The Lafayette Gardens

1st Draft of Final Report

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Lafayette Gardens Vignettes

Introduction

The Lafayette Gardens is a space of education, recreation, and place making for any member of the Lafayette College community, past, present, and future. Designed by a team of Engineering Studies students, the proposed layout implements a combination of artistic, technological, and environmental aspects as a way to display Lafayette College's interdisciplinary approach to education and the liberal arts. For anyone making their way towards Acopian Engineering Center, the Lafayette Gardens will become an eye-catching location that is filled with plants and seating areas, lined by a border of spires, and features a large living wall that runs across the northeast wall of the building's brick exterior. And while this unique design may be different from the rest of the infrastructure on campus, its motivation falls perfectly in line with two of Lafayette College's core values: sustainability and inclusion.

Anthropogenic climate change is a major concern in today's society due to the threats it poses to biodiversity, human health, and the current environment. Human activity since the industrial period has released high quantities of carbon dioxide and other greenhouse gases in the atmosphere, especially through the burning of fossil fuels, resulting in the deeply troubling increases in global temperatures. Many organizations and policy makers are taking steps to reduce problematic emissions by encouraging the transition to cleaner sources of energy and less wasteful behavior. Colleges and universities are among these climate actors, showing their support by developing climate action plans and promises to go carbon neutral in the near future. Lafayette College has been part of this movement for several years, and in 2019, the Office of Sustainability produced an updated climate action plan with the goal to achieve carbon neutrality by the year 2035 (2019 Climate Action Plan, 2019). While the construction of a living wall, or the Lafayette Gardens as a whole, was not part of this outlined plan, it will still play a significant role in the effort to make the campus more sustainable. According to the journal article "Green Facades and Living walls – A Review Establishing the Classification of Construction Types and Mapping the Benefits", green structures are associated with numerous benefits including air quality improvement, carbon sequestration capabilities, aesthetics, biodiversity and habitat assistance, better energy efficiency, educational opportunities, sound mitigation, and human health benefits (Radić et al., 2). As explained in the article, there are multiple types of vertical structures, but unlike a green façade, which is when plants start from the ground and grow up a wall, a living wall specifically refers to a structure where plants grow off of the wall and associated support system. In the early stages of the project, the team looked at numerous locations that already have constructed successful living walls including Georgetown University, Colorado State University, and Simon Frasier University (7 Schools that are Home to Green Walls, 2017), in order to grasp a scope of the work and the full capabilities of the structure. By expanding the benefits of the wall into the surrounding space through the use of gardens for pollinators, the Lafayette Gardens will be capable of assisting the Climate Action Plan in its quest to improve air quality and biodiversity, while also reducing carbon dioxide in the atmosphere, creating another miniature model of what sustainability looks like on Lafayette College's campus.

The integrative design of the Lafayette Gardens was developed over the duration of the fourteen-week semester in the spring of 2020, but the idea of combining art and the environment into an engineering setting did not originate from this project. Engineering Studies (EGRS) is a unique major offered at Lafayette College that joins the engineering mindset with a liberal arts education, giving students the chance to develop skills necessary to approach problems in technical as well as economic, environmental, social, and political contexts. As with all majors, EGRS requires its seniors to complete a capstone project, in this case one that encourages students to realize how engineering impacts society through solving a problem specific to Lafayette. In 2017 and 2018, two different EGRS capstone groups attempted to develop solutions that addressed the negative atmosphere associated with Acopian Engineering Center. Both teams found that Acopian is perceived as a stressful and intimidating

environment by both engineering and non-engineering majors. Many of the surveyed students reported that the competitive atmosphere within the engineering community increases stress for individuals in the major and creates a divide from non-engineers whose own efforts are sometimes written off as being easier or incomparable to the engineering workload (Blake et al., 2017 and Guarana et al., 2018). Unsurprisingly this atmosphere creates an unwelcome feeling in the communal building, thus in an attempt to relieve this negative tension the capstone teams proposed altering the existing space through the inclusion of art which is known to have the ability to both reduce stress and change the associations within the building. While the 2017 capstone group looked at creating a river design in the main stairwell, the 2018 group focused their efforts on the northeast wall, proposing the use of a mural, light art, or a living wall on the bare exterior. Both of the teams proposed solutions that applied art in a manner that mixed well with the engineering ideals as a way to show that Acopoian is a place for all disciplines to work together. By looking at their analyses and solutions, the project team for the Lafayette Gardens was able to expand on their ideas and develop a full design that incorporated the inclusivity goal.

