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From Archaic To contemporary : Energy Efficient Adaptive Reuse of Historic Building

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FROM ARCHAIC TO CONTEMPORARY: ENERGY EFFICIENT ADAPTIVE REUSE OF HISTORIC BUILDING

A Thesis Presented

by

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ABSTRACT

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Over recent decades, the global focus on climate change and on conservation of resources has brought about a paradigm shift in the adaptive reuse of old and historic buildings. Adaptive reuse is now seen as a key factor in the conservation of land and environment, preservation of cultural identity, and reduction of urban sprawl. Increasingly, engineers, architects, and urban planners are making concerted efforts to realize the reuse potential of existing and outdated structures. Therefore, those involved in building design have studied the viability of adaptive reuse and generally favor the repurposing of old/historic buildings to suit new patterns of occupancy and use without disturbing the environment or increasing carbon footprints. Redesign and reconstruction through refurbishment, remodeling, renewal, repair and retrofitting is carried out to meet new requirements and provide performance that was not in the original design.

Buildings are one of the largest energy users in the United States.[1] In total, buildings used around 40 percent of energy in 2015, which accounts for the largest share among forms of energy consumption. Many of the buildings are not energy efficient but do have historic value; while giving them a new purpose, their historic legacy can also be preserved. There are many

[1] According to the U.S. Energy Information Administration, "in 2017, about 39% of total U.S. energy consumption was consumed by the residential and commercial sectors." https://www.eia.gov/tools/faqs/faq.php?id=86&t=1. October 2018.

challenges like program modification feasibility, structural issues and energy efficiency which need to be addressed during pre-construction and can be addressed by careful planning and innovative techniques. To understand the various challenges involving adaptive reuse, this study employs the Clark Hall at the University of Massachusetts to test the efficacy of design and performance interventions. Clark Hall was originally used for science classes and botany research and later was converted into painting studios. Presently the building structure is still intact, provides enough room for program modification, and has significant reuse potential. Therefore, Clark Hall is a suitable candidate for adaptive reuse as an academic office building that satisfies contemporary building standards and meets the growing demand for office space.

Through this project, an attempt has been made to explore and understand the complexities and challenges as well as the various possible ways to change the function of Clark Hall from a defunct structure to a modern energy efficient and environmentally sustainable academic office building with measures for energy conservation through contemporary innovative design approaches.

The research work begins with a background study of the building's history and its different purposes, along with three precedent studies of contemporary and innovative design examples. It also identifies relevant local, federal, and state building and zoning regulations and incorporates existing energy-saving technologies and materials appropriate to Clark Hall. Keeping in mind the financial viability of project, an attempt has been made to control and bring down the operating and the maintenance costs by carrying out extensive energy modelling and simulations to support these recommendations.

In conclusion, the final outcome of my project is a design plan for the adaptive reuse of Clark Hall as a new energy efficient and environmentally sustainable office building for the

benefit and the use of University of Massachusetts Amherst that mitigates costs and improves design utility and aesthetics, while preserving its historic value.

TABLE OF CONTENTS

Page

LIST OF FIGURES

CHAPTER 1

THESIS JUSTIFICATION

Buildings account for almost forty percent of energy consumption in the U.S.,[2] a number that could be reduced. Nevertheless, in improving energy efficiency, the historic legacy values retained by certain buildings should also be recognized. It is important to preserve legacy buildings by repurposing them rather than demolishing and replacing them. The adaptive reuse of old and historic buildings comes with many more challenges as some structures seem out of step with new ideas in design and construction and as the old building can no longer fulfill or satisfy present-day performance requirements. This research and project work attempts to explore and understand the various methodologies employed in the reuse of an existing structure, in this instance Clark Hall, to reduce a building's carbon footprint and, with it, the commensurate impact on climate without extensive alteration to its original form, while addressing the important components of occupant comfort and architectural aesthetics using a contemporary innovative design approach.

Despite an interesting history, Clark Hall presently is in disrepair and is mostly unoccupied. Stockbridge Road on which the Hall stands came into existence in the first quarter of eighteenth century. The University of Massachusetts Amherst was established in 1863 and the earliest buildings were opened around the pond area which is now on the west side of North Pleasant Street (see campus plan in the Appendix).[3] After the University's first buildings along this road developed in phases, the campus started to spread to the east of today's North Pleasant Street. A phase of development between 1906 and 1909 included the construction of

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[2] According to the U.S. Energy Information Administration, "in 2017, about 39% of total U.S. energy consumption was consumed by the residential and commercial sectors." https://www.eia.gov/tools/faqs/faq.php?id=86&t=1. October 2018.

[3] Marla R. Miller and Max Page. *University of Massachusetts Amherst: The Campus Guide*. Princeton: Princeton University Press, 2013.

Clark Hall. The area surrounding the Hall was referred as “Clark Orchard” which featured imported plant specimens from both Japan and local Massachusetts forests.

Clark Hall and the road on which it is located has a memorial link to the foundation of the University of Massachusetts Amherst campus. Clark Hall’s role as a landmark for the University throughout the campus’s history recommend it for preservation. Also, its preservation is another example of the campus community’s commitment to the maintenance of legacy sites.

At present, there is a growing demand for office space/buildings near the central campus of the University of Massachusetts Amherst.[4] These needs can be addressed either with new construction or with the conversion/modification of under-utilized or abandoned existing structures.

In view of the above factors, it would be prudent to pursue a strategy of adaptive reuse and to plan to convert Clark Hall into a modern energy efficient and environmentally sustainable office building.

[4] Pamela Rooney. “Re: Info needed for thesis project.” Message to Nisha Borgohain. 19 July 2018. E-mail.

CHAPTER 2

METHODOLOGY

This thesis research will begin by exploring the history of Clark Hall as it relates to the historical development of the University of Massachusetts Amherst campus. An investigation of the building context will provide insight into future design directions that will best maintain the historic memory of the building and life on the campus during the early twentieth century. Strategies for improving the tectonics, scale, materiality and envelope of the original construction will be incorporated into the design proposal. The investigation will include a programmatic change in the use of the building from an agricultural building to an administrative office. This change will give rise to studies related to shifts in function as well as the application of new materials and systems.

2.1 Insertion and juxtaposition Interventions Approach

This thesis will consider two formal approaches to working with existing structure: insertion and juxtaposition. Through design iterations, the thesis research will consider when and where to employ each of these approaches. Francoise Bollack explains the insertion method as the following:

> *Insertions are those group of interventions where the new piece is inserted into the older volume using existing structure as protection and nestling in it. Generally, the inserted piece has its own identity. The container is the carrier of memories and emotions and the insertions provides the revitalized design. This approach of reoccupying an often marginal structure forms a new component into the existing urban fabric with historical lineage.*[5]

As Bollack explains, insertion allows for the accommodation of new techniques and ideas into pre-existing structures. During renovations of the Old Chapel and South College Building at the

[5] Bollack, Francoise Astorg. *Old Buildings New Forms*. The Monacelli Press, 2013.

University of Massachusetts, Amherst, the junction between the old and new construction were radically transformed, implementing 21st-century design principles similar to the insertion design intervention. Bollack continues, the juxtaposition approach preserves the characteristic autonomy of each structure:

> *Juxtaposition interventions are the additions that stands next to the original building and does not engage in any language with the existing building. The new piece is integrated into the functional pattern of the combined work which is often accessed through the original building but it contributes through distance and aloofness. The visual separation here is achieved by total contrasts established by combination of distinct styles, different materials palettes, contrasting color and textures or volumetric abstraction and this formal separation adds a value to each.*[6]

An example of this intervention would be on the Smith College campus, where two buildings to be completed in 2020 flank a "historic core" that dates to 1909.[7]

Both approaches have informed the design practice this thesis will outlined in this thesis's subsequent sections. The processes mentioned above are skillful compromises between historic preservation and contemporary innovations but the original building retains its primacy.

2.2 Renovation Constraints

One step in the thesis will be to examine the existing building conditions in advance of proposed modifications. Due to programmatic shifts, a code analysis will yield insights into updated accessibility and egress requirements. The program change from an educational space to an academic office space would require reprogramming of the space which will in turn require studying and proposing modifications to the existing structure and interior partitions. Although the exterior brick walls and the fenestration system appear to be in good condition,

[6] Ibid

[7] Chris Lindahl. "Celebrated architect Maya Lin blends old, new in library makeover." Daily Hampshire Gazette. Accessed online 15 October 2018.

this project can propose various modifications to the interior which is in poor condition. The heating, electrical and mechanical infrastructure of the building is obsolete and need to be renovated.

2.3 Design Considerations

The objectives of passive design strategies and energy efficient building systems are designed to improve building performance to meet new demands and needs, reduce energy consumption, maximize energy savings for fiscal benefits, and reach net zero goals by utilizing renewable and existing surrounding energy. Substantial energy modelling and simulating multiple design considerations will lead to optimal material selection, improvements to the building envelope, retrofitting of HVAC and lighting systems, assessment of occupancy loads, and application of renewable energy sources.

CHAPTER 3

LITERATURE REVIEW

Adaptive reuse is not new and is widely implemented in projects seeking to rejuvenate urban areas, as exemplified in the restoration of the City Hall annex in Cambridge, Massachusetts (discussed below). Adaptive reuse has been a technique to repurpose structures in disrepair. In this thesis, however, the words “modern adaptive reuse” is deliberately used on a broad scale to denote the intervention to implement present-day requirements for energy-efficient and environment-friendly buildings. It is always a challenging task to implement adaptive reuse techniques to heritage buildings, and hence there is a range of scholarly literature giving deep insight into these challenges. This study draws from two primary sources to inform the methodology of this thesis. Stewart Brand’s *How Buildings Learn* (1994) underscores how each building accommodates to its environment, by bringing about changes to the urban landscape. Liliane Wong’s *Adaptive Reuse* (2017) uses the model of Frankenstein’s creature to propose a design practice that privileges function and choice.

3.1 Inspiration

3.1.1 Stewart Brand. *How Buildings Learn*. New York: Penguin, 1994.

Brand addresses what happens to a building over time. He talks about how function reforms form constantly in a building: “First, we shape our buildings, then they shape us, then we shape them again—ad infinitum” (3). Brand points out how buildings always revolve around three irresistible forces—technology, money and fashion (5). The reason, he argues, is that the tread of technology is inevitable and accelerating. Furthermore, the building’s form “now follows funding” and fashion always creates a constant state of “imbalance” (5). Age is overly

valued in America which gave birth to widespread fakery, which ironically is this reason that it makes us respect aging even more (11).

During the design and construction phase, Brand explains, originally the “six S’s” layering sequence was applied to building work. The “six S’s” include site, structure, skin, services, space plan, and stuff (13). This approach defines how buildings relate to users. He argues that “quick” changes can “provide originality and challenge” while “the slow provide continuity and constraint” (17).

Brand interestingly points out the reason behind old buildings being freer (24). According to his survey, the response he got from the public was very simple. Older buildings tend to be shabby but spacious and always have “an adventure behind it” (24). Hence, any changes done to the building are considered likely to be an improvement. He also shines light on how economic activity reflects low road activity.

Brand examines how people really use buildings. In his opinion, some of the most remarkable and cherished reused buildings are “Low Road buildings”; as the users are able to alter the space effectively to further suit the requirements of that time (29). In contrast, the high road is best seen in styles like country estates. Here the emphasis is on building both for durability and resilience and for the personal needs of the owner. In Brand’s view, Modernist designs are intended to impress rather than to be comfortable to the inhabitants (44).

Many buildings strenuously avoid relationships with time (45). These buildings show no functionality whatsoever as they exemplify image driven architecture where the shaping force is taste not use (55). Brand uses these buildings to provide examples of “Magazine architecture” (52). The particular architecture of the building impresses the crowd instead of accommodating the users (57). The author also describes the impact of real estate on architecture as it is a surprisingly “unexamined phenomenon,” despite how market value is determined by the looks

of the building in the context of the neighborhood (81). People get into a mentality of treating their house as an investment (70).

Brand conveys that the best approach to preservation is adaptive reuse as the old buildings have extra fabric at the seams of growth. Brand states that the present grows from the past. The better the obsolete design, the better the new design. Remodeling is inexorable and can reveal both past and the future. The constraint to the building is the regular maintenance which is without rewards and can instead be a constant, draining expense. But in a building conservative economy, low maintenance and well maintained buildings hold their rental and sale value, because of the fact that the traditional materials used for the building are rich in texture and have a time dimension.

The final chapters offer Brand an opportunity to look out and forward. Not calling it programming as most architects conventionally call it, Brand coins the phrase “scenario planning” (182). The results of skilled scenario work are not a plan but a strategy (183). While a plan is based on prediction, strategies are designed to encompass unforeseeable changing conditions (184). No matter what may be the situation, a good strategy always ensures room for maneuvering to accommodate change and adaptability.

3.1.2 Liliane Wong. ***Adaptive Reuse***. Berlin: Walter de Gruyter GmbH, 2016.

In this book, the author looks into the new definition of adaptive reuse through the context of climate change. She explores the fundamental question of how historic structures should incorporate and encompass designs for future use as the changes in the structure must meet the needs of new programs and functions with practical solutions (30). She redefines adaptive reuse as a tool for “transformative interventions, continuation of cultural phenomena

through built infrastructure, and connection across the fabric of time and space and preservation of memory" (30-32).

She also draws a metaphorical connection between buildings and Frankenstein's creature (34). The theory behind the failure of Frankenstein's creature was due to the introduction of new and incompatible parts into an existing built space which she coined the Frankenstein syndrome.

The author addresses issues of existing structure and adaptive reuse by promoting clear and creative exploration of this subject through multi-faceted investigations and paradigmatic examples of work where sustainability plays an important aspect. The examples Wong draws from include ancient examples to the most recent work of contemporary designers and tackle issues which offer broad but distinct viewpoints on adaptive reuse.

The author looks into the history and theory, typology, materials and construction aspects of preservation, urban environment and interior design as a drive for adaptive reuse (47-54). Her examples show how functional construction allows for significant flexibility by taking into account the design parameters based on the building's characteristics (150). The important takeaway from the review of this book is as follows. First, historic buildings exemplify a spirit of perennial endurance, often withstanding the trials of time and adversity (83). Second, the analysis of existing buildings is crucial in the building of new structures. A sensitivity to digital components and electronic/mechanical devices are necessary before they are woven into the structure so that the building doesn't fall prey to the Frankenstein syndrome (38). A critical analysis which identifies the best elements of the existing building to retain and also assesses the most applicable interventions is essential to adaptive reuse work.

CHAPTER 4

PRECEDENT STUDY

Taking the approach of repurposing structures, the new design is incorporated within the older building fabric while preserving its historic characteristics. This is done by inserting new interior elements into the original envelope which creates a juxtaposition of old and new elements. With these transformations, a building can become a vibrant element in the built environment once again. Below are a few examples.

4.1 Cambridge City Hall Annex

Location: Cambridge, MA

Originally built in 1871, renovated in 2004

Principal use: City hall with commercial offices

Gross Sq. Footage = 33,216

Distinction: LEED-NC Gold, 2006

Architect and Interior Designer: HKT Architects, Inc.

Client: City of Cambridge

Occupancy: 109 people (for an estimated 40 working hours per week)

Figure 1. Cambridge City Hall Annex, Cambridge, MA. Credit: William R. Hammer. “Old is New Again” High Performing Buildings: spring 2008, pp. 42-51.

- Purpose: retrofit into an institutional building using passive design strategies for a stable consonant role in shaping and interacting with the surrounding culture, society and history
- Objective: to maximize energy savings and reach sustainable energy goals by utilizing renewable energy and sustainable strategies.
- Existing structure: three-storied 134-year-old historic building
- Profile: The Cambridge City Hall annex was originally constructed in 1871, as the Harvard School. It was a two-storied brick building with a mansard roof, with a third story added later. The building's original design was criticized for being poorly lit, with a confusing layout, unclear signage, poor handicap accessibility, and only a single bathroom. The crumbling parapet and chimney were removed in the 1950s, for safety reasons, and the building was contaminated with mold, lead, and asbestos.

As described in a case study published by *High Performing Buildings* in spring 2008, the renovation turned the annex into a commercial office building, implementing passive daylighting ventilation and daylighting.[8] The envelope was improved: the 19th-century building façade was preserved, but with operable windows, transoms, transparent sidelight, and skylights installed. A large array of photovoltaic panels were placed on the top of a flat steel superstructure above the rooftop units with no visibility from the ground (Figure 2). For sustainability, a water efficient landscape reduced water use by fifty percent. Indoor air quality was taken into consideration with the installation of CO_2 sensors and low-VOC-emitting materials. Also, the building received high-performing thermal glazing with mullions that matched the historical profile. The HVAC system was renovated with ground source heat pumps that permit variable air volume and air distribution.

