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An analysis of skylight and alternative applications in the adaptive reuse of the Ridgedale Mill

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I. Abstract

Designing sustainably, at its core, holds the health and wellbeing of the users of the space and the price of ongoing maintenance and installation costs in balance with environmental wellbeing. With each of these points playing a major role, spaces can be designed to be healthy and affordable while also benefiting the overall functional health and efficiency of the space. A key method in designing sustainably is the incorporation of natural daylight within a space to provide general lighting in an energy efficient way and to positively impact the atmosphere of the built environment. For the users of the space, natural daylight can affect the mood, productivity and performance, and overall state of being of each person. After analyzing the pros and cons of three types of daylighting options, traditional skylights, solar tubes, and artificial skylights, the level of daylight entering the space was simulated and the effects applied to human wellbeing, energy efficiency, and environmental health. The results of the lighting simulation informed the design about the best option to incorporate natural daylight. The simulation resulted in solar tubes as the most ideal option for this space with regard to user benefit as well as environmental benefit and savings. Through this thesis, environmental benefit, human wellbeing, and economic viability within a space with regard to the lighting effects of various daylighting options was analyzed.

II. Chapter 1: Introduction

A. Introduction

Best said by Bille (2007), “The relationship between persons and things is at the heart of most material culture studies” (p. 5). This relationship is one that is akin to the relationship between people and the places that surround them, both natural and artificial. The human experience is greatly influenced by the spaces we frequent, and the way that design has evolved through the years reflects the idea that the relationship between people and things is at the heart of our cultures. With recent designs, research by the EIA (U.S. Energy Information Administration) (2019) states “almost 50% of CO2 is emitted by buildings” has influenced the nature of building design and architecture. Modern sustainable design often focuses on energy efficiency and aspects of indoor environmental air quality (Zymeri, 2019) in order to benefit the space’s users and the environment itself.

For hundreds of years, natural light has been one of the most important parameters in the design of buildings (Cheirchanteri, 2017). Prior to artificial light, the sun served as the sole source of light which was a major factor in historical building design. As technology advanced, the use of skylights became more varied. Now, skylights serve as the most efficient form of natural lighting as well as a form of passive heating and cooling, as well as for ventilation (Cheirchanteri, 2017). When it comes to sustainable design, it is important to note the use of skylights as an option for energy efficiency as well as human wellbeing. The performance of skylights in sustainable designs is seen through the energy savings, human welfare, and environmental health. (H.W. Li, 2009).

Another hallmark method of sustainable design is the ability to reuse and repurpose existing buildings, better known as adaptive reuse. Adaptive reuse has gained popularity as an

effective strategy to improve the sustainability of existing buildings as reusing the existing building stock has been identified as having an important impact on sustainability of the built environment (Bullen, 2007). The incorporation of skylights within adaptive reuse buildings combines the reuse of existing materials from the site with the natural environment and benefits to people, place, and profits (See Figure 1.0).