While the capstone teams consisted only of senior Engineering Studies majors, the project team is made up of a small class section of the Sustainable Solutions course. This elective is an upper level Engineering Studies class that is open to all majors, It takes a real-world problem and requires the students to develop a solution, which in the case of the Spring 2020 class, focused on the plan to improve the atmosphere of Acopian Engineering Center. The project team, referred to as Greening Acopian at times, consisted of six individuals: Professor Cohen, Dominique (Nika) Cinicola, Bryce Currie, Diana De La Torre, Major Jordan, and Lisa Sholtz, each of whom had a specific role that that was essential to the development of the final project. The team's acting Project Manager and course adviser was Professor Cohen. Having been the professor in charge of senior capstones in the past, he was familiar with the idea of integrating art and the environment into Acopian. In his role, he assisted in key communications with various resources on campus, ran the weekly meetings, and provided suggestions on the overall design. Nika Cinicola was the Communications Director, a role that required her to focus on organizing meetings, presentations, the final report, and the Greening Acopian website. Bryce Currie acted as the Chief Economist where he worked on determining the overall cost of the Lafayette Gardens. By working with Professor Liu in the Economics Department, as well as contacts from potential vendors, Currie developed a cost estimate that accounted for both financial and non-financial attributes. A survey was created during the semester for the purpose of assessing the potential non-financial benefits, but due to unforeseen circumstances was not distributed to the Lafayette community. The role of Environmental and Sustainable Engineer was taken on by Diana De La Torre. Throughout the semester, she investigated ways to ensure that the space became one for both the college community and the various living organisms that will interact with it. She looked specifically at the possibility of incorporating native plants and bat boxes on the living wall to help increase biodiversity and also determined the plant types that will be used in the surrounding pollinator gardens. Major Jordan took on the role of the Structural Engineer where he was responsible for determining the various structural aspects for the proposed design and ensuring that the final structure will be both structurally sound and financially feasible. His role has thus involved accounting for all necessary parts of the structure, calculating the stress and load of the structure, and ensuring that the proper procedures for installment are outlined. Lastly, Lisa Sholtz was the team's Artistic Design Director and was responsible for developing the visual components of the project in a way that created a cohesive space that will be aesthetically appealing, practical, sustainable, and feasible. Sholtz has been in charge of creating a complete design plan for the Lafayette Gardens, as well as developing a computer-generated rendering of the final design. Together, this six person team brought into reality a design that has the capacity of improving the atmosphere associated with Acopian. Through the assistance of on-campus resources, especially Professor Mary Wilford-Hunt, Professor Joe Biondo, Professor Jim Toia, and Professor Scott Hummel, the project team was able to develop an entirely unique and beneficial space for the Lafayette campus. While the project scope may have started off small, with the team looking only at the wall itself, it gradually expanded to include the surrounding ground space

thus creating a collaborative space for community members of all different disciplines and interests to interact and learn.

Design

As the project progressed, it quickly became clear that to facilitate interaction between students of all areas on campus the project would have to be composed of more than just additions to the wall of the Acopian Engineering Center. In order to facilitate interaction, a communal space was needed to supplement a living wall. The proposal incorporates design elements that will make the Lafayette Gardens a space that students of all majors, faculty, and visiting families will seek out.

The design proposal is divided into four component areas: the wall, triangle, spires and wires, and the ground surface.

Literature Review

Wall

Initially, a number of art forms were considered to incorporate into the wall design. These included light, painting, fabric, and plants. Quickly plants stood out as the art form to proceed with.

Once the decision was made to proceed with incorporating plants into the wall design, the next consideration was if these should be in the form of a green facade or a living wall. Both systems would achieve our goal of bringing greenery to the area but in different ways. A green facade often uses a trellis system which allows climbing plants to climb and cover the wall. To achieve a living wall there is a wide variety of structures available that incorporate soil and irrigation into the wall, so plants can grow in containers off of the wall.

From a design perspective, the big attraction that a living wall offers, over a trellis system, is the ability to incorporate patterns into the wall. A living wall system exponentially expands the plant choice options that are able to grow. A trellis system would have limited the plant choice to vines and strictly vertical patterns. With a living wall system, the design can incorporate a wide variety of plants which can be arranged in various patterns on the wall.

The next consideration was how much of the wall to cover in a living wall and what shape we wanted the structure to take. Four different orientations were considered: vertical stripes, horizontal stripes, diagonal stripes, and an abnormal shape that represents engineering. Ultimately, the decision came down to what would be the most technically feasible. We determined vertical stripes, between each column of windows, would simplify irrigation, attachment points, and maintain some visibility of brick. Maintaining some of the brick on the wall will tie the building into the surrounding campus. Then, to break the linearity of vertical stripes, careful plant choice selection will add color and pattern to the design.

Triangle

Upon initial observations of the wall, the large triangular concrete block stuck out as an was not being artistically utilized in any way. Currently, the face is a blank canvas and would be a logical area and great opportunity to add another artistic component into our design. The concrete triangle sits between the brick portion of Acopian and the grass hillside, which makes it an artistic opportunity to transition between the living wall and the grassy area.

A variety of different options for the triangle section of the wall. These included plants, a mural, or writing in the form of a free speech wall. The decision was made maximize the number of stakeholders as possible in the space. The triangle is a blank canvas and would be a great location to feature another big audience of the space, admissions! The mural will creatively express the school motto, Cur Non: Why not you? Why not here? Why not now? Once the project progresses to the next stage, we believe the space would be a great way to feature a student or local artist. The exact visuals of the mural will be defined when an artist is selected.

Spires and Wires

In order to meet the project definition of creating a multidimensional collaborative space, the team determined that the design would have to physically define the space, so it feels like a destination to visit. In order to do this, incorporating spires and wires into the space will provide the physical definition.

Spires

For the spires, incorporating six curving spires into the space will add an artistic statement to the space while still providing definition to the space. Then, arranging the spires in a snake-like pattern curving along the road will combat any fence-like feelings to maintain the area as an inviting space. The six spires represent the six different disciplines of Engineering at Lafayette. Increasing the height of the wires as the hill slopes down will scale the space down to create a welcoming entrance while opening up the space as the user enters.

Wires

The wires will create the idea of an enclosed space without actually closing off the space. Selecting a thin 1/8th inch wire will allow vines to grow across the space while minimizing the weight of the load that the wall and spires will have to carry. There are nine attachments on the wall, within the living wall sections, and six wires to attach to. So, a 3-1-3-3-1-3 pattern to balance symmetry and enough wires to provide a semi-enclosed feeling.

Ground Surface

What are the various pieces being incorporated into the space? Why?

Once the scope of the space was established, the team focused on maximizing the functionality of the area and aligning it with the sustainability initiatives of the College. There are three additional primary components within the ground surface plane: a stepping stone pathway, native plant gardens, and seating.

Path

One of the current primary uses of the space is to provide a pathway for students traveling down to the sports complex. This is apparent by the worn grass path in the existing landscape. The design proposal includes the pathway as an intentional and functional component of the space. As there is a sidewalk on the other side of the road leading down to the parking deck, a stepping stone path is the best way to create an intentional, but informal, pathway. PA Blue Stone will tie the space into its surroundings by connecting the space to Skillman Library and use a locally sourced material.