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[8] *William R. Hammer. "Old is New Again"* High Performing Buildings*: spring 2008, pp. 42-51.*

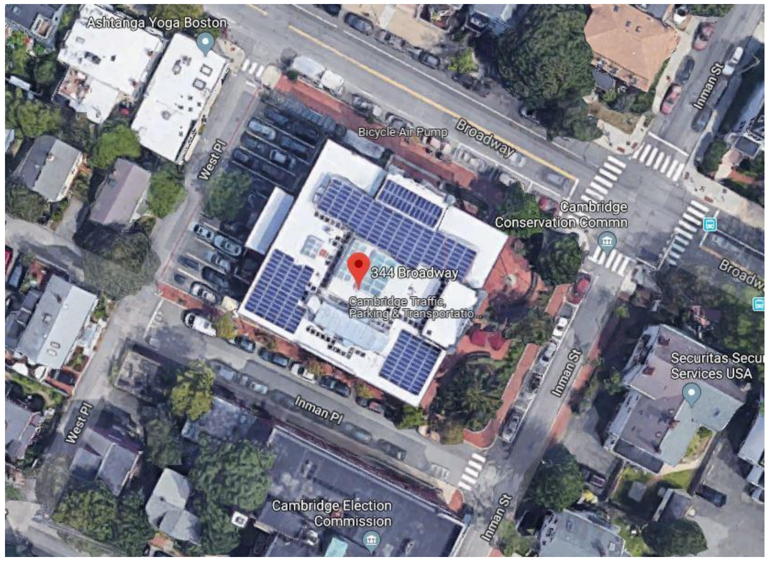

Figure 2. Site Plan showing Photovoltaic System with Canopy. Credit: https://www.google.com/maps/

Figure 3. Improved Section Layout. Credit: Jean Carroon. Sustainable preservation- Greening Existing Buildings, Hoboken: John Wiley and sons (2010), pp. 190-194.

- Strategies: Eight-five percent of the constructed waste was recycled including steel framing, carpet, and ceiling tiles, and fifty percent of the framing lumber came from a certified forest. Key sustainable design strategies were implemented, including ground-source heat pumps, a photovoltaic system, and intelligent lighting. Three 1200-feet-deep wells were created in a

small parking lot which house the building utilities. A heat pump freed up usable space by eliminating the need for large towers and chillers which in turn allowed the architects to turn the basement into office space and to create a large open entry hall. Daylight and occupancy sensors reduce electric lighting use while providing full control to end users. The building is equipped with perimeter lighting fixtures with addressable diming ballast and daylight sensors which allow lights to dim to presetting levels. Ten percent of the building's energy is provided by a photovoltaic system. The new design has a welcoming entry and lobby, large public meeting rooms, a clear layout and signage, energy-efficient offices, several staff lounges, and restrooms and code upgrades including handicapped accessibility. The new main entrance, reoriented from a side street, offers a handicapped accessible stairway. The two-story entry lobby sets a more appropriate civic tone and makes it easier for the visitors to locate the services they need. The new design contains a two-story atrium with above grade window openings in the previously uninhabitable cellar. As William R. Hammer observes,

> *"The value placed on transparency, flow, growth and pleasure are directly inspired by the mission statement of the city department that occupies the building. Site-specific artwork in the lobby depicts a mixed-use space, with pedestrians and bicyclists moving through a dramatically green space, and underscores the complex connections between civic goals, green design, historic preservation and public transparency."*[9]

4.2 Indiana Tech's Wilfred Uytengsu Sr. Center

Location: FORT WAYNE, IN

Originally built in 1857, renovated in 2010

Principal use: University Administration and Offices

Gross sq. footage = 11806, conditioned space sq. footage = 11806

[9] William R. Hammer. "Old is New Again." *High Performing Buildings*. Spring 2008, pp. 42-51.

Distinction: LEED Gold, 2010

Architect, LEED Consultant: Viridian Architectural Design, Inc., Fort Wayne, IND

Client: Indiana Tech

Occupancy: 28 people (with an estimated 40 working hours per week)

Figure 4. Indiana Tech's Wilfred Uytengsu Senior Center. Credit: Lubbehusen and Thornsbury, "Better with Age" High Performing Buildings: summer 2012, pp. 58-69.

- Purpose: To create an optimally energy-efficient administrative building with the original structure intact maintaining a particular heritage and implementing energy-efficient design strategies so the building can be utilized for another 150 years.
- Existing structure: A three-storied antebellum-era building
- Profile: The building was originally constructed for academic purposes. The brick exterior, including the attic and door/window framing, was not sealed properly. The plumbing fixtures are obsolete, with no landscaping.

After the renovation, the building is used as an administrative office building. The envelope has been improved, minimizing thermal bridging issues with added insulation. The existing windows and door openings have been maintained in an effort to retain the historic nature of the building, while bringing in natural sunlight and ventilation. The existing windows

were replaced with high-performance window systems. Air filtration was minimized through a framing system with tight sealants and new roof systems. Water is provided with the use of a rain garden and rainwater collection designed and incorporated to minimize reliance on local city water supplies in the resourcing of the building's landscaping (Figure 5). The consumption fixtures include low flow faucets with sensor based metering system, while the HVAC is based on community geothermal loop heating and cooling systems and lighting is provided by user-controlled LED fixtures and hydraulic elevators.

Figure 5. Wilfred Uytengsu Senior Center Backyard Rain Garden. Credit: Lubbehusen and Thornsbury, "Better with Age" High Performing Buildings: summer 2012, pp. 58-69.

Figure 6. Wilfred Uytengsu Senior Center Building Section. Credit: Lubbehusen and Thornsbury, “Better with Age” High Performing Buildings: summer 2012, pp. 58-69.

- Strategies: In this building’s renovation, a high R-value for exterior wall system and roof systems can be observed by measuring the interior temperature. The renovation made use of double-pane low-E metal clad window with an integral thermal break system. The roof system includes structural insulated sandwich panel system with the use of light colored shingles which minimizes the overall heat gain. For HVAC, the building system consists of eight geothermal heat pumps with an electrically commuted motor (ECM) supply fan and a dehumidification control mode. The architect not only prioritized keeping the existing building closer to the original but had to fit a new program in (from academic to office building) so that multiple considerations were brought to bear on decision making (Figure 6).

4.3 Blackstone Station Renovation

Location: Cambridge, MA

Originally built in 1887-1929, renovated in 2006

Principal use: Faculty and administrative offices

Gross sq. footage = 42,000

Distinction: LEED NC – Platinum 2007

Designers: Bruner/Cott Architects and Planners, Inc.

Client: Harvard University Operations Services

Occupancy: 142 people (with an estimated 40 working hours per week)

Figure 7. 46 Blackstone Renovation. Credit: Harvard Green Campus Initiative, High Performance Building Resource, May 2006.

Figure 8. Site Plan

- Purpose: To retrofit an office building so that it epitomizes the doctrines of green design. Three historic masonry structures were transformed into a single, state-of-the-art sustainable building that would provide a collaborative workspace while ensuring occupant health and comfort.
- Objective: To renovate and provide new office spaces for university operational services and to demonstrate cost effective, sustainable design.
- Profile: The building was originally built as a part of a coal fired electricity plant which has provided steam to Harvard's campus since 1930. The exterior was brick masonry with a designated area for parking. The building's plumbing had become obsolete, and no particular attention was given to landscaping features.

After the renovation, the building was converted into the first consolidated headquarters for Harvard's university operation services. The former parking lot in front of the building was transformed into a green courtyard. The vertical light slot connects two previously detached buildings, delivering daylight to the newly discovered interiors (Figure 9). The original timber frame and decking was incorporated into the interior design. The open floor plan consists of a skylight canopy, with operable windows. The low flow plumbing fixtures and dual flush toilets and waterless urinals contribute to the low water use consumption, with bioswales and permeable pavement (Figure 9) added for outdoor water use consumption. The valance unit system heats and cools spaces through convection. The geothermal and ground source heat pumps feature a four-inch-diameter, 1500-feet-deep well. Energy-efficient equipment such as hydraulic fluid free elevators, low VOC materials and occupancy and lighting sensors were installed. The flooring was made of bamboo, with linoleum in linseed oil rather than petroleum products.

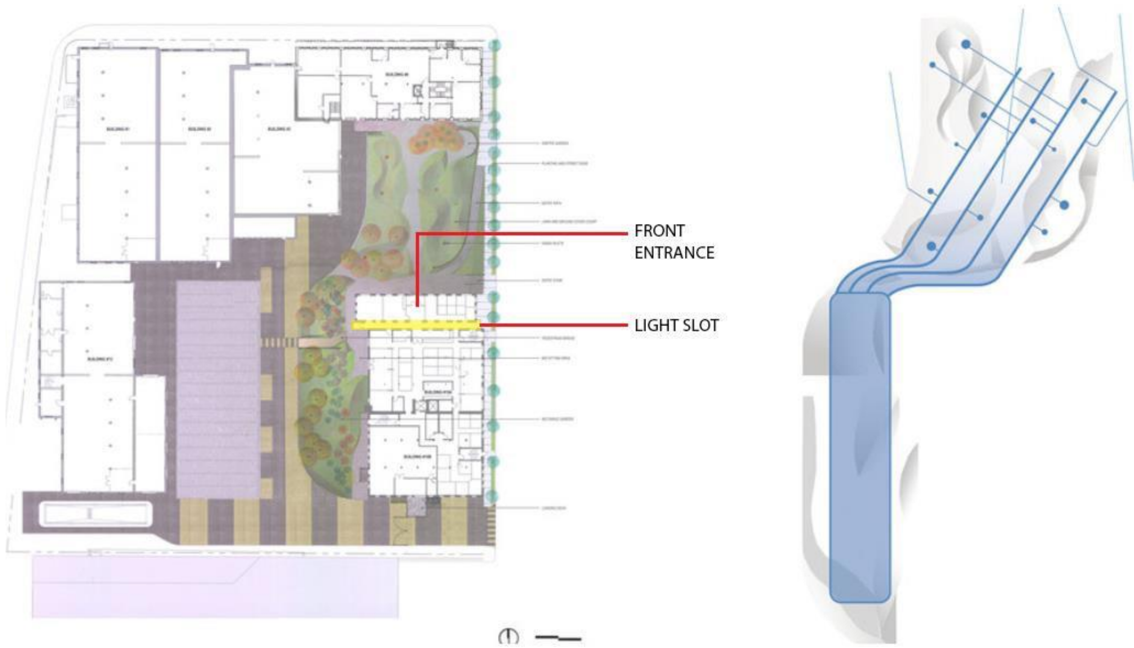

Figure 9. 46 Blackstone Renovation Plan and Drainage Points. Credit: Jean Carroon. Sustainable preservation- Greening Existing Buildings, Hoboken: John Wiley and sons (2010), pp. 153-156.

- Strategies: The inclusion of the vertical light slot connection for the two buildings announces a contemporary intervention within the original framework. The large skylight canopy allows light to penetrate into an interior three-story communicative stairway. New steel studs were installed two inches inside the exterior walls and the walls were insulated with open spray polyurethane foam. New windows and rigid foam on the roof completed the renovated thermal enclosure. An applied Icynene foam insulation reduced consumption and allowed for smaller mechanical systems. The open floor plan encourages interaction among occupants and affords an outdoor view to over 90 percent of the workstations. The building features operable windows for natural ventilation within the interior to maintain a comfortable work environment. The energy star roof reduces occurrences of heat island effect and Xeriscaping, limiting storm water runoff to 37 percent. The recycled material used in the renovation includes structural steel, TPO roof membrane, synthetic gypsum wall

board, concrete with fly ash, aluminum window frames, carpet tiles, ecostone pavers, metal door frames and building insulation. Blackstone is designed to be 45% more efficient than code requires.

4.4 Comparison chart

Based on the observation of these three examples, this chart compiled by the author of this study compares common green design elements used in each project. All the three buildings had some features in common in all the green elements. There are six types of green elements; Sustainable Site, Material, Energy, Water, Indoor and Additional. For example, referring from Figure 10, under the Energy section, features such as renewable energy, internal thermal mass efficient lighting and heat pumps are common in all the three buildings. Regarding sustainable site, all the buildings have bicycle parking, proximity to the different transportations system and use a highly reflective roof. Figure 10 shows that the materials in all the buildings used are low VOC, locally harvested, and can be reused or recycled. All the buildings have operable windows and have access to natural daylight which benefits and improves the indoor environment. Some additional features are used in Indiana Tech and Cambridge City hall are additional insulation and PVC systems.

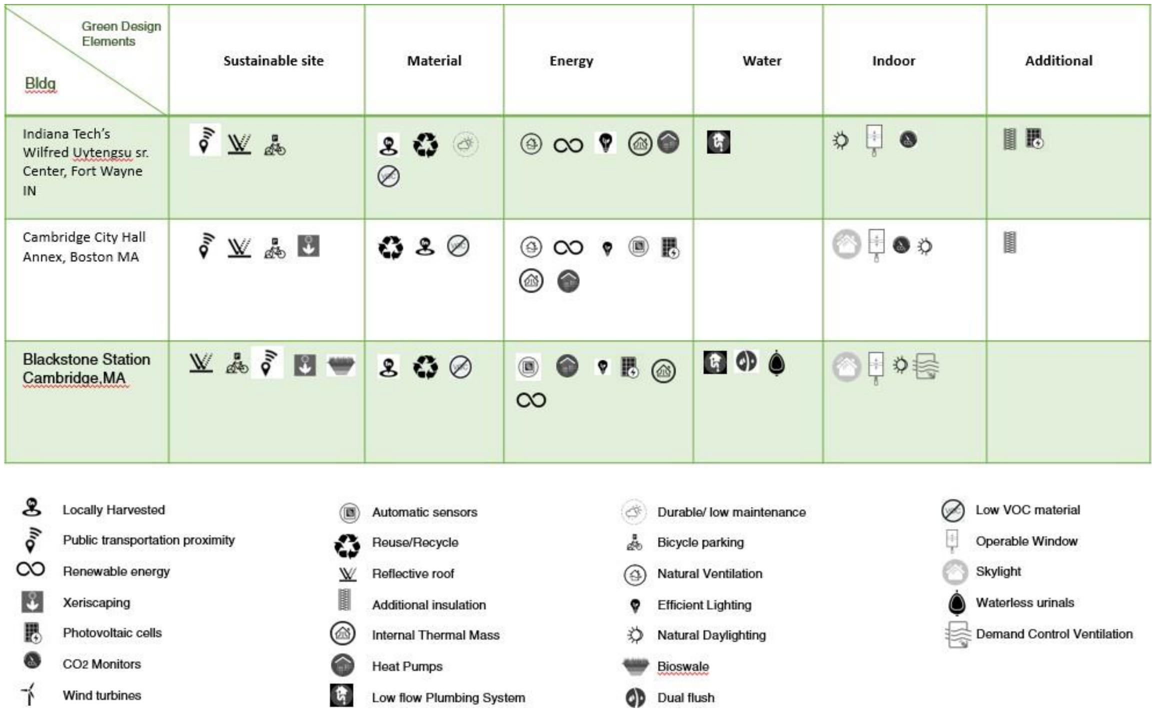

Figure 10. Comparison Chart

CHAPTER 5

SITE STUDY

CLARK HALL, UNIVERSITY OF MASSACHUSETTS

5.1 History

The University's growth was represented by brick and frame residential buildings. The historic buildings along Stockbridge Road developed in two phases with the first phase establishing the Stockbridge house (1728) and the original Durfee plant house (1867). The second phase took place from 1906 to 1909 with the construction of Wilder Hall, Clark Hall, Clark Hall greenhouse, French Hall and French Hall greenhouse. During these years, Stockbridge Road was a tree-lined, pedestrian-scaled roadway that integrated residential and small academic buildings. Modern vehicular access routes, parking, and buildings have changed the scale and landscape of the area over more than two centuries. Designed by architect Frank Irving Cooper, Clark Hall originated in 1906-1907 (Figure 24). The main hall and greenhouse were both constructed in 1907 and designated as two unique buildings. It was built to accommodate increasing student enrollment and was originally housing for faculty offices and classrooms for science and botany research.[10] It consists of two floors over a full basement plus a third-floor attic with partial headroom under a hipped roof. The overall footprint measures 93.5 feet (28.5 meters) by 54 feet (16.45 meters) with an 8 feet (2.43 meters) by 31 feet (9.45 meters) projected bay on each of the east façades. The existing documents from Cooper and Bailey Architects describe a structural system comprised of timber framed floors supported by brick masonry bearing walls. Over time, the lecture hall in the North West corner that was

[10] This information was taken from the website of Campus Planning (University of Massachusetts Facilities). The archives are located on campus at the SCUA Library. May 2009. Accessed October 2, 2017. http://scua.library.umass.edu/archives/Clark%20Hall%20and%20Clark%20Hall%20Greenhouse.pdf.