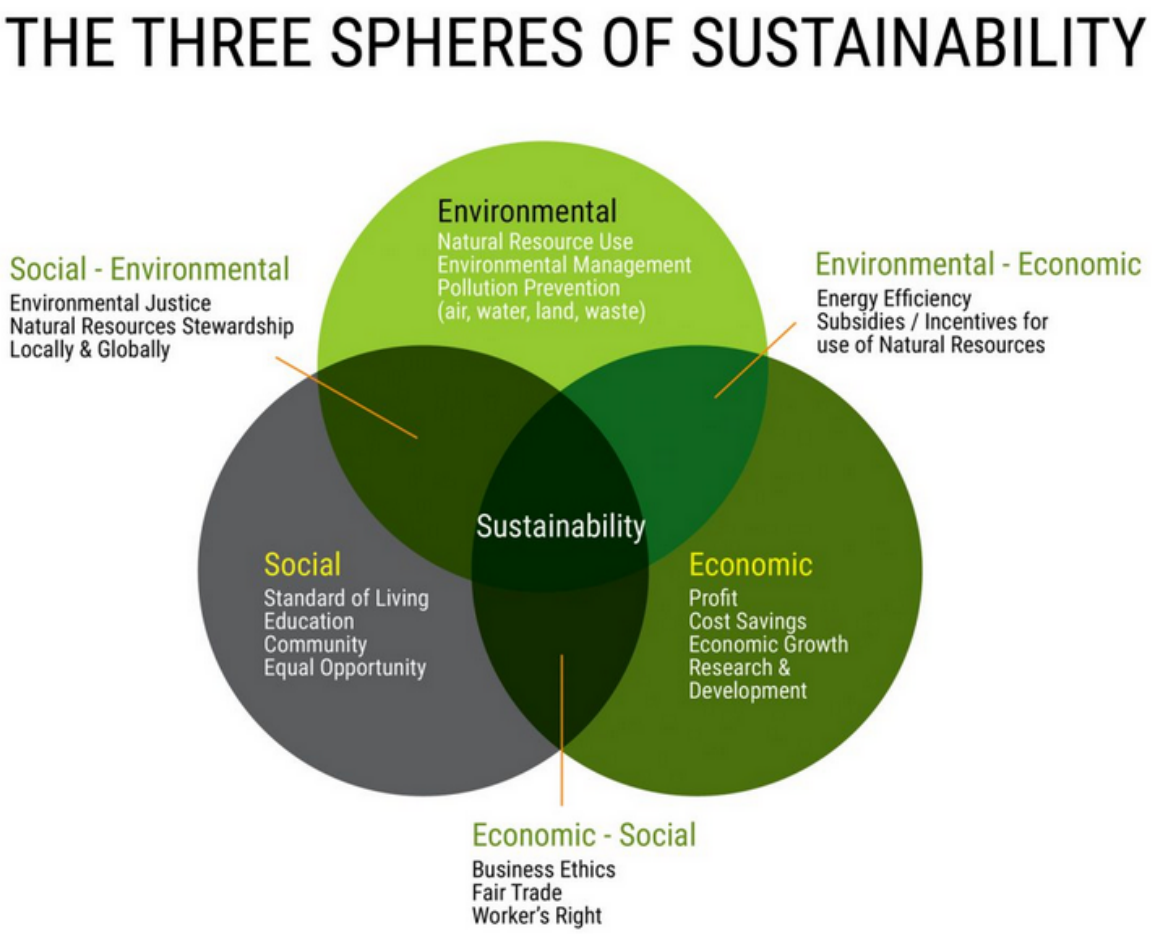


Figure 1.0 Three Spheres of Sustainability (Actco, 2023)

B. Purpose

The purpose of this thesis is to document a simple lighting simulation that will provide visual evidence of the effects of skylights and skylight alternatives on the spaces they occupy. Using these simulations, estimated costs were derived to conclude which daylighting option is

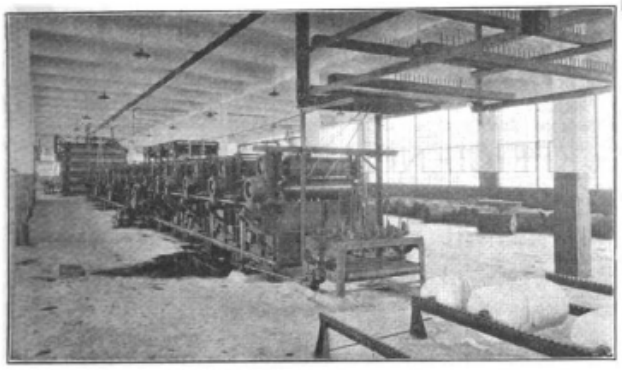
the most cost effective and beneficial for the space. Using an adaptive reuse model of a Chattanooga building, the Dixie Mercerizing Mill (now the Ridgedale Mill), traditional skylights, artificial skylights, and solar tubes were measured. Through analyzing the pros and cons of three types of daylighting options in terms of benefit to human health, the effect on the building and the surrounding environment, and installation and maintenance costs, the best solution for energy efficiency and human health was measured through a lighting simulation in an adaptive reuse model within a commercial occupancy.