Gardens

Adding native plants to the ground level will maximize the positive environmental impact the space has. This will provide critical habitats for pollinators. Aesthetically, the plants will add color and texture to the space.

Seating

To further solidify the purpose of the space, there are two forms of seating in the space. Adirondack chairs will provide comfortable seating and tie into the aesthetics of campus, as they are sprinkled across the quad and various courtyards. Further, two terracing notches will function and appear like a small amphitheater. Constructing this out of PA Blue Stone will create further unity in the space.

Structural

This chapter explains the fundamental building blocks of the Lafayette Gardens project. This section explains the process of selecting the company and material for the living wall, spires, and wires. The chapter also further analyzes the final selected products and the reasonings for choosing them. It analyzes the final components of the living wall, spires, and wires to ensure safety and structural integrity. Lastly, the chapter provides basic calculations on the three various structures using basic structural engineering calculations. To ensure further safety, refer to each structure's spec sheet on their website for more information.

Literature and Sources

_____Information was recorded using the internet to find various companies for the living wall project. Living wall technology and companies have recently scattered across the United States, so the objective was to find a reliable and professional company for the job. This company must be reliable in terms of the structure of the living wall and the irrigation system that supplies water. For the wires, information was founded using the internet. Internet sources being used were US cargo control and Knot and Rope. The design required a wire and a rope that would connect from a spire at one end of the open space to the living wall at the other end of the space. As a result, the wire or rope that was selected must be sturdy and structural supportive of the elements it may experience like snow or rain. The spires for the project were very similar to the remaining components. All information gathered was from the internet. Research began with using the Light Poles Plus website to gain fundamental background information for material used for these spires. Light Poles Plus is a certified company that provides sustainable poles for municipalities in the United States. After gaining the basic knowledge, Valmont Structures was a company that provided the aesthetically pleasing and abstract design we desired. So further information was gathered using Valmont Structures to find the spire necessary for the project.

Structures for Living Wall

Structure material for living walls were founded using the internet. With the rise of this new technology, the goal was to acquire a company with professional material to ensure the safety of the Acopian building and the people near it.

Grow up was one of the candidates for the living wall structure. It can be used from a small scale project to a very large project. Making the system very flexible to use and meet requirements. The system includes a water tank that is on the ground that holds and contains the water. This can be a problem based on our design standards and how we may go about the project. Will the project start at the bottom of the wall and go up, we also mentioned the design to go across horizontally, so this will be a design that can be considered based on our design standards. The system includes a pump for irrigation purposes to keep the tank full of water. Next is the vertical rails, its main purpose is to provide a connection component for the pots to adhere to the wall. Once again, our design standards can determine which way the vertical rails are installed. The next component is the pots which will be used to connect to the rails and be the main feature of the structural process. This is where the plants will be placed, specifically inside these pots. The irrigation line will take what is in the water tank and pump it to the top to which then will be released by the float sensor to water the plants.

The other living wall considered was WonderWall. The design is simple and efficient to use. The website even provides a video of installment for the wonder wall. It even mentions that it is so easy to do that children can do it. The video is very encouraging because it presents a scenario much like ours and the Acopian east wall. The video shows a brick wall, and the installment of the wonderwall to it using wooden boards as the anchors (batons) for the plant pots. Installment includes putting a 11-13cm plant pot, placing it directly into the planters ensuring the pot is touching the reservoir base. Once the plant is inside make sure no impurities or leaves are blocking the water pot outlet which allows for downward irrigation. The design states irrigation can be done either by self watering or a simple irrigation method. 14 planters take up 1m^2, so a total of 42 plants are required. Large projects recommend using a waterproof membrane behind the structure to protect the wall. The toughest aspect of the wonder wall is not having a low maintenance watering system, but they have also provided information on that as well.

Tournesol was one of the top candidates for the Lafayette Garden wall. The trellis panels have an extra coating of zinc prior to powder coating to resist rust and corrosion. Panels are manufactured with 3" and 6" grid elements spaced 3" apart. Two modular sizes are available with connecting brackets, larger panels are as easy to put together by using two screws. The gap between the wall and the trellis can vary depending on what design is wanted. Meaning it can be as far as 18" out from the wall if access to the wall still needs to be available. This can be helpful for protecting the wall and for structural wall purposes. Mounting to the wall will be a key part to the design. If panels are to be connected based on design use additional hardware to do so (1/4-20 x ½" Hex Bolt, Hex Nut, Lock Washer, and Flat Washer). Tournesol offered a safe and secure structure that would allow for a great living wall design. The modular trellis measurements were a great fit for the Acopian wall and would provide the pattern desired. It had the potential to take natural native growing vines from Lafayette College and allow them to grow up. Although it was a great candidate, the biggest concern for the modular trellis was the uncertainty. When working with a structure like this, the question was how were the plants or vines going to react to this structure? First this structure was only capable of working with vertical growing plants like vines, which would then take away the aesthetic diversity green walls have to offer. Secondly, these vines will need to take time to grow up the trellis. So how long will that be? It could take years for the plants just to grow up 10 ft. Instead other designs can allow plants to grow throughout the entire wall all at the same time.

LiveWall

The company and product that was decided for the Lafayette Garden Acopian wall is LiveWall. The LiveWall company and structure stood out because they are horticulture professionals with an elegant structure that embodies the natural orientation for plant growth. The Livewall, with its natural orientation, allows the plants to grow parallel to those in nature. Information provided from the LiveWall website states that structure can easily be installed with little construction knowledge.