equipped with sloped seating has been demolished creating a two-story space. A greenhouse was also added on the south side.[11]

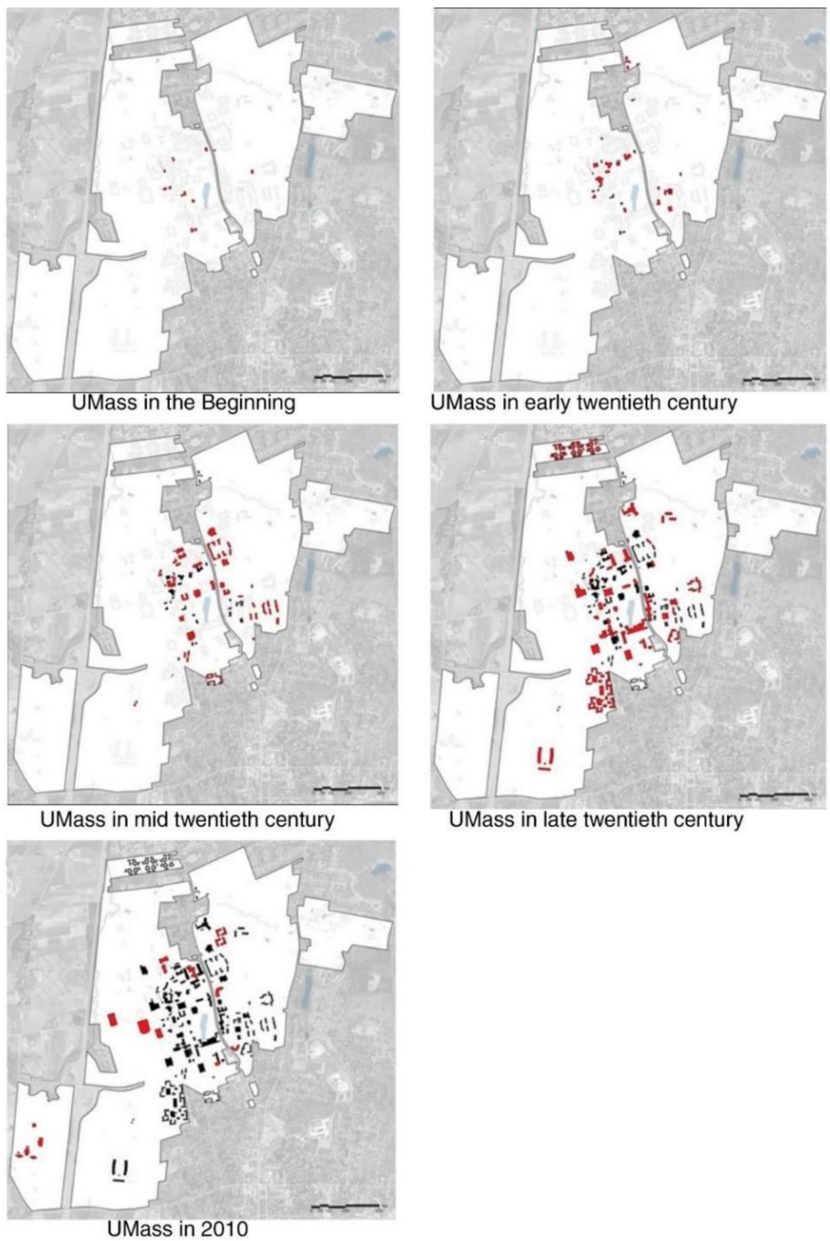

Figure 11. Evolution of University of Massachusetts, Amherst

[11] UMass Amherst Campus Planning. 2012. "Campus Planning." UMass masterplan. April. Accessed October 2, 2017. http://www.umass.edu/cp/master-plan.

5.2 Climate and Weather Conditions

Massachusetts lies in the northern climate zone (cold and humid) with cold winters and warm summers (Figure 12). Frosts are frequent all winter and due to its location, the area is vulnerable to hurricanes and tropical storms. Figure 13 shows that Amherst is characterized by summer highs of around 81 degree F (27.2 Degree C) and winter highs of around 35 degree F (1.66 Degree C) high with high humidity. The climate of Amherst leads to ample precipitation, the accumulation of natural and diffused air moisture, and also evaporation with a lot of vapor and heat loss in the process.

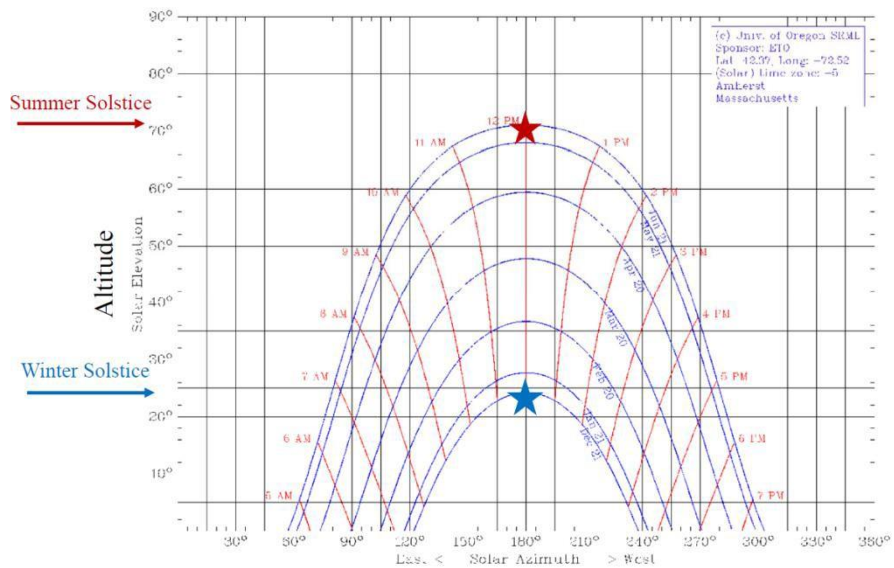

Figure 12. Amherst Sun Chart Diagram. Credit: http://solardat.uoregon.edu/SunChartProgram.html

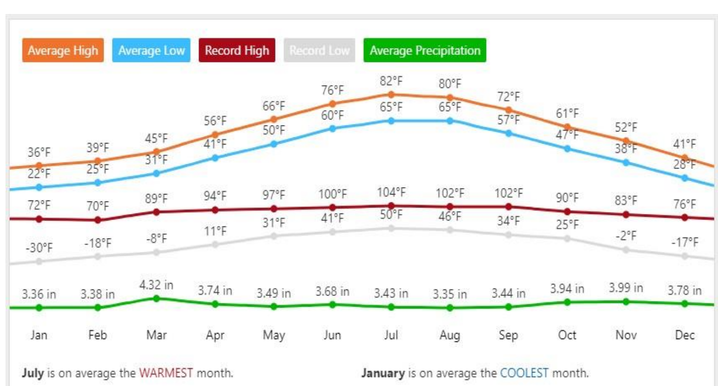

Figure 13. Average Temperature and Precipitation Graph. Credit: https://www.usclimatedata.com/climate/amherst/massachusetts/united-states/usma0009.

5.3 Graphic Site Analysis:

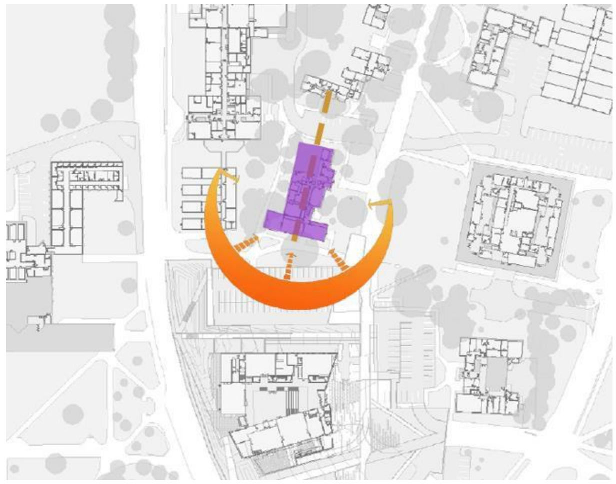

Figure 14. Solar Pattern

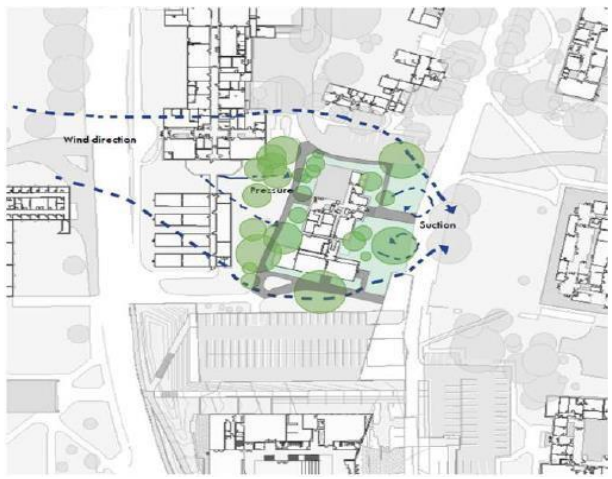

Figure 15. Landscaping

Figure 16. Vehicular Spine

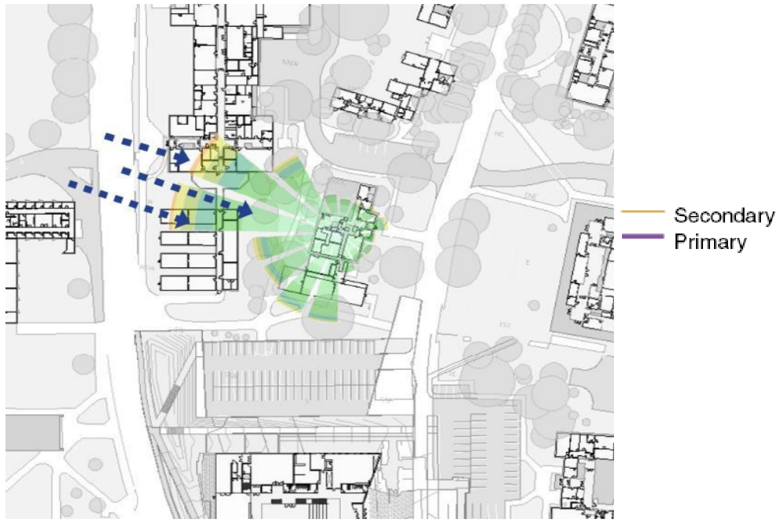

Figure 17. Wind Pattern

Figure 18. Pedestrian Spine

5.4 Site and surrounding context

Clark Hall stands on one side of Stockbridge Road, with Morrill Science Center to the west, the Design Building to the south, Franklin Dining Commons indirectly to the east, and Stockbridge House to the north (Figure 19). The main entrances of the building are on the east and west sides while a basement entrance is on the south side of the building. The vehicular roads (Figure 16) are on the east and north sides of the building respectively while pedestrian paths surround all four sides of the building (Figure 18). In Amherst, the southern side of

buildings receives more sun unless they are blocked by development. To cope with the wind suction on the east side of the building (Figure 15), there is landscaping on the west side which decreases the pressure. Figure 20 shows a comparison of the building's shadow formation during the summer and winter solstice during the time period 8:00am – 12:00pm. The comparison results will be used to address the problems of natural daylighting and HVAC during the new design phase. The result shows that the south side gets more sun; the accumulated natural light and heat of the interior space gradually decreases towards the north side (Figure 14). Figure 15 shows that the preserved trees from mid-18th century are used as a passive shading strategy for the existing Clark Hall.