C. Background

The site for the project was the Dixie Mercerizing Mill (DMM). Renamed the Ridgedale Mill and located at 1101 South Watkins Street in downtown Chattanooga, TN, it served as a key component in the growth of Chattanooga after its construction in the 1920s where it went into the production of mercerized cotton and quickly became one of the largest and best equipped facilities in the world at the time (Chattanooga Times Free Press, 1920). (See Figure 1.01 - 1.03) While creating history through its production and by being a massive economic stimulant for Chattanooga, the mill was important in another way. Being built in the 1920s, the Art Deco style was utilized. The Dixie Mercerizing Mill is unique in architectural style from other buildings that were constructed within the same year due to its solid concrete construction and art deco style. With low relief geometric designs, parallel straight lines, and solid concrete construction (Poppeliers, 2003), it holds history within its walls through the building techniques and the overall style used in construction. Due to this major historical significance, the Ridgedale Mill is a prime candidate for this adaptive reuse project. The reuse of the Ridgedale Mill maintains the historical integrity of the building itself and the surrounding community while also contributing

to a sustainable design through the reuse of existing materials and development to lower construction waste and construction costs. It served as a huge benefit to Chattanooga's economy in the mid to late 1990s (IBID). It was the largest locally based manufacturer in the City of Chattanooga and it was said to be the nation's largest producer of "yarns only" for the textile industry (Chattanooga Times Free Press, 1979). The development that took place in Chattanooga due to the textile industry that was led by the Dixie Mercerizing Mill is seen today on the bustling streets of downtown.

Figure 1.01 Exterior of the DMM (Chattanooga Times Free Press, 2019)



Mercerizing Machine; Creel and 16-Spindle Winder in Foreground

Wide Center Aisle in Winder Room, with Spiral Conveyor at End

Figure 1.02 and 1.03 Dixie Mercerizing Interior (World Magazine Interior Images, 1921)

Historically, skylights have been used as a main source of lighting since ancient Rome, where they can be found in buildings such as the Pantheon where they serve as an opening in the ceiling that allows natural light to flood the space (Bailey, 2020) (See Figure 1.04). As technology advanced and the Industrial Revolution came about, skylights became more functional and were able to be even larger, letting more light into spaces (Bailey, 2020). Building design soon followed the idea of constructing and designing to best occupy the space with natural lighting and in turn create a well lit space throughout the life of the building. Presently, skylights are advanced enough to provide insulation, energy savings, and daylighting benefits to buildings around the world. (VTechSkylights, 2020).

Figure 1.04 Pantheon Skylight (A Brief History of Skylights, 2020)

D. Significance

This project is significant to the architecture and design community because it includes well informed research into lighting design as well as options for the incorporation of natural daylight into the built environment. Each daylighting option -- traditional skylights, artificial skylights, and solar tubes -- have been tested and measured to find the best solution for an adaptive reuse space with a commercial occupancy. It is important to note that the space has high ceilings of 16’5” in the circulation areas and 10’ in private areas and is designed with the functionality of traditional skylights, artificial skylights, and solar tubes in mind.

E. Problem Statement

Sustainability is increasingly recognized as imperative to good, long lasting and healthy design. Using the opportunity that is presented through this adaptive reuse project, the ability to further test energy saving daylighting options with regard to the interior environment, the users

of the space, and the surrounding exterior environment is possible. The measurements and analysis of each daylighting option as shown in the simulation provided information regarding overall efficiency of the products themselves as well as the efficiency of the building in the years to follow the installation of the daylighting options.

F. Research Questions

1. What is the current condition of the DMM as it relates to the possible addition of skylights?
2. Which daylighting option provides the best balance of environmental benefit, human wellbeing, and economic viability?

G. Assumptions of study

The following are assumptions that have been made about this study.

