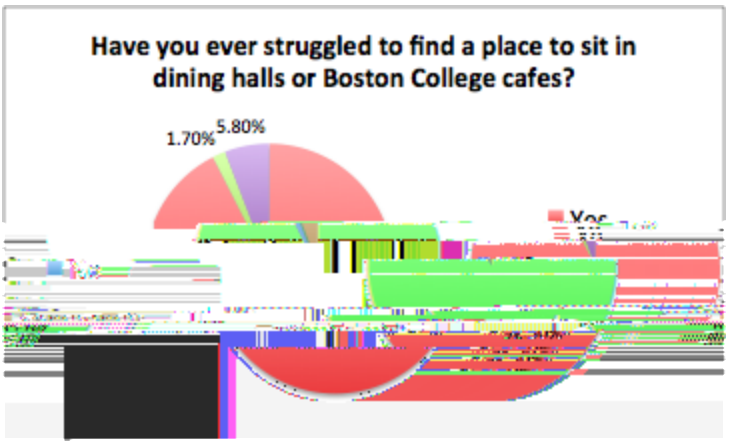

Figure 7

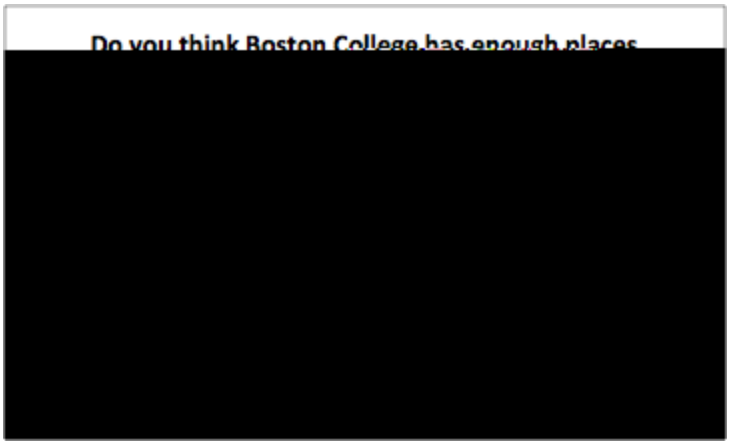

Figure 8

Our survey also showed a clear need for more outdoor space. Students preferred to socialize outdoors relative to other locations on campus. 47.5% of our sample population stated that the outdoors was their favorite place to hangout with friends. See figure 9 below.

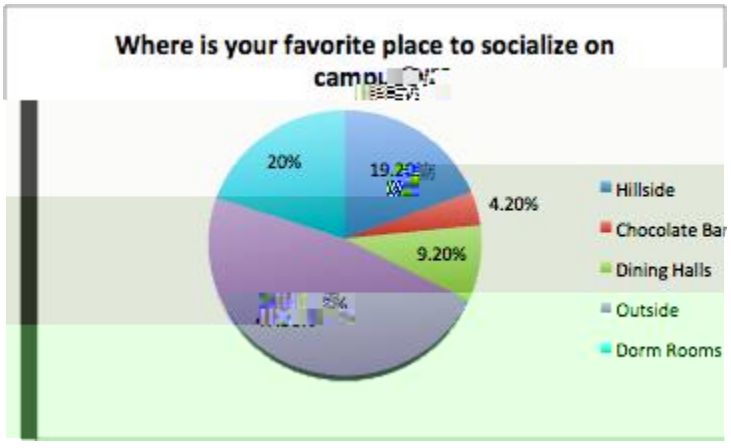

Figure 9

While 45.8% of the students surveyed did not know what a green roof was, once given a brief description they had good perceptions of the idea. Over 75% of students surveyed thought that green roofs improve air quality, energy efficiency, well being and are a good economic investment. See figure 10 below.