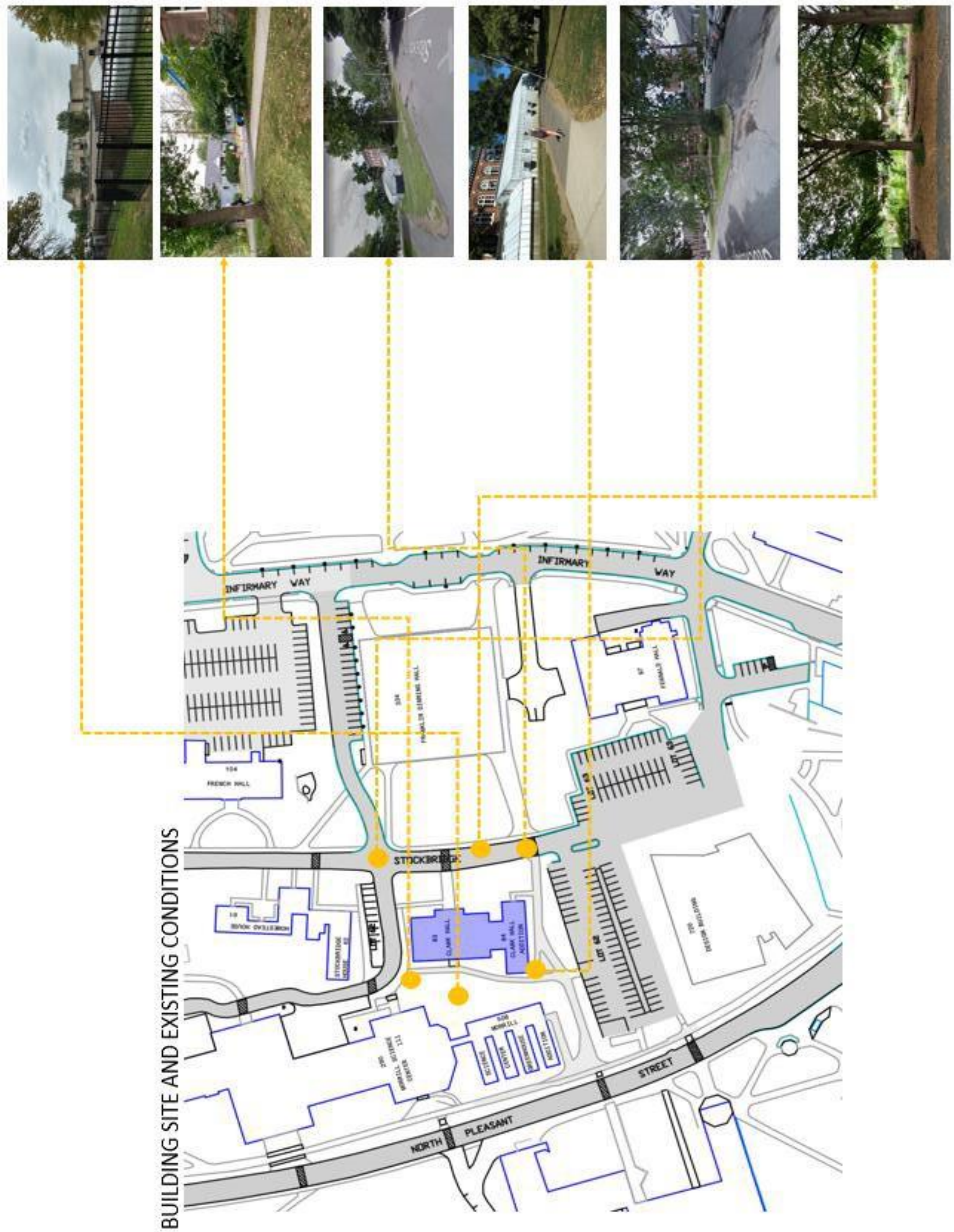

Figure 19. Clark Hall Surrounding Context

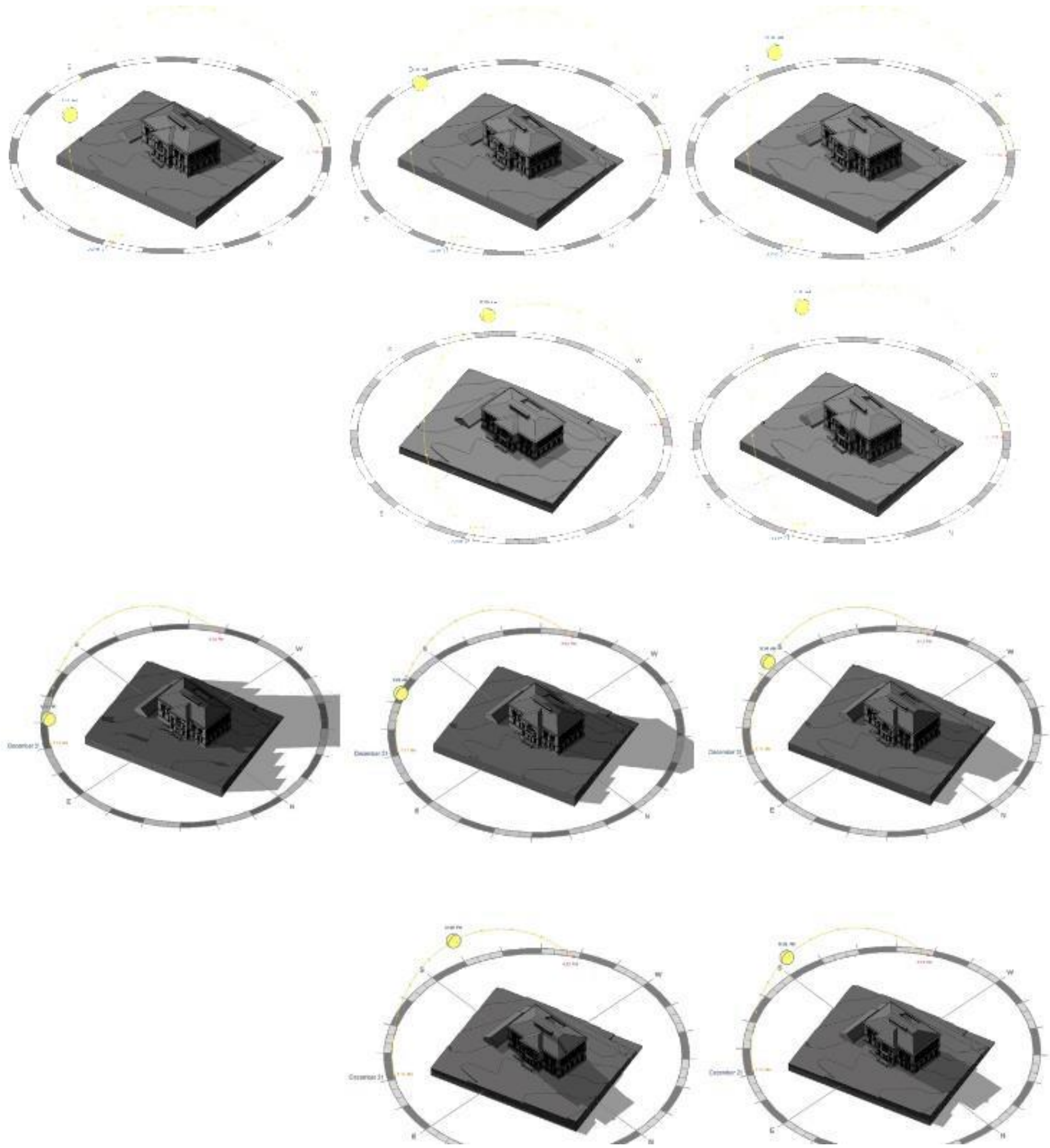

Figure 20. Shadow Formation of Summer Solstice and Winter Solstice.

5.5 Building Tectonics

The exterior wall and concrete interior spread footing foundations are cast in place. The foundation walls appear to be brick with some granite exterior along with the interior basement

piers. The interior brick bearing wall is 4’-4” (1.34 meters) thick constructed with a twelve-inch outer thickness interconnected with cross walls creating a series of two-foot-four-inch heating and ventilation shafts. On the first and second floors there is framing consisting of twelve-inch and fourteen-inch deep hard pine joists supporting wooden plank floors. Large timber beams carry the joists along with a few steel beams and the brick walls (Figure 21). There are a few steel pipe columns but most interior posts are six-inch or eight-inch square timber. The joist on the third-floor attic are arranged similarly except the joists are two-by-twelve-inch spruce. Heavy timber and story high-timber trusses combine to form the roof. Lateral stability for Clark Hall is achieved by interior and exterior unreinforced masonry bearing walls. In historic buildings, chimneys are very common. In Clark Hall, these were used for natural heating and ventilation. As shown in Figure 23, the fresh air comes in from the windows and the chimney. The building is ventilated through the chimney while in cases of heating, an underground radiator distributes the hot air through the chimney to each space through vents.

A shadow study was carried out on the building (Figure 20). The times set to cast shadows were 8:00 am, 9:00 am, 10:00 am, 11:00 am and 12:00 pm. This time period was set for both the winter and summer solstices. On analyzing the study, it was found that a 12:00 pm setting cast the least amount of shadow and the 8:00 am setting cast the most amount of shadow during both the summer and winter solstices. However, the area covered by the shadow was much greater in the winter solstice than the summer solstice. This analysis was done to determine the size and the position of overhangs needed for the windows on the south side.

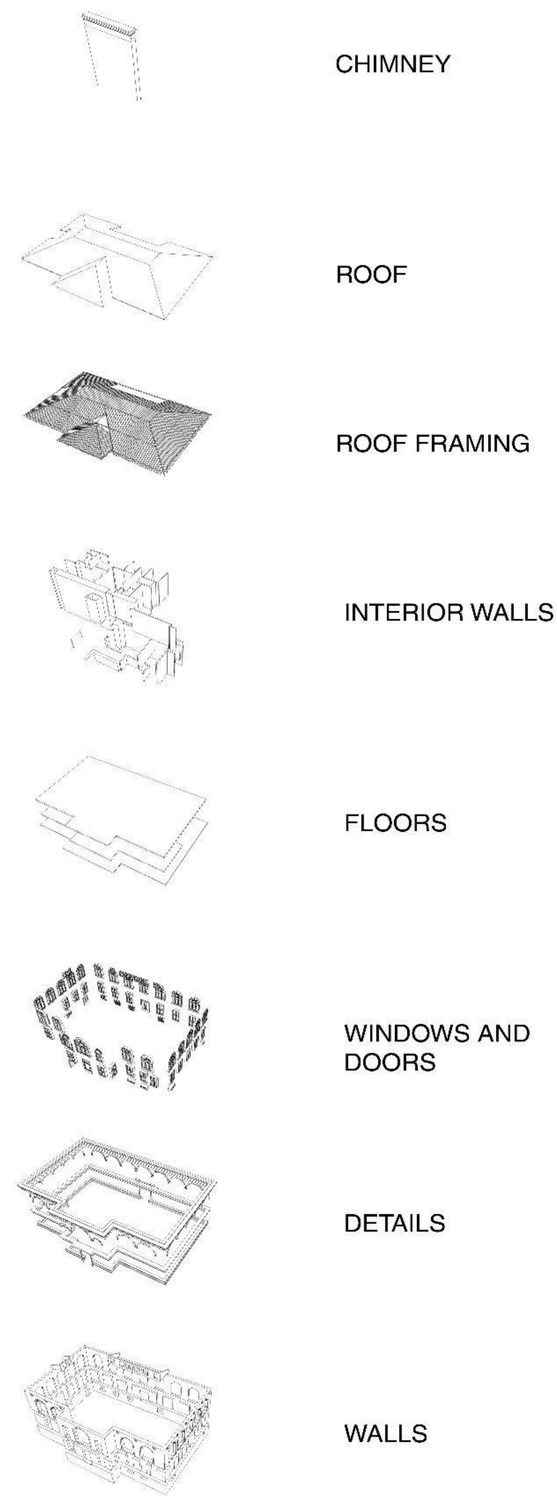

Figure 21. Axon view of Building Tectonics

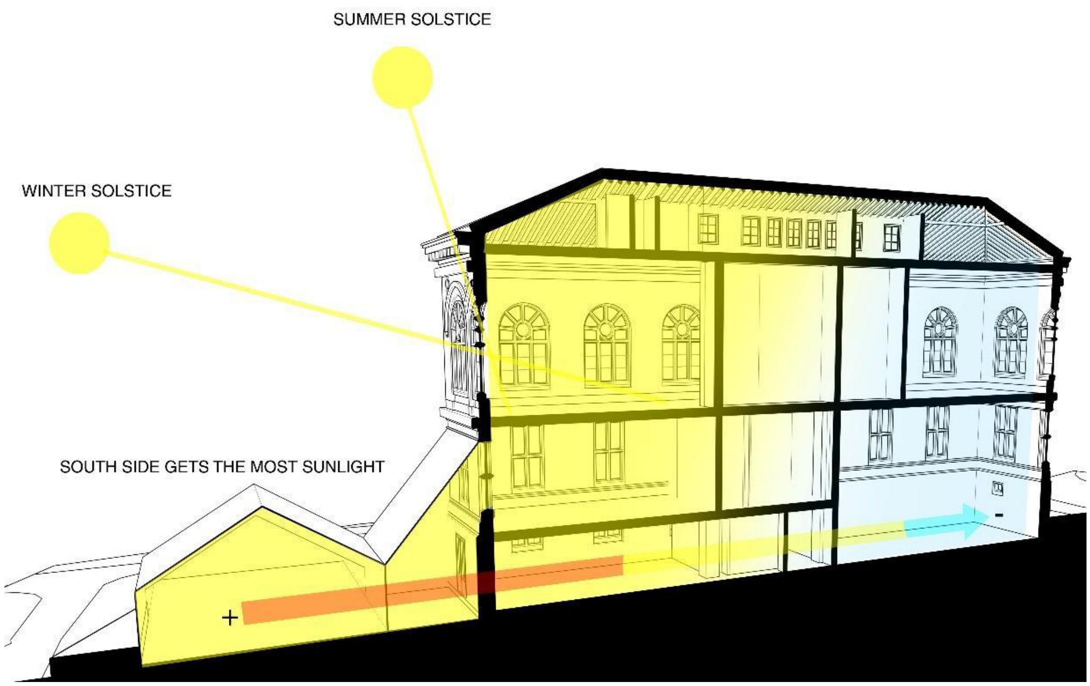

Figure 22. Heat and Light Gradient through the building

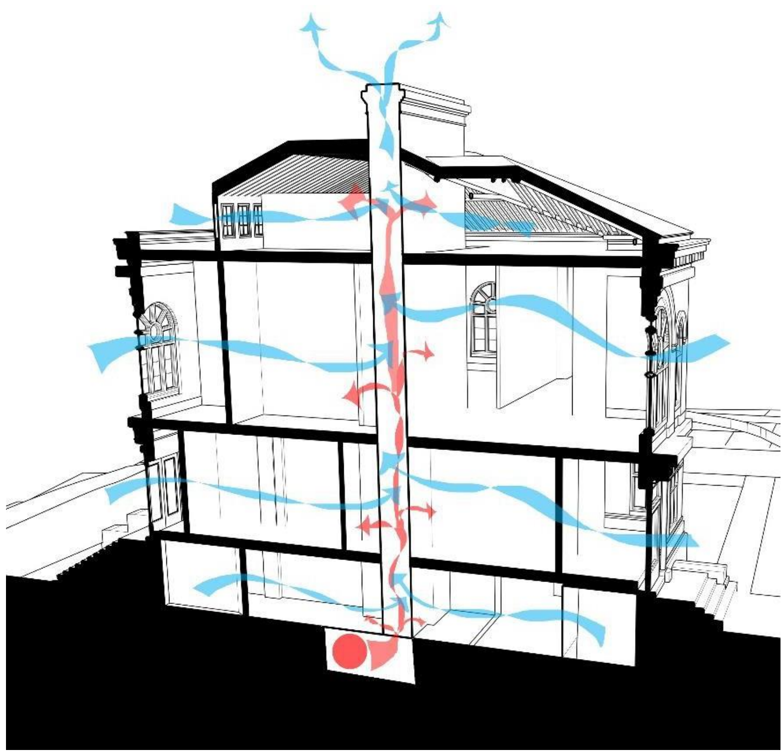

Figure 23. Existing Natural Ventilation and Heating through Underground Radiator

CHAPTER 6

DESIGN IMPLEMENTATION

6.1 Programming

To determine a logical next-use program, the author of this study consulted with Pamela Rooney, the Assistant Director of Space and Asset Management in the Campus Planning Department. Through this process, it was identified that there is a need on campus for additional academic office space. Studying the University of Massachusetts requirements and the existing properties of Clark Hall, a program prospectus was developed to outline quantities and qualities of new programmatic spaces.

6.1.1 Existing program

According to Pamela Rooney, the University has their own requirements for any prospective office space. Upon analysis, offices were found to be subdivided into three types of spaces: the receiving area, office space and seminar or meeting space. The receiving area consists of a reception or lobby, the office spaces are employee workstations which can either be open or closed and seminar or meeting space are places where the meetings or conference takes place depending on the number of people. According to University square feet requirements, Clark Hall could accommodate office spaces for staff (administrators), faculty and graduate students for a range of 6-8 staff members and 18-20 people in total. The university requires that the spaces should be designed for flexibility and balance between both closed and open workstations. The space allocated for seminar or meeting spaces are a mix of small, medium and large. The small spaces accommodate six to eight persons, medium accommodates ten to fifteen persons and a large space can accommodate up to thirty persons. Per best practices, University office regulations necessitate access to daylight and external views. Hence

there is a preference for transparent partition walls. The University also has standard space requirements assigned for each space mentioned below (Figure 24). The areas are categorized according to the number of occupants for a space (Figure 25).

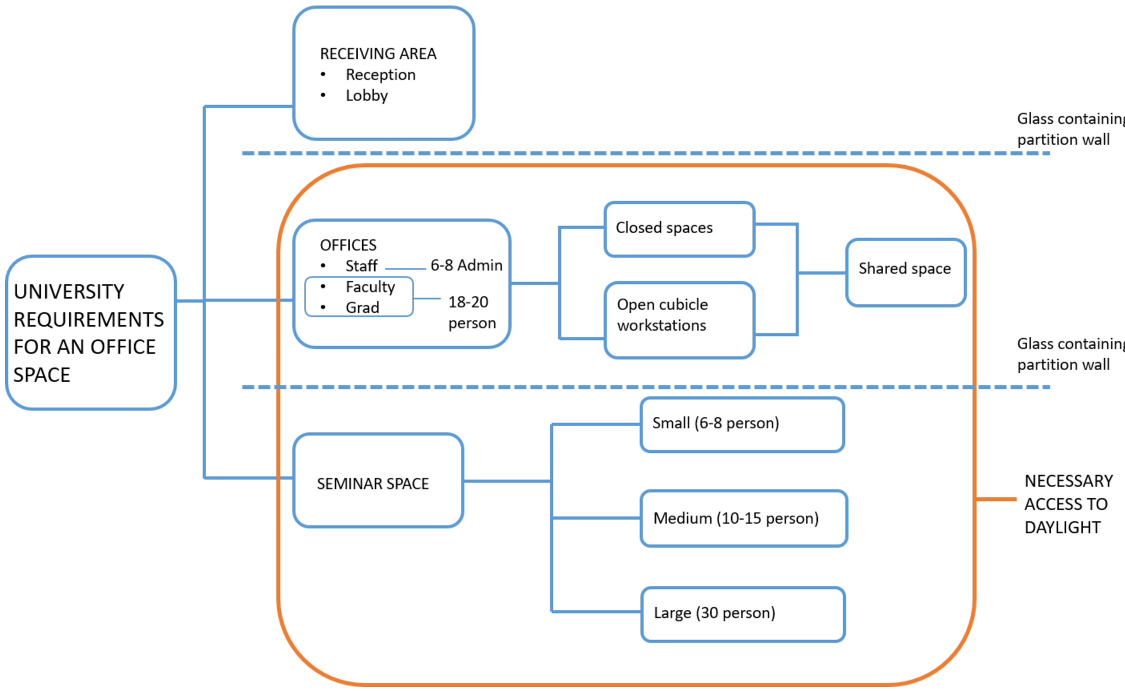

Figure 24. University Space Requirements

BASIC PROGRAM AREA REQUIREMENTS		
SPACE	PERSON	AREA
PERSONAL OFFICE	1	120
OPEN CUBICLE	1	55
MEETING ROOM	SMALL (6-8)	250
CONFERENCE ROOM	MEDIUM (10-15)	500
SEMINAR ROOM	LARGE 30	800
RESTROOM		100
LOBBY	SMALL(6-8)	350
WELCOME LOBBY	MEDIUM(10-15)	800
CUSTODIAL		40

ADDITIONAL PROGRAM REQUIREMENTS		
SPACE	PERSON	AREA
MECH ROOM		
CAFÉ	8	250
INDOOR GARDEN	SMALL (6-8)	250
PANTRY	SMALL (6-8)	80
FILE/COPY ROOM		60

Figure 25. University Basic and Additional Area Requirements

6.1.2 Intended program

After studying the existing program, the author developed three kinds of elements according to their intended use and users: Public, Private and Semi-Public. The public element considers the needs of the general public, the alumni, the students, the office employees and the different department employees; these different users are accommodated in a single space in which they can gather at different events which can take place at a variety of times. The private element considers the needs of the faculty and the graduate students who contribute and work at the University during office hours. The semi-public element facilitates the collaboration between the different departmental employees, the office workers, the students and the alumni where they can engage in University related work.