1. The renovation of the mill will bring it up to the modern health and safety standards and building codes.
2. Interior construction of nonstructural walls will take place.
3. The simulated space will have a business occupancy.

H. Limitations of study

The following limitations are to be considered for this study:

1. The project is simulated, limiting documentation.
2. There was a limited amount of time for this project, specifically 9 months from start to finish, affecting the amount of time dedicated to research and the simulation.

3. The entire site and building(s) are not included within the proposed design solution: included within this project is the Work Lounge within the commercial side of the building at 2,802 square feet.

I. Delimitations of Study

The following are the delimitations of this study:

1. The Ridgedale Mill (Dixie Mercerizing Mill) was the only building used in this study.
2. Only the commercial side of the site is to be used during the simulation.
3. The daylighting options simulated are skylights, solar tubes, and artificial skylights.
4. Only one kind of each daylighting option was included within this simulation.

J. Definitions

The following are important definitions and terms:

- Adaptive reuse: A process that changes a disused or ineffective item into a new item that can be used for a different purpose. When applied to a building, it preserves history and often benefits the community economically and socially (Merriam Webster, 2023).
- Art deco: A popular design style of the 1920s and 1930s. Characterized by bold outlines, geometric shapes, and the use of new materials (Merriam Webster, 2023).
- Artificial skylight: A technologically advanced lighting fixture that mimics natural daylight in interior applications (Merriam Webster, 2023).
- Business Development Center: Small Business Development Centers provide counseling and training to small businesses including working with the Small Business

Administration (SBA) to develop and provide informational tools to support business start-ups and existing business expansion (Business Development Association 2022).

- Circadian Rhythm: Circadian rhythms are physical, mental, and behavioral changes that follow a 24-hour cycle. These natural processes respond primarily to light and dark and affect most living things, including animals, plants, and microbes (National Institute of General Medical Studies, 2022).
- Daylighting: Natural lighting, also known as daylighting, is a technique that efficiently brings natural light into your home using exterior glazing (windows, skylights, etc.), thereby reducing artificial lighting requirements and saving energy (Merriam Webster, 2023).
- Embodied Energy: the total amount of carbon expended in the front-end creation of buildings. This includes the mining and manufacturing of the building materials, the transportation of the materials to the construction sites, and the construction of the buildings themselves (Merriam Webster, 2023).
- Facade: the face of a building, especially the principal front that looks onto a street or open space (Merriam Webster, 2023).
- National Register of Historic Places: The National Register of Historic Places is the official list of the Nation's historic places worthy of preservation (National Park Service, 2022).
- Skylight: A window installed in a roof or ceiling (Merriam Webster, 2023).
- Solar Tube: Solar tubes (also known as light tube, tubular skylights, solar tube lighting, or light pipes) are tube-shaped pipes that capture natural sunlight and distribute it to the interior parts of your home or office for the purpose of illumination. Compared to

traditional skylights, solar tubes are more compact and cost less to install (GoGreen Daylight Systems, 2023).

- Sustainability: The act of reducing negative impacts on the environment, and improving the health and comfort of people, thereby improving building performance through interior design choices. The basic objectives of sustainability are to reduce consumption of non-renewable resources, minimize waste, and create healthy, productive environments (U.S General Services Administration, 2023).

K. Conclusions

This chapter introduced the project, the measurement of various daylighting options within a commercial space and analyzed the benefits of each option with regard to how the physical space, users, and operating costs are affected. The next chapter explores topics that assisted in the development of a lighting simulation and a better understanding of energy efficiency within buildings through daylighting will be gathered.

III. Chapter 2: Literature Review

A. Introduction

The literature review serves as a collection of data and an interpretation of data. This research included a review of the current challenges with the Dixie Mercerizing Mill such as current condition and structural and design style challenges. The research discussed the importance of skylights and how they can benefit spaces as well as their users, and finally, a thorough review and comparison of an artificial skylight, a traditional skylight, and solar tubes was completed with additional information from a lighting simulation.