The components involved with LiveWall are efficient and very high grade material. The material and components are created with strict quality measures and allow for different compatible irrigation systems from other manufacturer providers. The components are also clearly supported with various measurements to allow for installation in very diverse projects. Many other structures considered were missing many pieces and required various parties to contribute to completion. LiveWall instead, contributes most of the components needed to complete the project. LiveWall will provide a contractor-sourced breathable hanging protective backing which will allow the building to safely breathe while the living wall is in place. Possible material for outdoor use is Tyvek Commercial Wrap D. Once installed the next component of the wall is the furring strips (VertiRail) usually centered at 16" using space wall anchors spaced 12" apart vertically. LiveWall will provide a horizontal slot rain on the bottom row of the wall to hold the bottom row planters in place. This installment is based on the design desired by planter drainage. The design we are considering is using bottom drain planters which will make the bottom of the slot rail align with the bottom of the furring strips (VertiRail). The installment of rainrails is the most crucial part to the LiveWall because it provides the water to the planters. A gap tool will be used to

correctly place rainrails in correct orientation to allow for proper irrigation. The rail rails will be directly drilled through the v-notch with fasteners and anchor to the furring strips (VertiRail). Rain Rails come in various sizes, so LiveWall prepares a Rainrail Connector to connect adjacent rain rails. They will provide a RainRail end plug at the end of each row to stop water. They will also provide RainRail Adapters for systems with side irrigation which is what we are considering. The RainRail Adapters will be used to connect to the irrigation structure. The irrigation structure or irrigation main line will need to be installed to a ¾" mainline with minimum 25PSI water pressure and 10 gallons per minute water volume. Access to water a source at Acopian is located at the bottom floor and the second floor. Typical mainline will include backflow preventer with an integrated air gap (required by code), and screen or disc filter. Descaling housing and cartridges may be included to prevent mineral buildup in nozzles or drip emitters. If fertilizer injector is included, follow instructions to dilute fertilizer solution and set rate of uptake. Fertilizer buckets must be placed below the fertilizer injector to allow uptake of solution.

Mount irrigation controller and hook up to electrical supply. LiveWall will provide pipe and fitting which will then be used to connect irrigation valves to pressure regulators and to RainRails to complete irrigation feed. Once finished, nozzles or drip emitters may be used along RainRails to control water release. Various spray nozzles and drip emitters are provided with desired flow rates. Brackets from LiveWall will then be provided to help hold the side irrigation feed. Refer to installation manual pg.12 provided by LiveWall for bracket configuration. LiveWall, after the irrigation system is finalized, advises for a facing material to be installed to cover the irrigation system. This in turn, will cover the unpleasant view of the irrigation system and provide a more aesthetically pleasing view of a material usually made of aluminium painted sheet metal, cedar, or something similar. The last component LiveWall provides is the most important for the plants. The planters are the last item to be installed. Planters have an overlapping lip for tight fitting, so they must be installed right to left. LiveWall includes limiting screws for the planters that are in areas of risk for wind damage and theft, the limiting screws are used on planters 20' above ground and those 8' or less. The standard sized planters are re architectural quality moldings formed from the same polymer as car bumpers (PC/ABS). 100% recycled post-industrial content, 150 mil. thick walls and no VOC content. Planters come in standard full width 16" and standard half width 8" to accomodate for diverse projects.

Figure of live wall planter

Additional to the components of LiveWall. They provide detailed drawings for each of one of its available design structures. The drawings are deeply detailed with information on location of each component and how many per row. The drawings are detailed for the indoor and outdoor LiveWalls and have different perspectives of the designs, like front view, side view, and irrigation side view.

Figure of live wall drawings

What makes LiveWall a very trustworthy company is their LEED certifications that designate them as one of the top professional living wall companies in the country. The living wall products from LiveWall contribute to stormwater control, provide habitat for wildlife, reduce cooling loads, and provide many other benefits. Most importantly above all, LiveWall provides an in depth installation guide for projects to be done personally and professionally by contractors. LiveWall provides an in-depth maintenance guide to follow as well to keep the LiveWall up to date. This includes information about how to set the water emitters to drip and the amount of times required to water the plants per day based on temperature. It is truly beautiful. Explains fertility management and maintenance required for all 4

seasons around the year. Which will be necessary for Easton, Pa. The preparedness and professional level that LiveWall presents makes it stand out from the remaining competitors in their market.

LiveWall was chosen because LiveWall is a professional and reliable company that provides state of the art live walls. But, what makes LiveWall stand out from the rest of the other competitors is its ability to perform diverse projects. For the Lafayette Gardens, the design is very abstract and LiveWall is the best candidate for the job. The northeast Acopian wall is a very challenging project. Due to the columns of windows, those columns will not have any plants on them. Instead, the LiveWall will be located between the columns of windows, because of this design, this provides challenges to the wall's irrigation system and location. Based on the design of LiveWall's structures it uses the RainRails to transport water horizontally across the wall. Since the proposed Acopian design does not have LiveWall going fully across the wall it creates a challenge for LiveWall. Variation to the traditional irrigation system must be done to accommodate for the Acopian wall design and LiveWall has the reputation and professional ability to complete it.

The only concern for the Lafayette Garden Acopian wall is the irrigation system design for the wall but LiveWall proves to be a company that could handle this diverse project. The foreseeable future concern would be proper maintenance of the structure. Maintenance for the LiveWall system should be completed once every 1-2 weeks. This specifically refers to the irrigation system and the various components involved with it as it is the most vital piece for the plants. Making sure the irrigation system is not blocked and is fully functionable is the first priority. Also, due to the seasonal changes in Easton, Pa. refer to maintenance manual provided by LiveWall to understand the changes LiveWall irrigation must undergo during the different seasons.

Calculations for LiveWall

Calculations are provided by LiveWall to ensure the longevity and structure stability of the wall. The information provided about LiveWall and the structure are supported with structural load calculations and wind load calculations. They provide engineering considerations for the height of the structure and the effects of nature on it. In March 2016, UL LLC tested the LiveWall Structure according to TAS-202 "Criteria for Testing Impact and Nonimpact Resistant Building Envelope Components using Uniform Static Air Pressure," Section 1619 of the Florida Building Code. The structure passed the Uniform Static Air Pressure Test at exterior (positive) and interior (negative) design pressures of 105 PSF. The engineers also provide information with regards to the irrigation system and the amount of water needed to properly sustain the living wall and its plants.