The relation between the three is complicated by the different accessibility of the different users. For example, the users of the private elements have access to all the spaces as they can participate in events and collaboration. By contrast, the users of the public elements have no access to the private elements and little access to the semi-public elements. Regardless of the level of access, all the spaces need to be day lit, insulated and ventilated as per the university requirements. There are 3 floors in this building, with the first floor easily accessible for public use. The second floor is semipublic, which both the public and employees can inhabit. And the third floor is isolated from the public and is only accessible to the employees.

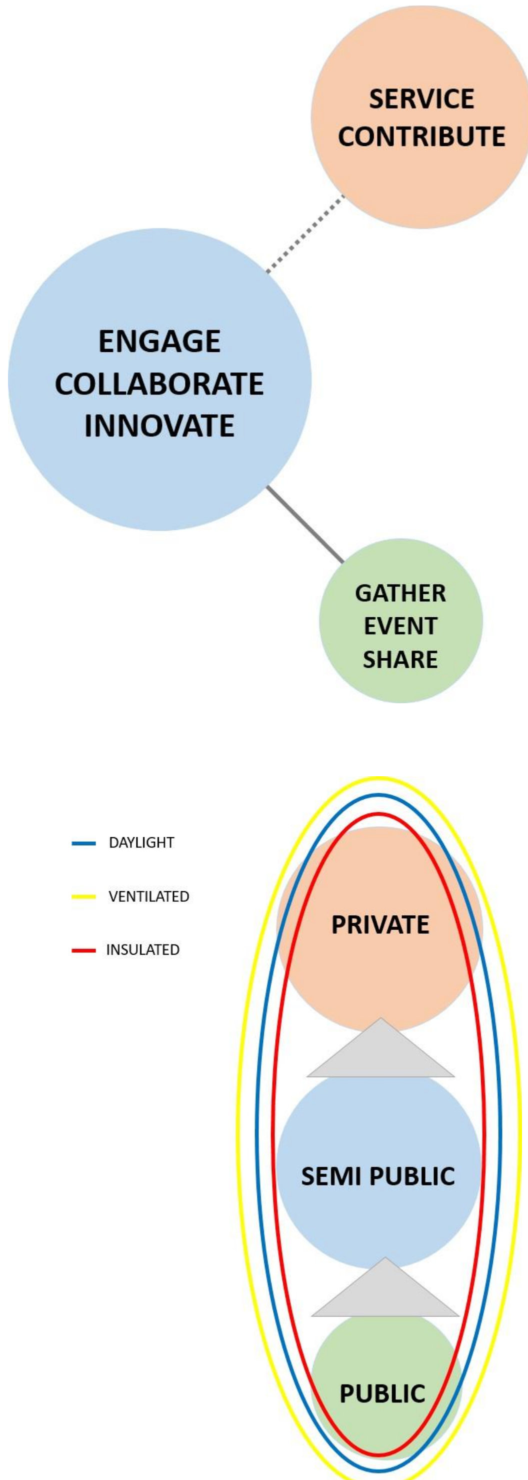

Figure 26. Intended Program Overview

BUILDING PROGRAM

GROUPING	NAME	AREA PER UNIT (S.F)	OCCUPANTS	QTY	TOTAL AREA (S.F)
PRIVATE	**OFFICES**				
	CLOSED WORKSTATION	120	6	4	480
	OPEN WORKSTATION (FACULTY)	55	15	15	800
	OPEN WORKSTATION (GRADUATE)	55	10	10	550
	PANTRY	80			
	FILE/COPY	60		2	120
	PRIVATE LOUNGE	500	10 TO 15	1	500
	PRIVATE CONFERENCE	350	6 TO 8	2	700
	PRIVATE MEETING	350	6 TO 8	1	350
	TOTAL PRIVATE AREA (S.F)				**3500**
SEMI PUBLIC	**COLLABORATIVE SPACES**				
	MEETING	250	6 TO 8	2	500
	CONFERENCE	400	10 TO 15	2	800
	WORKSTATION (ADMIN)				
	OPEN	55	10	1	550
	CLOSED	120	1	1	120
	MEETING	250	6 TO 8	1	250
	LOBBY	100			100
	TOTAL SEMI PUBLIC AREA				**2320**
PUBLIC	**EVENT SPACE**				
	LOBBY/ CAFÉ		10 TO 15	1	500
	SEMINAR		30 PLUS	1	1000
	INDOOR GARDEN				
	TOTAL PUBLIC AREA				**1500**
MISC	RESTROOMS	120		8	960
	MECHANICAL			1	1000
	CUSTODIAL	55		4	220
	TOTAL MISC AREA				**2180**
	TOTAL BUILDING PROGRAM (S.F)				**9500**

Figure 27. Intended Program

6.2 Renewable Strategies

For this renovation of Clark Hall, the recommendation is to implement both the strategies, Passive and Active. Passive strategies are carried out in/on building envelope, daylighting and ventilation, whereas the Active strategies are applied in the building systems in the heating and cooling of the building.

6.2.1 Building Envelope

The envelope of the building consists of foundation, walls, windows, roof/ceiling and doors. These five components of the envelope distinguish between the old and new to highlight the recommendations implemented on each parts of the building envelope.

6.2.1.1 Foundation

Foundation is comprised of floor slab and walls. The existing floor was a 6” concrete floor slab with epoxy coating, while the walls are 1’-4” thick brick bearing walls. The basement floors needed to be insulated and sealed to manage moisture inside the building and stop the groundwater from entering. The best way would be to insulate with a floating floor over existing slab with a drainage layer between insulation and the existing slab. In Figure 28, a drainage mesh or dimple plastic mat is installed over the existing slab and then covered with rigid foam and a floating subfloor. The above slab drainage layer must be connected to an interior sump pit which should be airtight with a gasketed cover; the assembly and the cover are designed to provide a dual function of keeping soil gases out and preventing groundwater from entering. The walls however should take a spray foam retrofit approach where 4” spray foam is applied on the interior of the existing wall assembly and then covered with smart membrane to regulate the moisture inside the building.

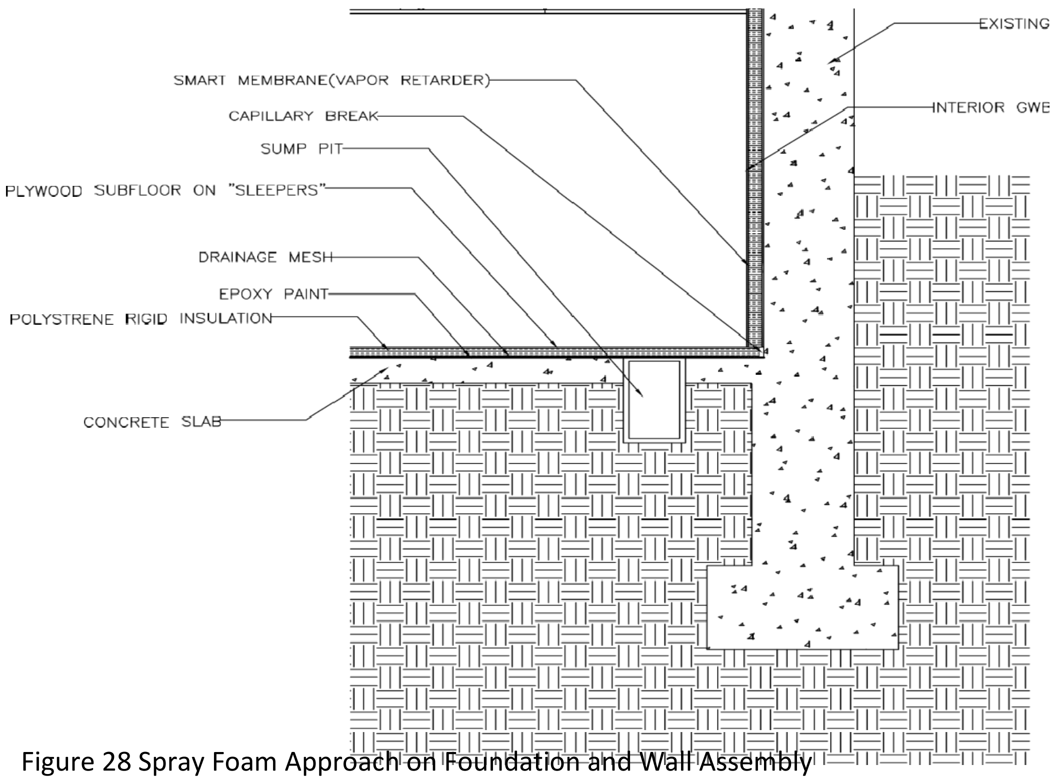

Figure 28 Spray Foam Approach on Foundation and Wall Assembly

6.2.1.2 Walls

Two-thirds of the building façade was preserved to retain the historic properties of the building. Clark Hall has load bearing brick walls with 2’-2” thickness on the first floor and 1’-1” thickness on the second floor. The wall assembly on each floor has brick as an exterior layer and gypsum board as an interior. The idea is to achieve an optimal insulated space with minimal air infiltration/exfiltration. With a high R-value in the exterior wall, the building was insulated with 4” open-celled spray foam which seals up all the leaky brick shells. Spray foam acts both as a thermal barrier and vapor barrier, minimizing the thermal bridging issues. It has a permeability of 13 perms and thermal resistance of almost R-20. Application of smart membranes over the spray foam aids in controlling moisture laden air infiltrating the wall cavity during the winter

while its change in permeability during the summer season presents an opportunity for drying to the interior when the drives reverse should condensation within the assembly have occurred. Hence the wall assembly from exterior to interior would be brick, open-celled spray foam, smart membrane and interior gypsum board as shown in Figure 28. The overall exterior wall system provides an R-value of 24. Due to addition of insulating material and other assembly components on the existing assembly, the wall thickness increased by 4" on each floor.

6.2.1.3 Windows

The windows selection depends on the U-factor, the Solar Heat Gain Coefficient (SHGC), Visible Transmittance (VT), Air leakage and Condensation Resistance (CR) as shown in Figure 30. The rate of heat loss is indicated in terms of U-factor. The lower the U-factor, the greater the windows resistance to heat flow and the better its insulating properties. The SHGC is the fraction of solar radiation admitted through a window. The lower the SHGC, the less solar heat it transmits and the greater it's shading abilities. The visible portion of the spectrum that passes through a glazing material is called VT. If the building is designed properly then higher VT can offset the electric lighting and cooling loads. The CR measures how well a window resists the formation of condensation on the inside surface. The standard glass and glazing are insulating glass with low E2 and argon/krypton gas. Insulating gases are pumped into the space between panes of glass to slow the transfer of heat, increasing the insulating power of a window or a door. The addition of these gases lowers the U-factor and increases the insulating capabilities in narrow airspaces.

Clark Hall has two kinds of historic windows- rectangular and arched. The existing windows were single paned wood window systems. All the existing window openings were maintained in an effort to retain the historic nature of the building and bring in as much daylight as possible. The use of splayed windows should allow the light to cover more interior space. The

rectangular clerestory windows were replaced with Marvin historic replacement windows which are double-pane Low E2 metal-clad wood windows with an integral thermal break system. However, the arched clerestory windows should be preserved to maintain the historic legacy hence, Innerglass Window Technology should be used similar to that in Figure 29. It also helps in noise reduction, saves money and energy, and has compression fit to eliminate the air leakage effectively. The window system which should be adapted for Clark Hall must be Low-E double pane glazing with higher SHGC in the west elevation while the lower SHGC on all other elevations.

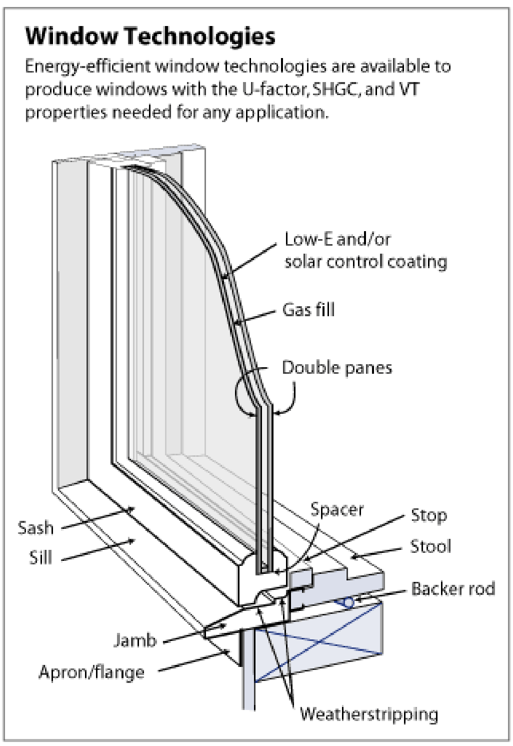

Figure 29. Low-E Window Assembly. Credit: Innerglass Window Systems, LLC,

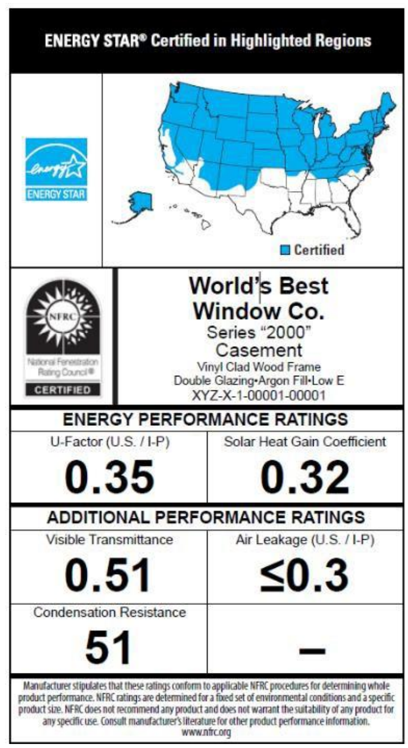

Figure 30. NFRC Labels on Window Units Ratings Credit: www.energy.gov

6.2.1.4 Roofing System

The roofing system is comprised of timber framing with the roof underlayment on top which is covered with slate shingles. In cold climates similar to that of Amherst, unvented roof systems should be used because it facilitates the control of ice dams, moisture accumulation, and heat gain or heat loss. The approach to this kind of roof is accomplished by the installation of an air barrier system across the roof system to eliminate exfiltrating air. In places that belong to climate zone five, such as Amherst, Massachusetts, an additional vapor retarder is necessary to supplement an air barrier. According to Straube for thermal resistance in cold climates, a high density rigid spray foam insulation is applied. In order to control ice damming caused due to snow accumulation, heat flow from the interior to the roof cladding must be minimized and to do so an R-value of the entire unvented roof should be R-40 to R-50. Underneath the interior high density spray foam, gypsum board is used to meet the code requirements for occupancy in an attic space. Figure 31 shows the principle behind new energy-efficient roof systems where the existing roof is closed with spray foam insulation but the thickness of the spray foam is determined by the minimum total R-value in the given climate zone.

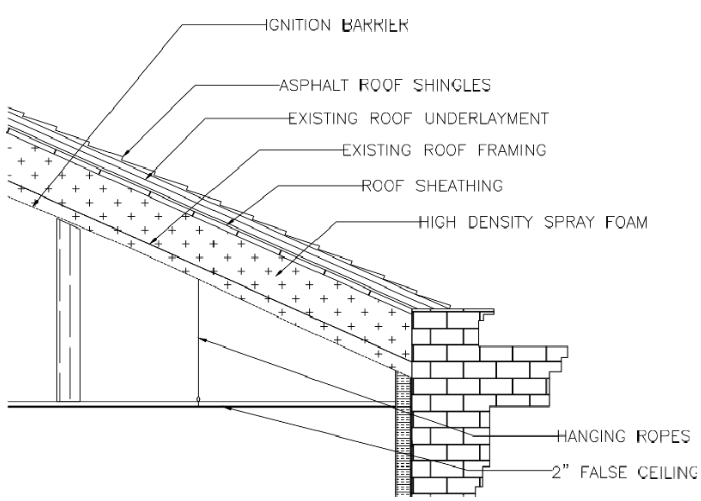

Figure 31. Spray Foam Approach on Roof Assembly

Mineral fiber ceilings are used in this building as it is 100% recyclable and has a positive effect on indoor environmental quality as it is highly acoustic, highly reflective and made of low VOC material. It delivers the highest level of post-consumer recycled content. Stone-coated metal-roof shingles are used to stimulate the look of authentic terracotta tiles. This type of shingles is highly durable and resistant to fire and wind. They are very energy-efficient and the shingles interlock for added strength. The overall R-value comes out to be R-40 for this roofing system.

6.2.1.5 Doors

The existing exterior doors were wooden doors which were not insulated or weather stripped. The exterior doors were not weather striped nor were they insulated. All the historic exterior doors were replaced with highly efficient weather stripped doors to avoid any infiltration or exfiltration. Some of the building interiors are comprised of curtain wall system and the doors installed are a part of the curtain wall. Opaque interior partition walls, such as the restrooms and mechanical room are equipped with two panel wooden door.