B. Topic 1: Current Conditions of the Dixie Mercerizing Mill

The Dixie Complex (Ridgedale Complex) retains a high degree of integrity and is the only mill or factory in Chattanooga that is of concrete construction and that is completed in the art deco style (Poppliers, 2003). The use of stepped parapets, geometric motifs, the streamline rectilinear form, and the smooth concrete finish all contribute to the overall art deco style of the building (Poppliers, 2003). The flooring is a mixture of maple wood and concrete flooring. (See Figure 2.0) It is unknown when the maple wood flooring was installed. There is a heart pine wood floor underneath (A. Rader, personal communication, August 24 2022). A portion of the pine floor was revealed under a section of buckled water damage flooring (A. Rader, personal communication, August 24 2022). The maple wood flooring is used throughout the first and second floor of the main building (See Figure 2.01).) (A. Rader, personal communication, August 24 2022). It is unknown if the heart pine is underneath throughout, but it is assumed that the maple floor was added to support the heavy equipment used. Sections of the flooring have been damaged by water and buckled on both floors (Longwith, 2005). Existing sources do not

speak to the conditions of the second floor and the ceilings to determine whether or not the use of skylights and/or skylight alternatives is applicable.

Figure 2.0 Existing Flooring (Wood, 2023)

It is clear to see from the above figures that the renovations of the Ridgedale Mill in the past have resulted in a clear account of the history of construction within the space.

Figure 2.01 Existing Flooring (Wood, 2023)

Additionally, with solid concrete construction, the building envelope including the roof remains in good form. Due to this, the addition of skylights and skylight alternatives is likely possible. For the Ridgedale Mill, more information regarding the structure of the ceilings and floors is needed prior to the addition of skylights and/or skylight alternatives to the proposed ceiling plan. It is important to note that existing structures often have higher construction costs and advanced engineering is needed to ensure that the skylights have been properly installed and will not negatively affect the structure (Marvin, 2022).

C. Effects of Daylight on Human Health

The benefits of skylights cover multiple areas of focus, some being human wellbeing, building design, and green building. The biological processes that regulate our sleep–wake cycle make up our circadian system. Primarily through the use of the neurohormone melatonin, our circadian system regulates our patterns of alertness and sleepiness. Without exposure to normal 24-hour light–dark cycles, a person's sleep–wake cycle can stray by as much as two hours per day (Van Den Wymelenberg, 2014). Circadian rhythm is the body's natural way of maintaining its internal clock, and it maintains the rise and fall of hormone levels and production of energy in tune with the position of the sun. As the sun rises, the body naturally wakes up and produces energy, and when the sun sets, the body begins to cease energy production. Electric or artificial lights are able to disrupt the body's circadian rhythm as they do not replicate the sun's position or lighting levels, while skylights are able to counteract that by allowing natural daylight to enter the space. Three tasks that are critical to a successful daylighting installation are glare control during occupied hours, properly balanced illuminance on interior surfaces, and ensuring sufficient ambient daylight illumination for visual tasks (Van Den Wymelenberg, 2014). With the incorporation of daylight, users are able to reap the benefits in spaces they frequent, fulfilling the need for daylight for those that may not be able to otherwise be exposed to it. While benefiting the body's circadian rhythm, the users of the space benefit from having increased serotonin production and an improved morale (See Figure 2.02)