Wires

Material considerations consisted of nylon ropes and vinyl-coated galvanized wire using the knot and rope company and the US cargo control. The ⅛" vinyl-coated galvanized wire from US cargo control provides a structurally stable wire that can appropriately hang from the spire to the wall creating the proposed space. Vinyl-coated galvanized wire cable is strong yet flexible, perfect for deck railings, porch railings, stair railings- anywhere you want to add a measure of safety without obstructing the view of the area. The vinyl adds an extra layer of protection to the wire while also making it easy to handle. An excellent multi-purpose cable for both indoor and outdoor use. The industrial uses for the wire provides evidence that it will be very suitable for our design in terms of loading and longevity. With the addition of wire clips and wire rope thimbles to help keep stress off the looped end of the wire, it will be a structure that can be very useful for the project. Warning has been provided through P65 Warnings to alarm some health concerns the metal provides. The wire is coated to prevent any chemical hazards it may pose to the environment. To ensure more safety and protection, a shrink and shield (nano) and shrink and shield protective coating may be used to cover the wire. This will help with the life of the wire and further protect potential dangers the metal wire poses. Wires will be connected to the brick Acopian wall with R-

RBL-E Rawlbolt® - Eye Bolt that are structurally safe and technically supported by the Building Research Institute.

Figure of wire

Figure of R-RBL-E Rawl Bolt

Figure of thimble and wire clips

Calculations for Wires

Basic calculations were done by Major Jordan. To further analyze professional structural information of the product refer to US cargo control.

Calculations: How were they done? What did they reveal?

BS= 2000#

Calculations have been provided to further the analysis of the wire

NOTICE: Calculation is an unrealistic representation of project design. Calculations are done this way just to provide evidence of sound structure requirements.

Assumptions:

210# weight directly in the middle of the structure wire.

Assumed 45 degree angle exit point for wires

Knowns:

Area of wire= 0.0123sqin

Break Strength (BS)= 2000#

Normal allowable stress:

Normal allowable stress= BS/A= 2000#/0.0123sqin

Normal allowable stress= 162,602 PSI

Wire on each side of 210# weight holds 148.5#

Normal Stress on Wire= 148.5#/0.0123sqin

Normal Stress on Wire= 12,073PSI

12,073 PSI < 162,602 PSI So wire is safe and will not break

Snow weight calculator- Done to provide realistic evidence on our wire

Wire width= 0.125in

Snow depth= 2 in

L= 50 ft max length of wire distance

Weights below are calculated based on

Fresh snow 0.27-0.37#

Wet snow 2.16-4.5#

Ice 4.49-4.99#

rain/water 5.42#

* No rain, snow, or water will be able to sit on ⅛ in diameter wire at 2 in

Taking the max weight of 5.42# calculate the max load upon the wire as a whole for 50ft

Load=5.42#/50ft

Load=.108#/ft or .0009#/in

Load must be extremely heavier in one given point to cause failure of break strength. Due to the design of the project, the wire will not withstand any super heavy loads. Realistically the only loads it may experience is snow or rain. Which in that case does not provide enough stress to cause failure to wire rope.

Spires

Steel was a considered option for the proposed spire section of the project. Ultimately though, aluminium provided the same results for our project as steel but at a cheaper cost. Both material considerations originated from the light poles plus company. Originally simple basic designs of spires were considered, but did not provide the aesthetically pleasing and attention grabbing design we desired. As a result, Valmont Structures provided a structurally safe and abstract spire design that was desirable for the project. Valmont structures is a highly recognized company for designing and engineering infrastructure for lighting, transportation and wireless communications industries worldwide. Valmont structures have a great reputation for creating customized engineered structures to fit the needs of the customers. Valmont structures provide a very aesthetically pleasing structure called the RTA Idyline Sigma Pole that is made of seamless alloy aluminium. The structure has a varying amount of heights that are structurally supported with calculations providing information on the effective projected area that may be affected by winds and forces. Caps for the spires will be furnished by contractors to create a design that allows for a wire connection.

Location and design: Note* Locations Start from bottom to top of hill

1st spire: S0-03

2nd spire: S0-03

3rd spire: S0-02

4th spire: S0-02

5th spire S0-01

6th spire S0-01

Figure for spires from spec sheet.

Calculations for Spires

Basic Calculations were done by Major Jordan. To further analyze professional structural information of the product refer to Valmont Structures.

Calculations provided further the evidence for this spire being the top choice. The calculations were done by using the estimated projected area calculations along with simple shear stress calculations. Based upon the equation engineers use to understand force from wind and the stress it places on the spire, the spire shows no results of failure.

Equation

F=A x P x Cd x Kz x Gh

A= area wind hits (Varied upon height of spire)

P=Wind pressure

Cd= Drag Coefficient

Kz= Exposure

Gh= gust factor

Wind pressure equation

P=0.00256(V)^2 where V is wind speed

V=70 mph based on American Association of State Highway and Transportation Officials

Cd Long cylinders standard coefficient

Cd=1.2

Kz equation

Kz=(z/33)^(2/7)

z= from ground to midpoint of structure

Gust factor

Gh=1.3 given from Valmont Structure website (load and dimensional data)

Wind Gusts from North and South will provide force (#=lbs)

S0-01 16’ spire= 148.55#

S0-02 20’ spire= 196.74#

S0-03 25’6” spire= 268.6#

S0-04 28’6” spire= 312.12#

Shear strength

1100-0 is the weakest aluminium metal

Known shear strength (T) = 9,500psi

Test our structures greatest force applied to it to see if it fails

T= F/A

A= is smallest diameter of spire, most likely near top of spire

T=312.12#/2in

T=156.06 PSI

Calculations for Cap of Spire with 3 wires

Basic Calculations were done by Major Jordan. To further analyze professional structural information of the product refer to Valmont Structures and US Cargo Control.