6.2.2 Daylighting

Allowing sunlight into our building decreases the need for electric light and heating loads, but at the same time can cause challenges like increased glare and increased cooling loads. If solar heat gain is properly channeled, there would be significant energy savings for heating and cooling and daylight could provide approximately 70 percent of a building's lighting energy.[12] To reduce the total amount of radiation entering the room, shading is provided. Solar control is particularly important on the south to west facing facades for buildings with large areas of glazing. By providing shading with components such as overhangs occupant comfort

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[12] *Norbert Lechner.* Heating, Cooling, Lighting: Design Methods for Architects*. Fourth edition. Hoboken: Wiley Blackwell (2008), p.p. 403.*

can be improved in the interior spaces. This strategy can also reduce the building's energy usage. Overhang geometry calculations can be run according to sun angle and then can help determine the size of the overhang needed to control the amount of radiation exposure on the building.

Shading devices such as overhangs are provided in the south side to all the windows and the glazing system. According to the Overhang calculation in Figure 16 the size of the overhang calculated comes out to be 3'-2" in Figure 33. The glazing system in the west side is electro-chromatic to avoid glaring from the afternoon sun while the other elevations have a normal Low- E double pane glazing. LED fixtures were used which consists of a combination of 2x2 lay in style fixtures and some recessed cans. All the fixtures are dimmable and provide full user control in each space with on-and-off light switches and installed occupancy sensors. It also controls the set-back periods and optimizing schedules to meet actual needs. Sufficient amounts of natural light will penetrate into the building due to the original generous window to wall ratio. The curtain wall system on the east and west wings also allows natural light into the building. The self-adapting sensors are accurate in detecting the occupancy in the space. Daylight harvesting sensors automatically control the lighting levels in spaces with large amounts of natural daylight.

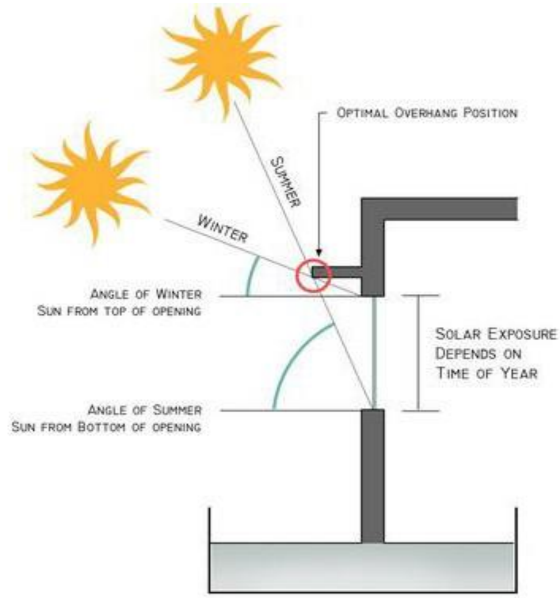


Figure 32. Basic Shading Strategy. Credit: https://www.tboake.com/carbon-aia/strategies1b.html

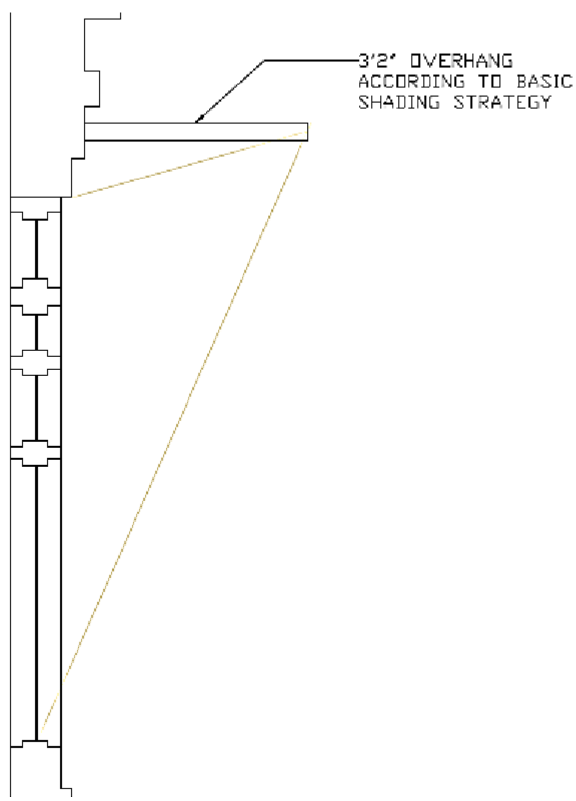


Figure 33. Overhang Calculation

6.2.3 Ventilation

This passive cooling strategy is cross ventilation. The air circulation inside the building is driven by the prevailing winds and breezes. It impacts the indoor air quality by bringing in fresh air. Operable Transom windows as a cross ventilation strategy are used in the interior partition walls where the air circulates to every space creating comfort within the building. This is done by studying the wind conditions of a particular place. The transom windows highlighted inside the red rectangle in Figure 34 allow fresh air distribution across the building. To ensure the proper distribution of pressure an open floor plan is preferable because partitions increase the resistance to airflow thereby decreasing total ventilation.

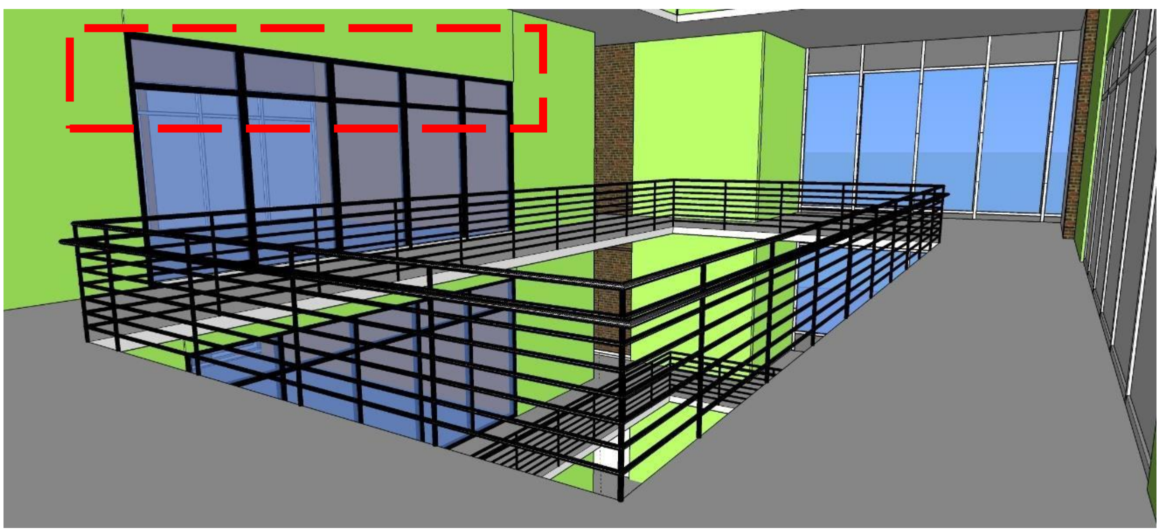


Figure 34. View of the Operable Transom Windows installed in the Interior Curtain Partition Wall near the Atrium

6.2.4 Air Conditioning

An active strategy is adopted for Mechanical System of this building. A Small Duct High Velocity (SDHV) AC systems would be a good implementation. Their function doesn't require an extensive buildout because they use a cooling module which also acts as a sound absorbing

material and provide a draft free operation. In addition, they do not disrupt the building interior or exterior. The advantage to using SDHV is to meet the demand of desired amount of climate control throughout the building. This allows a more individual control by separate thermostat.

6.2.5 Heating

The heating in Clark Hall is one of the active strategies applied and it comes from the steam, is supplied from the University Central Heating Plant. The plant provides 100% of the steam that is needed for heating for buildings across campus.[13] The original steam radiators are present in the building and will be reused.

6.3 Design Strategies and Intent

There are three intellectual influences shaping this project: philosophies of use and inhabitation informed by Stewart Brand's work; insights on performance, climate and adaptation compiled by the Building Science Corporation Digest articles as well as Lillian Wong's concepts of adaptive reuse; and lastly formal design strategies such as the concept of insertion and juxtaposition outlined by Francoise Bollack. These three are integrated with the analyses of similar precedent studies to create a foundation for pursuing the Clark Hall adaptive reuse project. The intended inhabitants range from employees to the general public, and from students to professionals. The intent in using these design strategies was to provide a comfortable space for the inhabitants which increases the chances of productivity among the employees as well. The renovated building will be well-lit, ventilated and insulated. These strategies will also help in the reduction of water and material. The material waste would be reduced by recycling the waste material produced during the demolition of the middle block of Clark Hall as described in the next section.

[13] https://www.umass.edu/sustainability/climate-change-energy/central-heating-plant

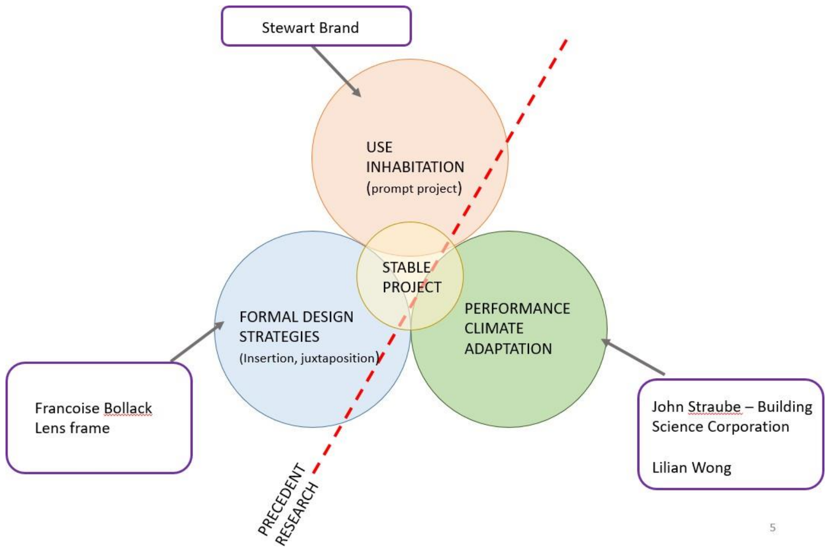


Figure 35. Design Strategy

6.4 Building Concept

The original building is physically divided into three blocks. In this design proposal, the middle block is removed and a new block is inserted in between the two existing blocks (Figure 36). The newly inserted block contains lines of circulation which run through a central void that replaces the eliminated middle block. The void divides the circulation path and those moving through the building to the two respective sides of the building. The building form results in the addition of two wings which are placed in the east and west sides of the building. The idea was to juxtapose the newly inserted parts into the old “language” of the building. The original building was orientated on an E-W axis, but after the addition of the wings it became a symmetrical building and the new orientation is in N-S axis. The building is divided into three groups, and each group is placed on each floor. The public group is located on the first floor, the semi-public group is placed on the second floor and the private group is placed on the third floor (Figure 37).

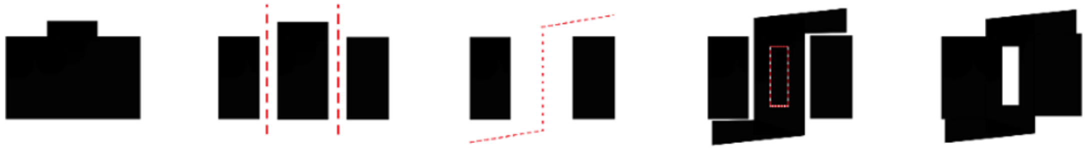


Figure 36. Design Concept

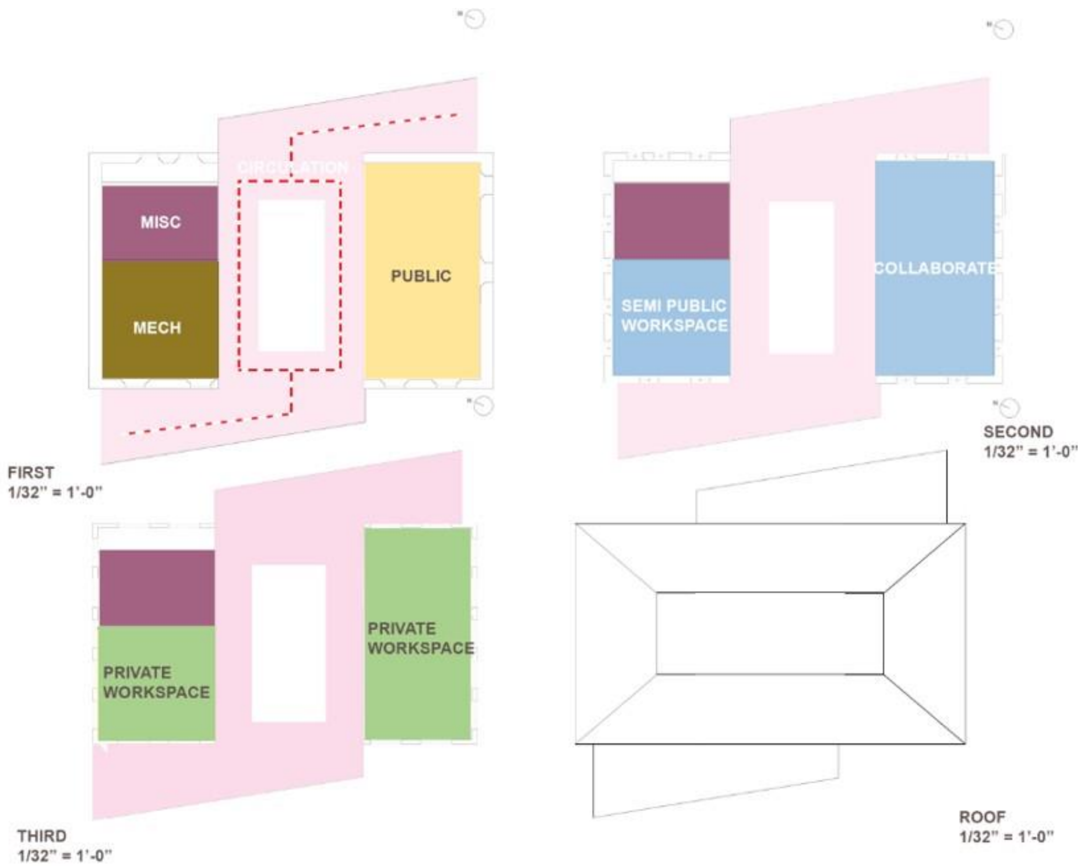


Figure 37. Design Program and Layout

6.4.1 Water Improvements

As Michael Lubbenhusen and Terry Hornsbury observe in the reconstruction of the Wilfred Uytengsu Senior Center, “The aim is to reduce the amount of rainwater runoff by using it as a resource for the buildings landscaping.” Applying Lubbenhusen and Hornsbury’s insights, this project implements drought tolerant and native landscaping for the collection of stormwater runoff from the building to be repurposed in a 1570 Sq ft. rain garden on the south side of the building. As the designers of the Uytengsu Senior Center did, this project, in order to minimize water usage, also installs low flow fixtures with 1.2 gallon per flush water closets, waterless urinals and a sensor based metering faucets. The problem of water stagnation was addressed with water porous concrete pavement.