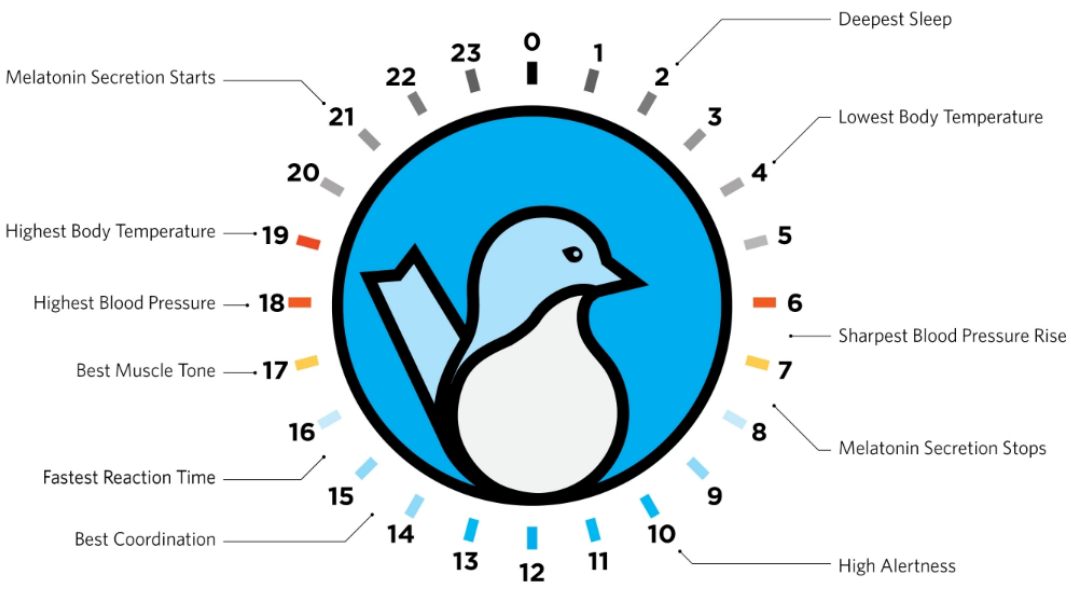


Figure 2.02 Process of Body Functions Throughout the Day in Time with the Rise and Fall of the Sun (Van Den Wymelenberg, 2014)

Skylights, while mainly encouraging the proper function of the user's circadian rhythms, also affects the overall energy use of a space by increasing the amount of light within the space without using electricity. Skylights can help lower dependance on electricity, and using tinted glass can help with any solar heat gain or loss on either side of the skylight (Vaillancourt. 2021).

D. Topic 3: Types of Skylights

1. Traditional Skylights

Traditional Skylights can be installed in spaces that are especially dark to allow for steady, regular light to enter the space. With the addition of skylights, spaces can gain huge amounts of natural light that acts as the main lighting source within the space. (Velux, 2015). Layered with artificial lighting, the need for energy to provide light in the space is minimized,

and during the daytime, low amounts of energy are needed to provide adequate lighting within the space. Traditional skylights can also benefit from the plug and play installation method, which increases the speed at which the skylights can be installed without jeopardizing the integrity of the overall system (Velux, 2015). Utilizing this method of installation, a cost effective skylight solution for the project in terms of overall installation cost, product cost, and energy efficiency can be achieved. It is suggested to consider internal roller blinds for optimal heat control and daylight, though window tints can be used to achieve similar performance. All units should include step glass on the outer side to ensure water tightness, lowering maintenance costs (Velux, 2015). Created with pultruded fiberglass and polyurethane, this composite material provides high insulation performance and thermal sustainability, again resulting in a lower energy consumption cost. With the use of these traditional skylights with high end insulation technology, visual access to the sky is achieved, and the users benefit from views of nature. This volume of natural light also benefits the user's mental and physical wellbeing by positively affecting the production of serotonin and balancing the user's circadian rhythm. See Table 2.0 for pros and cons of the addition of daylight within a space with regard to traditional skylights.