Note* Structural integrity will most likely be determined by the furnishing of pole caps.

For the spires with three wires connecting to it, they will have the highest load and force applied to the pole cap. The calculations below determine the minimum diameter of the cap connector to ensure the wires do not cause failure to the connector.

1 Wire = 148.5# refer to Calculation for Wire for more information.

Cap with 3 wires

F=445.5#

Shear stress allowed (T)= 9,500psi from 1100-0 Weakest Aluminium Metal

Stress Equation

9,500psi= 445.5#/D

D= minimum diameter needed for safe structure

D=0.0469 inches

Structure will be structurally safe as long as cap is furnished with aluminium and has a diameter equal to or greater than 0.0469in

All structures should be feasible for use.

The design of the spire and wires should be very beneficial for the Lafayette Garden Acopian wall because it is structurally supported and aesthetically pleasing. The spire and wire will help provide the desiring space the project is designed to have. Due to the circumstances of COVID-19, deciding on the number of wires to which spire, wire location on the wall, and spire location is difficult to determine at this time, it is something that can be further analyzed to decide the appropriate design. As of now, basic calculations are provided for a spire with 3 wires connecting to it. But, once access to Lafayette College is available again, further analysis can be done to design space.

Environmental

With the current climate crisis, there are many sustainable solutions around the world that are being implemented to help combat the effects of climate change. Many of the issues people face can be first-hand while others do not face serious threats towards their lives. Lafayette College along with many other colleges around the country have executed a climate action plan that states their individual goals to become more sustainable. More specifically, Lafayette College reinforced their initial Climate Action Plan in 2019 to the Climate Action Plan 2.0 that states various goals, one which includes reaching carbon net-neutrality by the year 2035. There are different sustainable technological solutions that are being carried out to help the college reach this goal. Considering such goals, the implementation of a living wall, which covers an entire wall with plants, can help Lafayette College enforce its goals for many reasons.

Installing a living wall has many categories that must be carefully sought out to effectively be able to implement and maintain a living wall for a long period of time. The environmental aspect of having a living wall has many benefits whether it is towards the environment itself, animals, or the people using the space. However, these benefits primarily depend on the plant choice, which leads to the second part of this. Not only is the project focusing on the living wall that will be placed on the Northeast side of the Acopian Engineering Center, but also the ground right next to it. Using this space wisely can help create a welcoming space that can be used by anyone. In order to effectively use this space to benefit the users, the following below must all be taken into consideration.

Environmental Impacts

Benefits for Animal Biodiversity

In creating a green space, the use of plants, and how they are used helps define a space. There are different aspects that must be considered when choosing plants. For example, the choice between perennial and annuals can make a big difference, such as how the live wall or the ground look throughout the four seasons as well as the maintenance required to upkeep the plants. Also, in order to help with native animal biodiversity, the choice of native species must be considered to create a safe space for them. After having talked to Dr. Michael Butler from the Biology department, there are different species of animals that need additional safe habitats; the integration of native plants, for the ground, will help native birds, especially because their population is slowly diminishing. In helping provide an environment for native birds, the plants chosen can help increase animal biodiversity; for example, the addition of other animals and insects, such as monarch butterflies, bees, and other pollinators can be seen in this space. From the *Edge of the Woods Native Plants*, they state that having native plants help support “birds, insects, pollinators, butterflies, and other wildlife, and design landscapes that are visually pleasing and support the ecosystem.” This project is intended for both humans and helping animal biodiversity especially when working with green spaces outside. Because of the connection between animals, plants,

and humans is all interconnected, it is imperative that the choice of plants is chosen accurately. In addition to the animals that can benefit from this space, implementing bat boxes at the top of the living wall structures can have a greater benefit. Bats do not have much shelter in Easton, so providing a sheltered space for bats not only helps keep them safe, but it also helps with pollinating plants.

Benefits for Humans

Plants chosen have many benefits, which include the benefits both animals and humans can see and experience. More specifically, when focusing on the benefits for the people who will use this space, there are many benefits. The plants chosen, which will be addressed below, were all chosen for specific reasons. For example, fragrances, aesthetics, and plant growth patterns have been considered in deciding what plants to choose. A study was done by the University of Delaware that focuses on the benefits of a living wall which includes the following: "[boost of] a stronger sense of community, [cope] better with everyday stress and hardship. [perform] better on tests of concentration, and managed problems more effectively." Because college can be stressful for many and can also be difficult to find spaces to relax and escape from daily stressors, using the space on the side of Acopian can be beneficial for many. Furthermore, the research study stated that "psychologists have found that access to plants and green spaces provides a sense of rest and allows workers to be more productive" (University of Delaware).

Although Lafayette College is known for its beautiful landscape, the addition of a living wall only helps tie the community closer and allow for people to have more green spaces they can interact with. Some of the plants chosen have strong, calming fragrances that can also help people; green spaces can work as therapy for many people. The scents that this space can further offer is helping students improve their productivity, mood, and can help calm students (*How Aromatherapy Can Help Students Achieve Academic Success*, 2018). A lot of these benefits help improve health and a person's well-being. Apart from the benefits users can experience from being in this environment, there are further advantages including "lowering energy consumption and greenhouse emissions, reduction of urban heat island effect, increasing the thermal performance of building (lowering energy costs), positive effects of hydrology… [and] reduction of noise pollution" (Loh, 2008).