Figure 10

Lastly, 94.2% of our survey participants believed that Boston College should build a Green Roof on campus that is accessible to students. From looking at figure 11 below, you can

Figure 11

Discussion

Social/Survey

Our survey made it clear to us that a green roof on the new Margot Connell Recreation Complex would not only be accepted by students, but also widely encouraged. Our results show r need for additional social spaces, especially ones outdoors. Students already

go to the recreation complex to get away from schoolwork it would be an even better escape if they could also relax with friends in a green space. In addition to being a new fitness center, the Margot Connell building also includes lounge areas, kitchen space, and classrooms. Although the building will provide plenty of indoor space, we believe including an accessible outdoor area for

In addition to selecting the area for a green roof structure, we consulted the Green Roofs Healthy City Organization to collect data from cases and experts to determine what additional infrastructure is required for green roofs. As seen in Figure 6, an extensive green roof requires the following materials (from the top down): vegetation, growth substrate, filter layer, drainage layer, and a waterproofing layer with root barrier. Taking into account extreme weather conditions, it is critical that the vegetation planted on the roof can withstand drought and flooding, provides good ground coverage, requires low maintenance and no irrigation system, has rapid multiplication, and short soft roots. As mentioned in the results section, the best species for the proposed green roof is a combination of Sedum and native grasses. One benefit from Sedum is the species has soft roots, therefore the risk of root penetration and infrastructure damage is significantly reduced. While Sedum is able to withstand drought, we recognize

species on green roofs maximizes efficiency and durability (Vijayaraghavan, 2015). Therefore, in addition to Sedum, we suggest planting a variety of grass species that thrive in the local climate. In addition, incorporating native landscaping will increase biodiversity, and provide an ecosystem for native invertebrates and bird species.

One draw back from Sedum, is its inability to store excess water (Vijayaraghavan, 2015). However, the existing sloped roof on the recreation facility, allows excess water to collect in one area. In order to manage stormwater, we recommend installing an rainwater harvesting system to make use of the excess water collected by the roof. This water then has the ability to be used in a variety of ways on campus. The collected water can be purified and used as drinking water, or in toilets, or used for crop irrigation on campus. Boston College is known for priding themselves on their vast amounts of luscious green grass, but the grass doesn't just look that way on its own, it requires extensive maintenance. This maintenance requires a massive amount of water to be used, leading to Boston College having a very high water footprint. Irrigation is known to be the biggest consumer of the freshwater we have available, more specifically it expands approximately 70% of the freshwater worldwide. Water is not an expendable resource, so it is important for Boston College to do its part to reduce its water consumption. By using the water from the rainwater harvesting system we will not only alleviate pressure on local municipal

environmental water footprint.

Figure 12: Blueprints of the Boston College New Recreation Center from a birds eye view. The areas in yellow are potential areas for an extensive roof structure. In the center of the blueprint is the pent house which has roof access and holds mechanical equipment.

Figure 13: Blueprints of the new Boston College Recreation Center from a side view

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also important to note that if fertilizer has to be used it should be organic. Organic fertilizer helps reduce excess nutrients from entering and polluting our watersheds. The other benefit of organic fertilizer is that as the water that isn't absorbed by the green roof makes its way into the drinking water if it became necessary.

The advantage of extensive green roofs is that they require little to no maintenance, but massive role in how well it functions. To ensure it is kept clean and in prime condition there would need to be people to check in and support its growth. This provides an opportunity for environmental clubs on campus to incorporate tending to it as part of the clubs mission. We

In addition, we believe there is a potential opportunity to dedicate part of the roof to a communal gardening site. We believe gardening not only has the power to bring people together, but it also encourages students and faculty to interact with their food and nature. Sustainability clubs, like UGBC Environmental Caucus, and BC EcoPledge, can adopt a portion of the green roof in addition to holding educational events and conversations. This space has the ability to educate the community about the crisis our planet is facing as we continue to ignore how our lifestyle impacts our fragile ecosystems, and spark a conversation among peers that could result in more green initiatives being incorporated on campus.

While this study analyzes the benefits of green roof structures, we realize there are areas for further study. Our study is based on projected models, and a building under construction. We were unable to determine the current energy consumption, and compare it to what it could be with a green roof structure. However, throughout our research we concluded that the largest economic incentive is municipal water storage and flooding management. We recommended implementing a water collection system that would provide opportunity for recycled water and greywater systems. Further research is required to analyze how that system would be implemented.

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