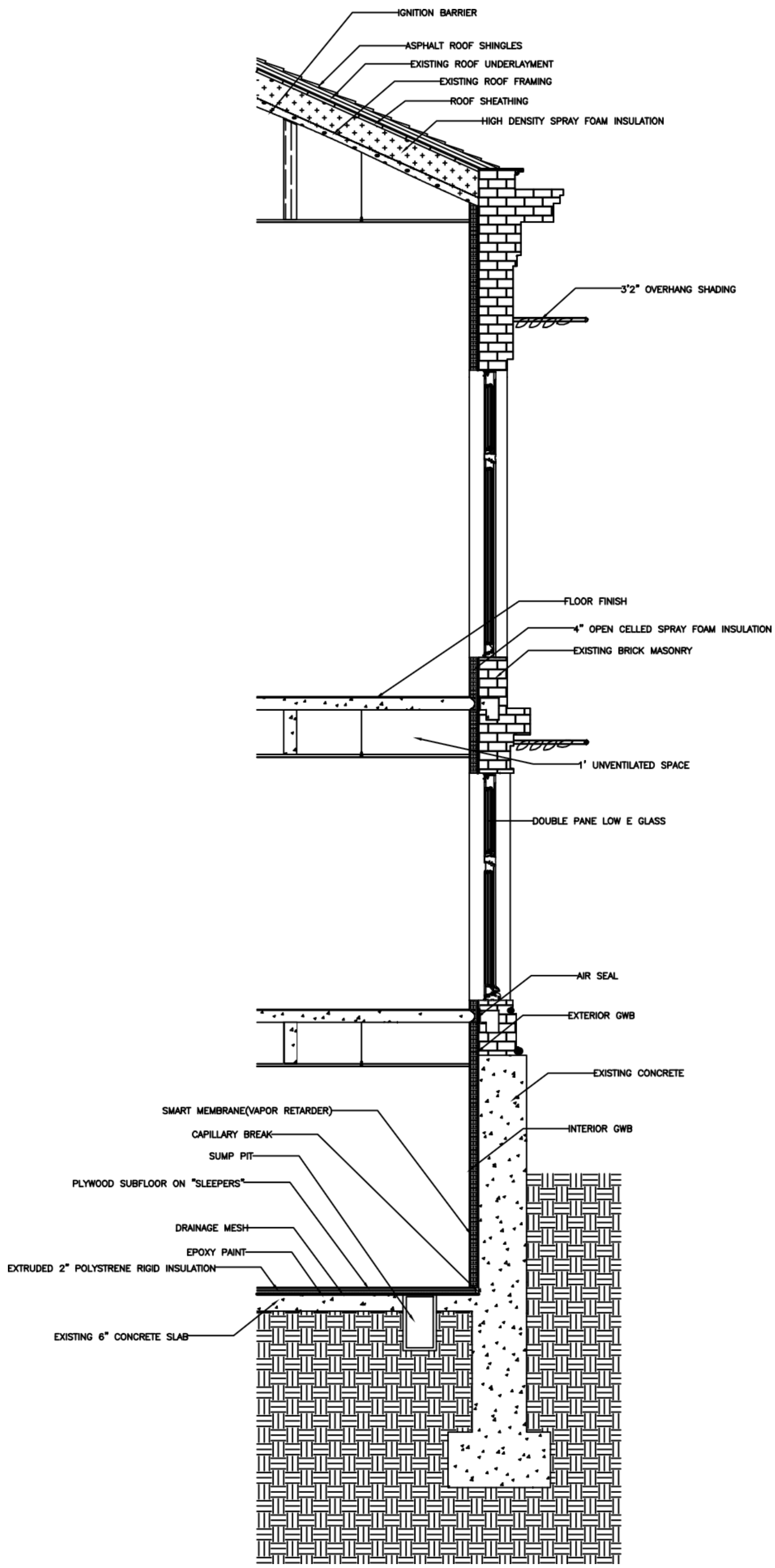


Figure 38. Wall Assembly

Figure 39. Rain Garden towards the South of the Building.

6.5 Building Overview

The building has two entrances. One from the east side directly entering the second floor and one in the west entering the first floor (Figure 40). Both entrances have ADA access. The site access points and the existing roads were kept unchanged. The pavements leading to the building are all made of porous concrete. The building's interior stresses spatial layering and visual transparency with ventilated fresh air circulation throughout the whole building (Figure 41). On the first floor when entering from the west, the users find themselves in a large atrium or gathering at a Zen garden in the middle (Figure 42). It provides a peaceful and a tranquil place for the users, along with a café for relaxation which provides a break from their busy schedules. Various sections of the walls are enclosed with glass so as to let maximum daylight in. The use of operable transom windows inside the space leads to cross ventilation. The atrium is two-stories high and provides a view to the Zen garden from the topmost floor. This establishes sightlines internally and externally, horizontally and vertically between the floors and the rooms. All rooms have operable windows to let fresh air in. These elements prompt the users to explore the building beyond their individual workspace. The building has an open-plan layout for flexibility

and is designed to allow for repurposing in the future to accommodate alternate programs that necessarily change over time. All the offices are on the third floor and that is only accessible for the employees and public access up to the second floor as the second floor has big conference rooms and have an admin office which basically manages events and provides information to the public.

Figure 40. Site Plan showing the Renewable Strategies applied on the Site

Figure 41. Renewable Strategy adopted inside the Building

Figure 42. View of the Atrium comprising of Zen Garden

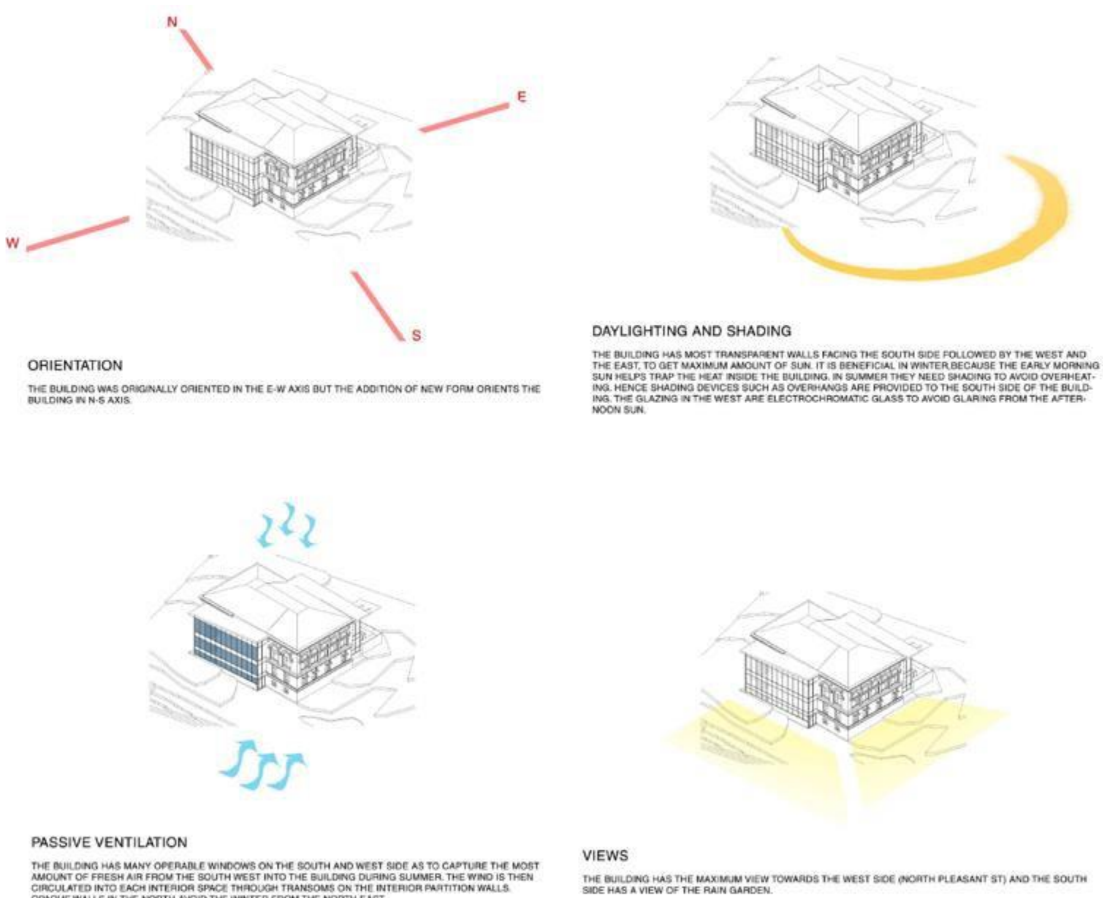


Figure 43. Passive Strategies Overview

6.6 Building Simulation

During the design development phase, a building simulation was carried out in eQUEST. The results were quite astonishing as they demonstrated that all the interventions imposed on baseline model resulted in an Energy Use Intensity deduction from 58.60 kBtu/sf/year to 27.21 kBtu/sq.ft/year. The total yearly electric consumption turned out to be 853.03 (kWh x 000), with greatest consumption being for space cooling, area lighting and miscellaneous equipment, and the total yearly gas consumption was 1953.7 (Btu x 000,000), with the only two consumers being space heating and hot water.

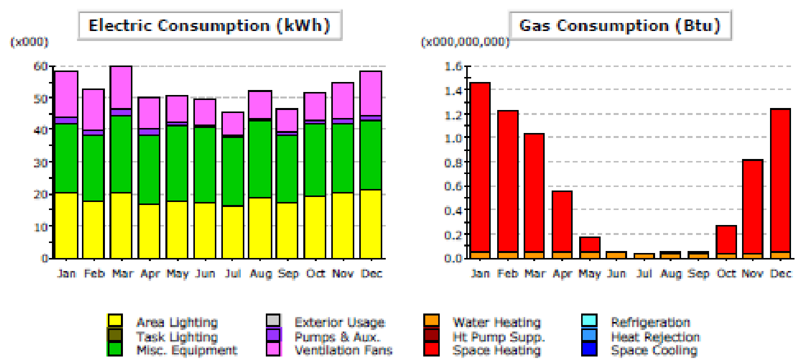


Figure 44. Baseline Simulation Results

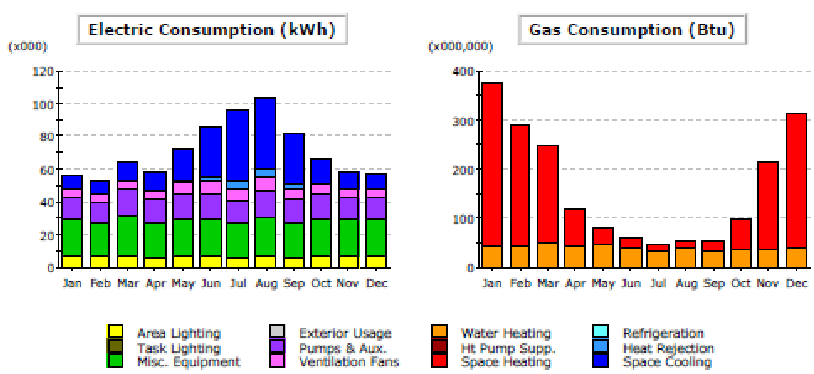


Figure 45. Altered Design Simulation Results

CHAPTER 7

CONCLUSION

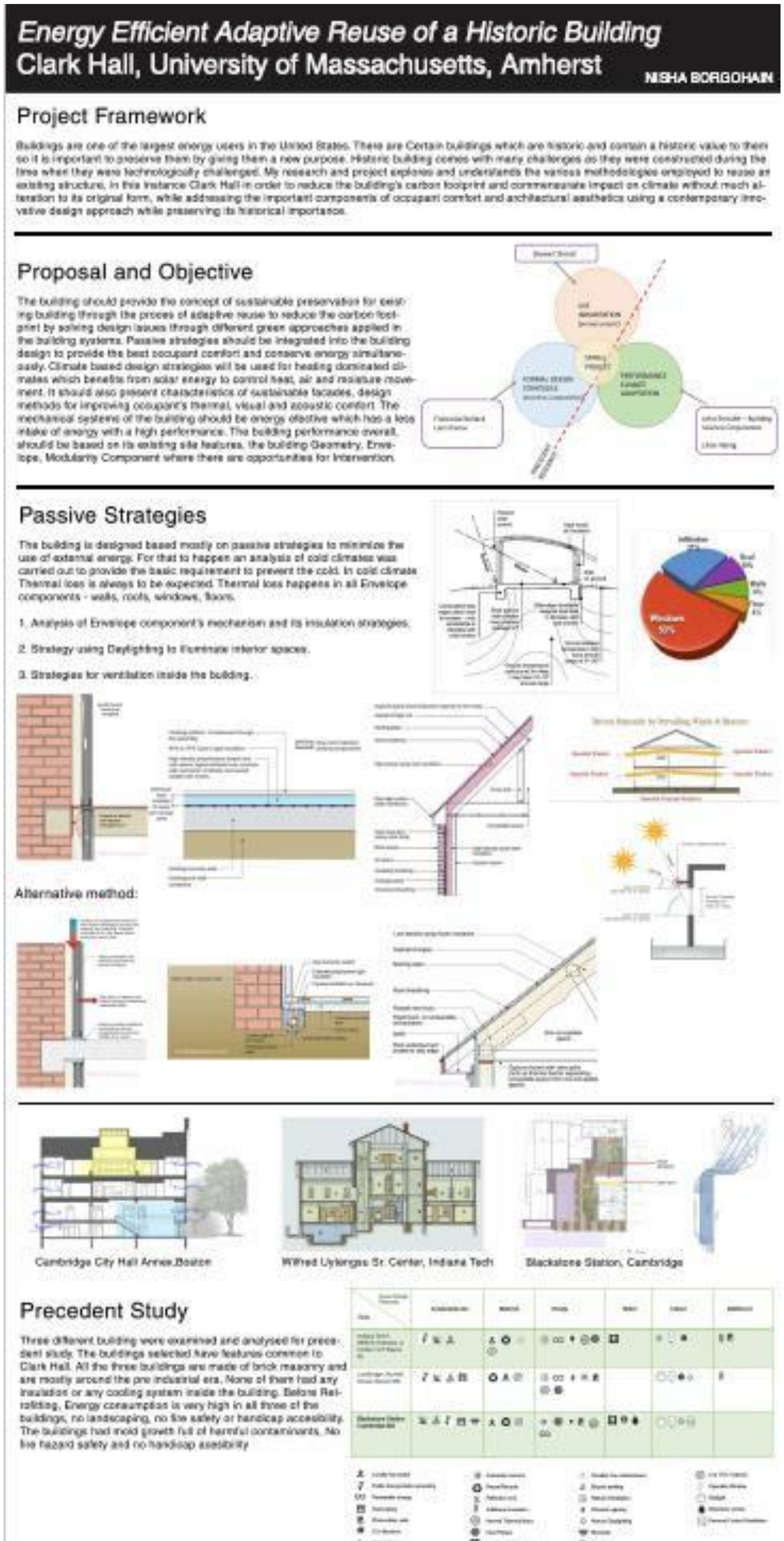
The final design proposal was presented before a diverse jury comprised of architecture and historic preservation students, educators and local practitioners on December 14, 2018. The jury gave some positive comments about the research and the design process. Some comments regarded the improvement of the project for future and how this project would create a positive impact on the UMass community. The jury asked for more development of the façade/ curtain wall system – more iteration to find a language that is clearly juxtaposed with the existing but also shares some datum lines with the existing level of detail on the masonry façade. Secondly, implementing more development of the landscape strategies to a higher level of detail. Furthermore, paying more attention to the distribution of work spaces with respect to current research on office work.

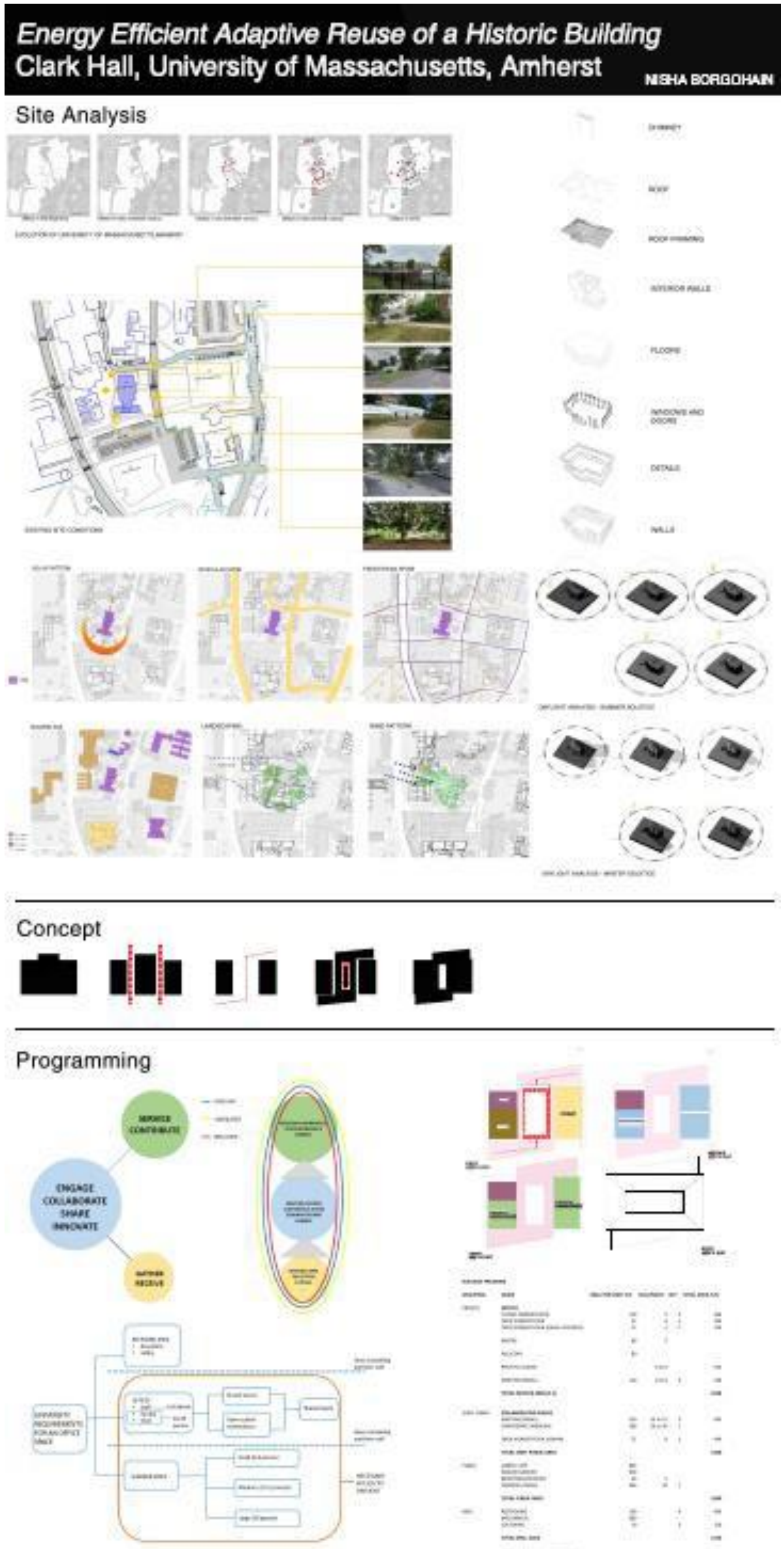
The primary focus on this project was the development of strategies for adaptive reuse of the building. Program and design development were in support of this objective and simulated energy savings reflect this work. There is still more work to be done on the specific design details of the project, but with the overall adaptive reuse strategies in place, these can proceed with greater clarity.