Pros	Cons
Improved Productivity	Possible Heat Gain
Encourages Regular Circadian Rhythm	Possible Heat Loss
Improved Mental and Physical Wellbeing	Structural Penetration of Roof
Views to Nature	Possible Leaking due to Sealing

Table 2.0 Pros and Cons of Traditional Skylights

2. Solar Tubes

Solar tubes can act as a main lighting source within many spaces, small and large. The goal of the implementation of solar tubes in spaces according to one owner was to "revive and beautify the historic space by filling it with natural light and greenery…to enhance the guest experience while improving well-being and health" (Solatube, 2020). Capturing the rays of sunlight during the winter months when the sun is lower can prove to be a challenge, but the use of solar tubes provides a solution. With a light collector at the top of the solar tube, maximized daylight is delivered into the space. The light collector on a solar tube is able to collect and store light at all times of the day, where a traditional skylight is only able to efficiently transfer light into a space when the sun is able to directly hit the skylight. By ensuring the capture and redirection of light year round with solar tubes, spaces can benefit from natural light even through the winter months. This also ensures that the use of artificial lighting is minimized year round, effectively reducing the cost of lighting for projects. With the incorporation of solar tubes, heat gain and loss are non applicable issues, once again reducing the need for excess artificial thermal control throughout the year. Maintaining such lighting year round also benefits the interior environment and the users as it encourages serotonin production and the balancing of circadian rhythms, as well as fighting against Seasonal Affective Disorder (National Institute of Mental Health, 2020). See Table 2.01 for pros and cons of solar tubes.

Pros	Cons
Lower Price Point	No Views to Nature
Encourages Regular Circadian Rhythm	Function is Dependant on Weather
Improved Mental and Physical Wellbeing	Limited Design Choices
Minimal Structural Damage Upon Installation	Lack of Lighting Control

Table 2.01 Pros and Cons of Solar Tubes

3. Artificial Skylights

Artificial skylights are also highly applicable. The reproduction of natural light with the visual appearance of the sky with artificial skylights opens up the possibilities of spaces where penetrating the ceiling might not be an option. Careful curation of spaces through the architecture and furniture selections creates a space that is designed with proportion in mind, further allowing the artificial skylights to find their place within the space and feel as natural as possible. The use of an artificial skylight in spaces can be implemented to aid in the design of a restorative environment while keeping the restrictions of the space in mind. Designing the space to mimic the “behavior of the earth; atmosphere and is proven to support mental restorative processes, reduce stress, heighten a sense of comfort and emotional wellbeing, and enhance cognitive functions” (Standard Dose, 2019). While benefiting from the artificial daylight that enters the space due to the skylight, the space also develops a more permanent sense of place and grounding for the user’s experience. With the ability to “recreate " natural lighting (CoeLux, 2019) through their Sun&Moon system, the vital ingredient is able to penetrate the otherwise windowless space, therefore positively impacting the built environment as well as the user’s of the space. While comparable to a traditional skylight or solar tube with regard to effect on the users, the artificial skylight is more versatile in placement and installation costs (see Table 2.02).

Pros	Cons
Improved Productivity	High Price Point
No Chance of Leaking	Use of Electricity to Function
No Heat Gain or Loss	No Ventilation Option
No Penetration to Roof Footprint	Less Efficient With Concern For Mental And Physical Health Of Users

Table 2.02 Pros and Cons of Artificial Skylights

E. Topic 4: Examples of Applied Traditional Skylights, Artificial Skylights, and Solar Tubes - Case Studies

1. Traditional Skylights: Urban Outfitters Building #18, Philadelphia, Pennsylvania

The Anthropology Headquarters located within Philadelphia has a rich history. Situated within a former metal foundry, the headquarters has undergone an inspiring transformation. Originally, the space was extremely dilapidated, but the existing open glazing system over the length of the building proved to be a vital part in the renovation of the design. Relying on that existing structure as a foundation for the remodel naturally included the use of daylighting as a key design factor. Additionally, this influx of natural light within the building benefits users by boosting morale and productivity as well as providing a high enough CRI for proper fabric viewing during product development (Wasco, 2018). Wasco developed a custom tinted glazing system utilizing a combination of Solarban 70 Low E bronze and clear laminated glass to provide all the positive benefits of natural daylight without suffering the undesirable effects such as excessive heat gain, glare and fading (Wasco, 2018). Reusing the building's existing design with another look at skylights and their ability to properly serve the space resulted in a beautiful, well lit area that benefits the users of the space (See Figures 2.03 and 2.04).