Plant Choice

Living Wall Plant Choices

In deciding the best plants for the living wall, understanding what kind of space is being worked on is crucial to help implement plants that will be successful growing on the living wall as well as the ground. The wall where the living wall will be located faces the Northeast side, which receives very limited sunlight exposure. Having this information helps narrow a choice of plants by choosing plants that will grow with limited light, but still take into consideration aesthetics, fragrances, and benefits. LiveWall, an organization that specializes in living walls across the United States, has shared valuable information that helps understand the different characteristics that must be considered to effectively grow different plants on the living wall. The initial list that was created is shown below:

- Bergenia cordifolia
- Blackeyed Susan
- New England Aster
- Common Yarrow
- Geranium
- Mint
- Lavender
- Sage
- Lemongrass
- Coleus
- Petunia

- Caladium Cultivars
- Golden Sword Yucca
- Golden Creeping Jenny
- Japanese Pieris
- Violas
- Winter Flowering Iris

These plants were chosen for various reasons such as their success in pots, color, scents, aesthetics, and plant growth patterns (perennial and annual). The goal was to have a variety of plants that would show different patterns throughout the seasons; however, after speaking to Mike Haynes, a representative from LiveWall, all the living walls they have worked with use about 3-5 different plants. The list above contains over 10 different plants, so after careful consideration and advice from Mr. Haynes, this list has been reduced to six plants, but still taking into consideration the characteristics mentioned previously. The new, finalized list is the following:

- Coleus
- Bergenia cordifolia
- Fuschia
- Golden Creeping Jenny
- Japanese Pieris
- Violas

The plants will be successful when implemented on the standard planters, provided by LiveWall, but during the first couple of weeks, there will be a need of high maintenance to ensure the plants are growing well. receiving the right amount of water, and other requirements.

Ground Plant Choices

The space surrounding where the living wall can be further defined by the choice of plants. Taking animal biodiversity, the slope's water problems, and environmental benefits into consideration, the plants chosen are shown below:

- Joe-Pye weeds
- Goldenrod
- Black-eyed Susan
- Milkweeds
- Wild bergamot
- New England Aster
- Purple coneflower
- Little bluestem
- Virginia Rose
- *Viburnum dentatum (*Arrowwood Viburnum)
- Jolly Red Winterberry
- Blackhaw
- Virginia Rose

One of the issues that have been discussed in regards to the slope is water problems. When it is raining, a large amount of the water from the top of this slope descends to the bottom. The pattern that it falls creates this space to be dangerous to walk through because it can get slippery and cause people to fall. In order to prevent this from happening in the future, some of the plants will purposely be set at the top of the slope to avert some most of the water from going down this slope, thus making it safer to walk through this path. Aside from this, the plants chosen are native plants to Pennsylvania, which will ultimately help with animal biodiversity and providing a habitat for species that need it. Not only that, but the plants will help define the space and can become an interactive place for people.

Economic

To begin, Lafayette Gardens should be seen in the light of an investment, not in the light of just another cost on the balance sheet of the school. This project has tremendous value to bring to the college in a variety of different ways including environmental, educational, recreational, and reputational pathways. For these reasons it is logical that the project come with some degree of financial investment in order to be completed. Through our calculated and revised estimates we expect the project in total to run right about $XXX,XXX. This is a far development from our initial estimates in which we used other projects to extrapolate an estimated range of $50,000 to $300,000+ for the green wall alone. (citation) In order to reduce our initial estimates we made a number of assumptions. Chief among those assumptions was the decision to pursue Live Wall as our green wall consultant and provider. Live Wall provided us exact pricing figures in order to narrow down our cost range significantly. Live Wall broke the costs into several areas including design components, plants, and construction as well as acknowledging the need to think about maintenance figures.

(Insert Chart with Live Wall Breakdown)

Utilizing Live Walls system was pivotal in our decision making process because we were able to further explore the other aspects of the project once we had nailed down a realistic pricing range with extensive customer support from the Live Wall team. We are still in contact with the team at Live Wall and they are ready to work further on the project with us as the time comes to move forward on the Lafayette Gardens from an admissions perspective. The rest of the costs on the project were attained using a variety of resources including wholesalers, manufacturers, and extrapolations from prior projects. For products such as the spires, wires, and adirondack chairs we were able to obtain costs quickly and easily online. For features such as the path, flower gardens, and terracing it was necessary to utilize extrapolation from similar projects in order to reach realistic figures for the budget.

There are a number of costs that we have yet to be able to determine such as a cost to gain permitting, consulting from additional parties, and the long term maintenance fee. All of these figures will likely be determined by the school administration in the long run. We would recommend increasing the number of gardeners on the facilities staff in the future so they may be able to maintain this area. According to Scott Kennedy several members have retired this year and so at current capacity facilities does not have the manpower to maintain this area. Keeping the maintenance work on the gardens within the Lafayette employees would keep the area looking fresh and up to college standards. Hiring an outside contractor reduces the connection and responsibility the workers may feel to the project and its overall image.

When looking into the scope of funding, Scott Hummel of the Engineering Division determined the funding for the project will likely come through a donor to the college. Due to this it has been determined the name for the gardens may change from Lafayette to the last name of the donor as an appropriate measure for the generosity of the individual or family. In addition we are looking at securing funding from different departments here on campus for certain features of the project. For example the Biology or Environmental Sciences departments could donate the bat boxes as it is a focus on increasing biodiversity and animal populations. Similarly, admissions could possibly donate money for the mural as it is a direct tie into the school image and would likely be pointed out on each prospective student and visitor tour.

Now that we have covered the hard numbers surrounding what it takes to complete and implement this project we can shift our focus to the tremendous value that this project is able to bring to the college. Our goal was initially to conduct a survey this semester within the Lafayette community in

order to gain a pulse on the community's feelings towards the implementation of the Lafayette Gardens. Due to the recent world events with COVID 19 we were unfortunately unable to conduct such a survey. Instead we have structured the survey and will include it in our final report and recommendation to the administration for their discretion on whether or not they would like to see this survey used in the future. Even though we were not able to gauge what the community valued in the project as a team we have determined there is significant opportunity within this project. By creating the Lafayette Gardens the college is opening the door to educational, environmental, recreational, and reputational value. Each one of these four categories shares overlap and influence, creating a strong foundational reasoning for why this space is so important.