APPENDIX

FINAL THESIS BOARDS

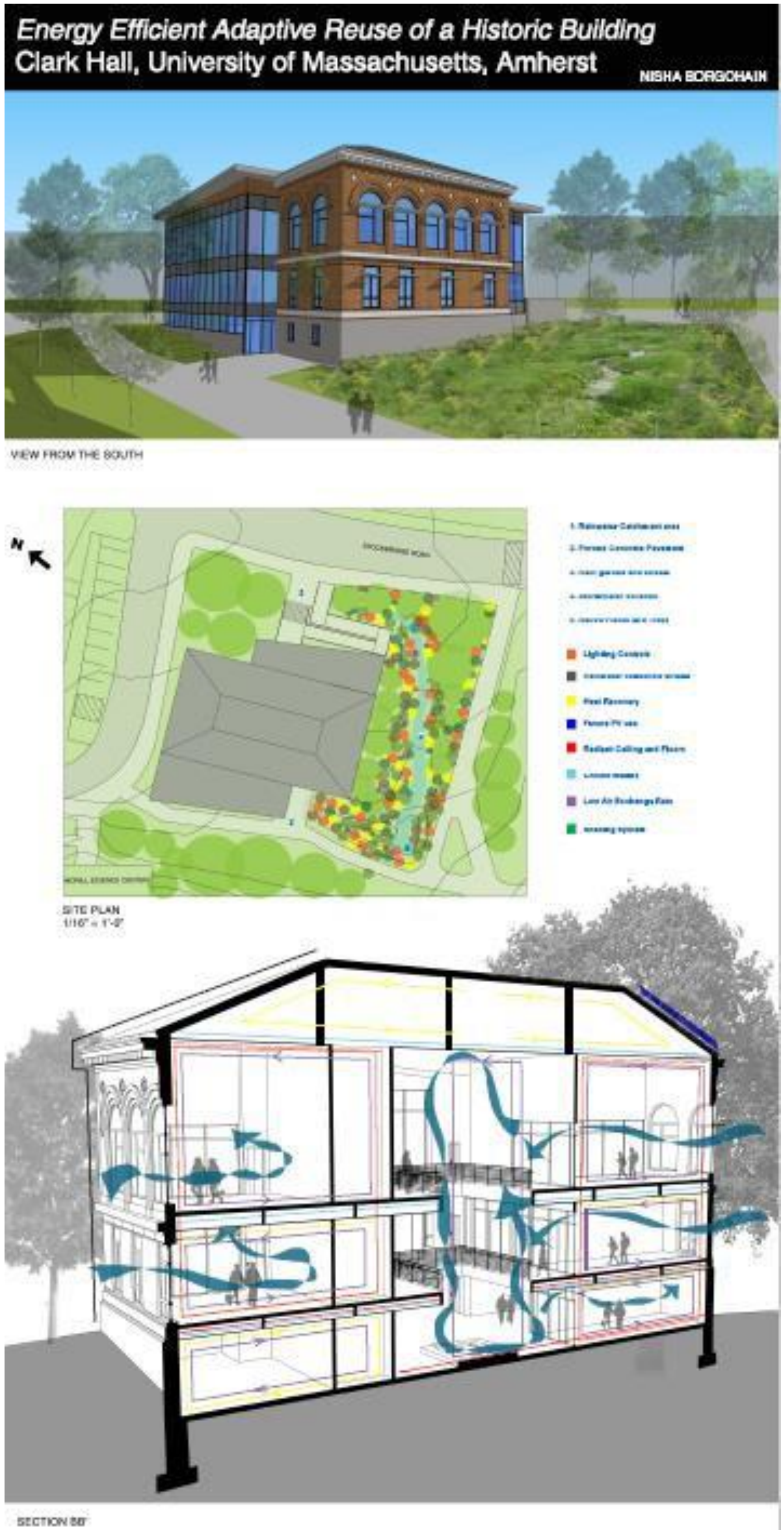
Board 1:




Energy Efficient Adaptive Reuse of a Historic Building
Clark Hall, University of Massachusetts, Amherst
NISHA BORGOHAIN
Site Analysis
Concept
Programming
SERVICE CONTRIBUTE
ENGAGE COLLABORATE SHARE INNOVATE
GATHER RECEIVE

Board 2:

Board 3:



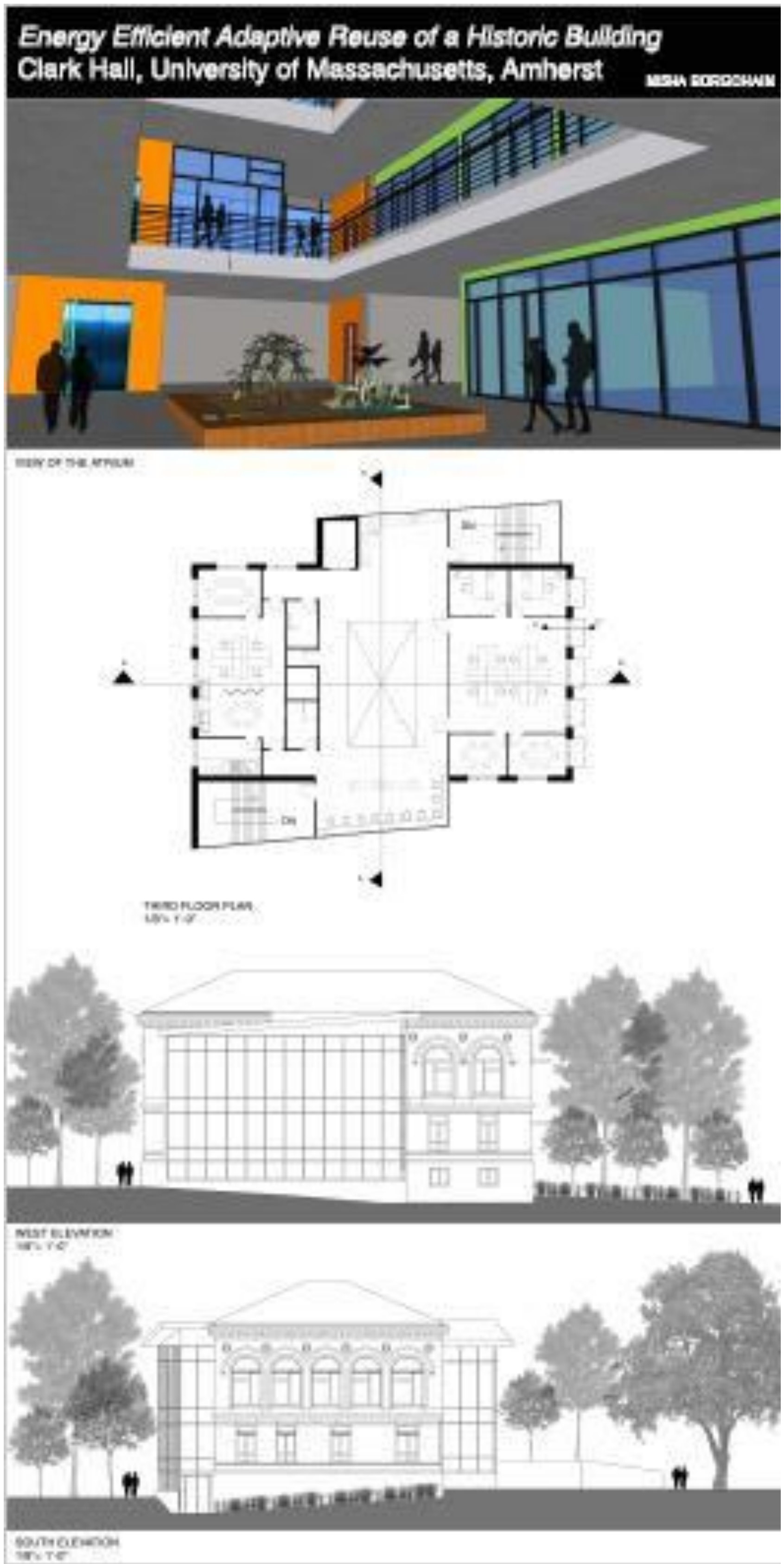
Energy Efficient Adaptive Reuse of a Historic Building
Clark Hall, University of Massachusetts, Amherst
NISHA BORGOHAIN
VIEW FROM THE SOUTH
N
Lighting Controls
Heat Recovery
SITE PLAN
1/16" = 1'-0"
SECTION BB'


Energy Efficient Adaptive Reuse of a Historic Building
Clark Hall, University of Massachusetts, Amherst

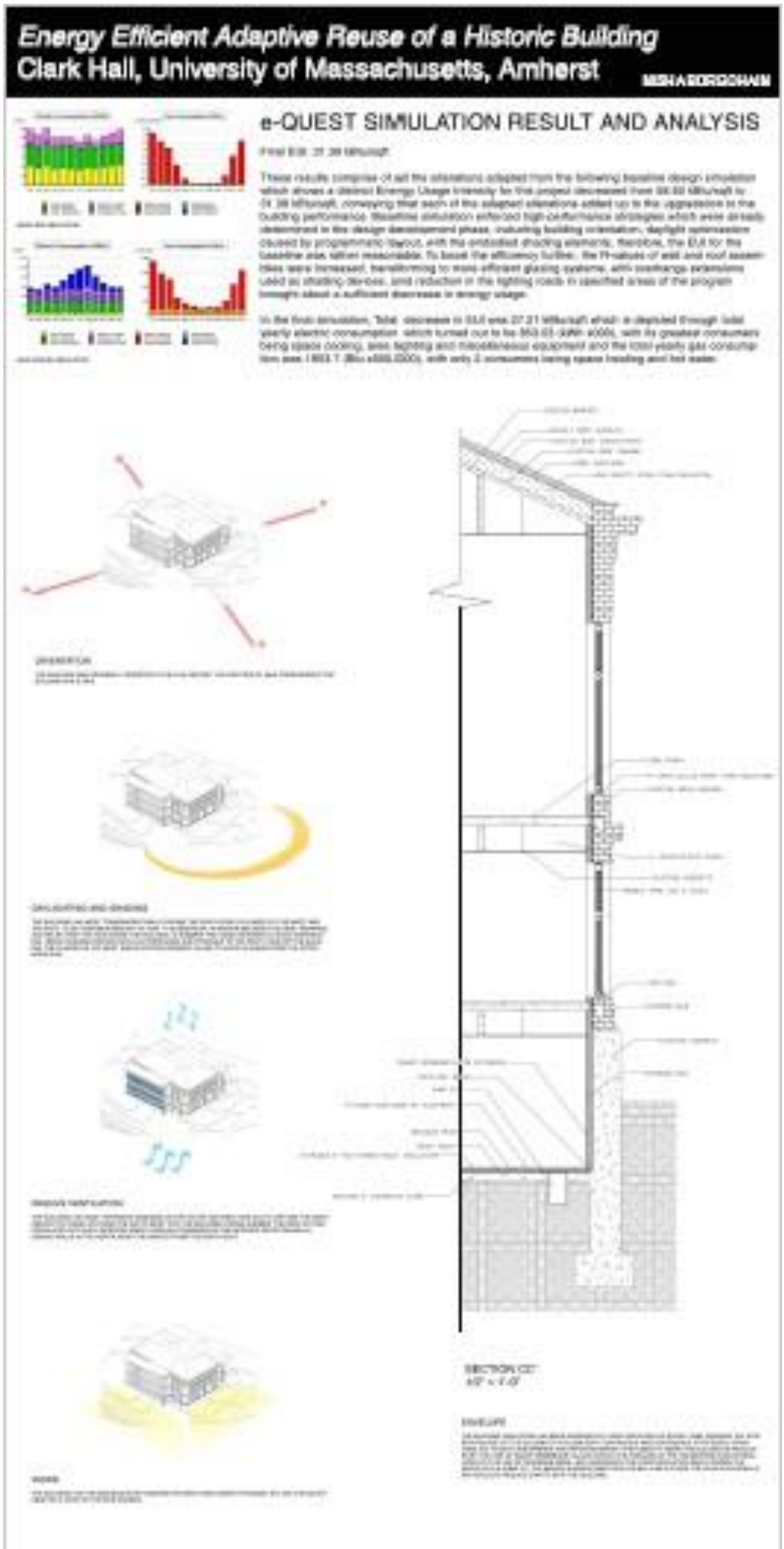

MECHANICAL
ZEN GARDEN
FIRST FLOOR PLAN


SECOND FLOOR PLAN

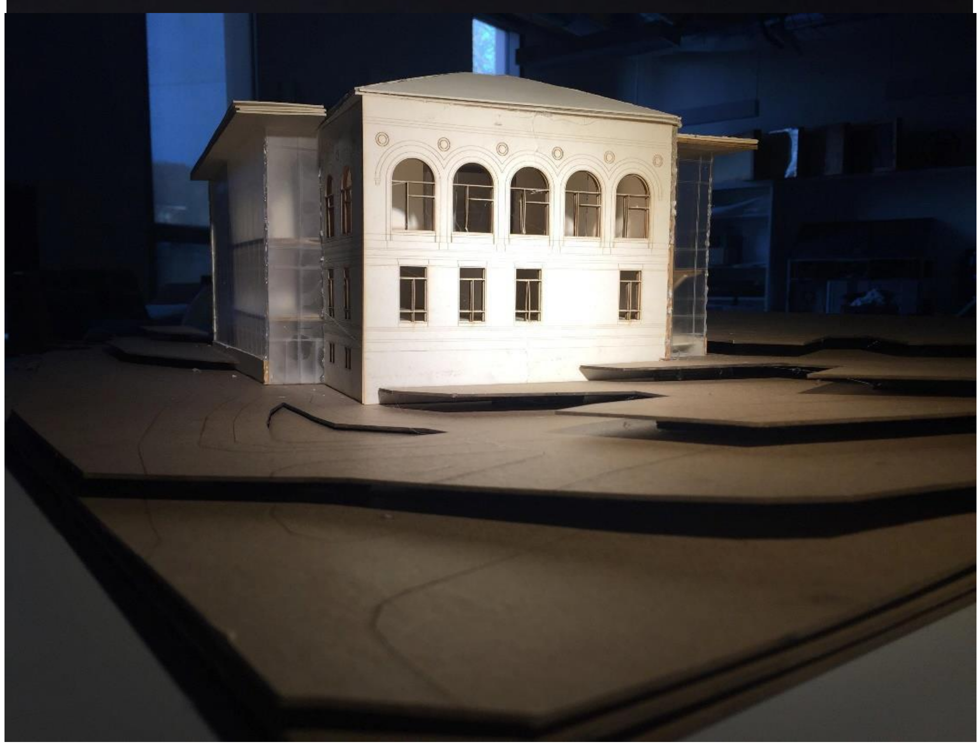
Board 4: ______________________________

Board 5: 
Energy Efficient Adaptive Reuse of a Historic Building
Clark Hall, University of Massachusetts, Amherst
VIEW OF THE ATRIUM
THIRD FLOOR PLAN
WEST ELEVATION
SOUTH ELEVATION

Board 6:


Energy Efficient Adaptive Reuse of a Historic Building
Clark Hall, University of Massachusetts, Amherst
e-QUEST SIMULATION RESULT AND ANALYSIS

Model Pictures :



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