Environmental

This wall is ll about how we can incorporate the environment into a dull and utilitarian area here on campus. By adding the green wall and pollinator gardens we are able to benefit the college hill environment in a positive way. Not only will the green wall utilize native plants to increase air quality and biodiversity on campus, but we also plan to implement bat boxes to provide shelter for endangered bats on our wall. Our goal with the pollinator gardens below is to create an active haven for pollinators such as bees and birds to increase the health of their populations here on campus. The environmental allure in this space is not only limited to nature but is also proven to benefit humans. Our usage of fresh herbs such as mint, lavender, and lemongrass in the wall can create scents linked with improved memory and school performance as well as reduced stress levels. The environmental value of this project is also seen in its sustainable features aligning it with the goals of the climate action plan here at the college.

Educational

The educational value that this project brings is directly connected with the environmental and reputational values as well. Below is a short excerpt on how students from different areas on campus may be able to work in this space.

> *"Many classes here at Lafayette are shaped and molded into a basic classroom learning experience. Rows of chairs all facing a set of chalkboards in a monotone utilitarian classroom. If students are lucky they may get the opportunity to change rooms and visit a laboratory setting once a week. With the addition of the Lafayette Gardens this monotony of learning is about to be changed for a handful of students taking courses within the Engineering Studies and Environmental Studies divisions. Instead their class will be a combination of traditional work in the classroom paired with field work on the northeast facade and surrounding area of Acopian Engineering Center, now known as Lafayette Gardens. Over the next 16 weeks these students will have the opportunity to study this sociotechnical system and evaluate its ever changing impacts on campus. For the environmental studies students they may look at a variety of different aspects such as biodiversity in the plants and animals on campus or they may evaluate the impacts of the new pollinator gardens and bat boxes on bee and bat populations. On the other hand the Engineering Studies students will be able to finally see a tangible representation of engineering and the world coming together to create a new experience apart from the blueprints and hard numbers of traditional engineering. These students will have an opportunity for hands-on research and work in areas that they previously could have only experienced through lectures or textbooks. The Lafayette Gardens has not only added a whole new aesthetic dimension to campus but also a new dimension to the Lafayette educational experience."*

In order to culminate the educational value of this project into a single streamlined experience, we have designed an exhibition trail guide that features all of the important information on the space in one location. A layout of the information on the guide can be found below. Note the guide features different areas on the wall, pollinator gardens, bat boxes, and even a section on the background to the meaning of "Cur Non".

Recreational

The original idea for this space was to provide an area away from the busiest parts of campus for students to relax and hangout. The space was also meant to be an escape from the intensity and draining seriousness of Acopian Engineering center. The new gardens have created just this space for the community of Lafayette. No one person is more qualified than another to be in this space. If a viewer looks onto the mural on the triangle one of the statements they will see is “Why not you”. This is a message that anyone belongs here at Lafayette and similarly anyone has the right to be in the Lafayette Gardens. This space has been shaped as an area of collaboration,and area of discovery and development, but most of all this is an area for everyone to enjoy. The beauty of the space is that it is not meant for one singular purpose but instead it can be used in a variety of ways to provide each person their own unique experience. Creative yet refined as well as busy yet relaxing, there is no one way to live in the Lafayette Gardens.

Reputational

The gardens stand to bolster and solidify Lafayette College as on the forefront of design, sustainability, and experience when it comes to college campuses and public domains around the world. The project falls right into line with sustainability aspects of the ongoing and public Climate Action Plan 2.0 passed by the school in recent times. This project could provide a tangible example for people to see the work the college is doing every day to help reach their goal of a better tomorrow. Already known for tremendous value, the Lafayette Garden can help admissions in selling prospective students in the College. The first sight that you currently see when you walk out of Markle Admissions and turn right is the barren landscape of the north east facade of Acopian Engineering Center. The implementation of the gardens could change this into a focal point of tours. The mural painted onto the lower triangle sporting “Why not you? Why not here? Why not now?” will certainly leave prospective students and visitors thinking about and remembering all that this college has to offer.

Throughout this project there has been a focus on quality, intentionality, and value. Each decision that has been made into the design of the space has been with those primary focuses in mind. For this reason, even though the price tag may seem steep for a “garden” the investment is justifiable. This project brings values to the Lafayette community that end up elevating the space far beyond that of a simple garden. This project showcases the college's ideals of growth, sustainability, and collaboration from all areas on campus. The Lafayette Gardens stand to be a living example of what the college represents and strives to be, and that in and of itself is priceless.

Conclusion

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Attachments

Attachment 1 - Draft Budget (Updated 4/24)

Section	Component	Cost Low	Cost Medium	Cost High		
The Green Wall						Live Wall
	Provided Materials	$68,850.00	$91,800.00	$114,750.00		Toia
	Plants	$15,300.00	$22,950.00	$30,600.00		Paul D.
	Contractor Installation	$53,550.00	$23,850.00	$68,850.00		Major
	Water / Electric					
The Triangle						
	Preparation					
	Installation					
The Grounds						
	Flower Beds					
	Plants					
	Terrace Construction					
	PA Bluestone Path	$20,000.00	$25,000.00	$30,000.00		
Wires and Spires						
	Wires	$133.00	$133.00	$133.00		
	Wire components	$17.39	$17.39	$17.39		
	zipper tubing shrink&shield					
	Connection piece to Brick wall					
	Spires					
	Pole Cap	Will be handled by fabrication later on				
Seating						
(4 Chairs)	Adirondack Chairs	$280.00	$400.00	$800.00		
	Total Cost	$158,130.39	$164,150.39	$245,150.39		