Figures 2.03 and 2.04 Pinnacle Ridge at Urban Outfitters Anthropologie Headquarters (Wasco, 2018)

2. Solar Tube: Ecofibre Warehouse, Lexington, Kentucky

At its core, Ecofiber is a leading innovator in hemp technologies where sustainability plays a large role in manufacturing. The development of this North American location needed to portray their ideals, and in doing so the decision to use the LEED rating system to achieve LEED Platinum Certification (See Figure 2.05). Along with the goal of LEED Platinum Certification, the need for a bright and welcoming space that would "instill employee pride" as well as "provide a healthy environment to optimize the wellness for the occupants within" (Solatube, 2021). With such high sustainability goals, the optimization of daylight was essential to the success of the project. In the end, a total of 66 Solatube systems were used, and Ecofiber saw a 58% decrease in total energy consumption (Solatube, 2021).

Figure 2.05 Solatube Exterior View (Solatube, 2021)

Due to the thoughtful and extensive research that fueled the lofty goals of this warehouse, it holds the title of the first warehouse and distribution facility to achieve LEEDv4 Platinum Certification in the United States.

3. Artificial Skylight: Light Cognitive, Barcelona, Spain

Light Cognitive, a brand that focuses on lighting design, has created a large circular artificial skylight by the name of Oculus (See Figure 2.06). The artificial window was designed to mimic the center of domes in ancient Roman architecture, which allowed natural light to filter into the space below (Hahn, 2020). Based on an actual model of the sky, the Oculus uses patented technology to match the color and intensity of the real sky outside (Salomaa, 2020).

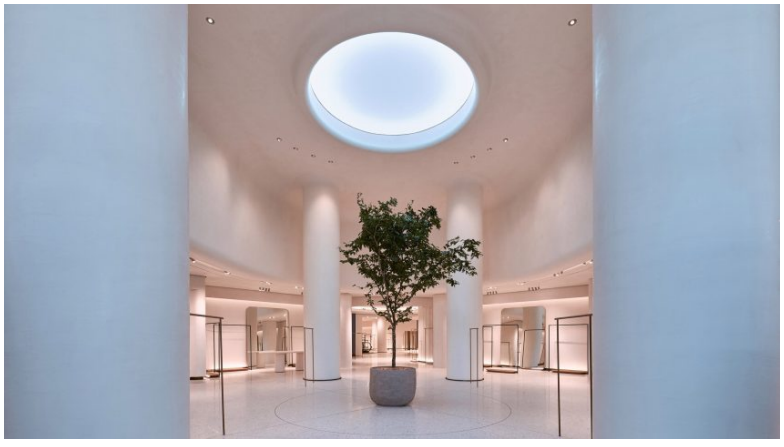


Figure 2.06 Light Cognitive Artificial Skylight (Hahn, 2020)

Within the light, the LEDs are arranged underneath a circular diffuser which creates an ever evolving impression of the light on the surface while reducing shadows and glares (Hahn, 2020). This is extremely important as it affects the function of the circadian rhythm within the users of the space, and the Oculus has the technology to support a healthy sleep/wake cycle throughout the day.(Salomaa, 2020). Additionally, it is believed that the visual impact of the Oculus on the users of the space has been in support of an improved psychological impact, and the ability to so accurately recreate daylight in space where it would typically not be possible results in an improvement in user experience. (Salomaa, 2020). This application of an artificial skylight is a great demonstration of the possible effects that it can have on the space it occupies.

E. Topic 5: Technical Information/Performance Data

1. Overview of Performance for Traditional Skylights, Artificial Skylights, and Solar Tubes.

Daylight devices are able to deliver a large amount of daylight into a space, though there are lower prices than traditional skylights found in solar tubes, mainly due to construction costs (See Figure 2.07). Additionally, as previously mentioned, artificial skylights can prove to be more versatile in application than both solar tubes and traditional skylights. In a test by the Construction Technologies Institute of National Research Council of Italy, the performance of traditional skylights and solar tubes was measured.

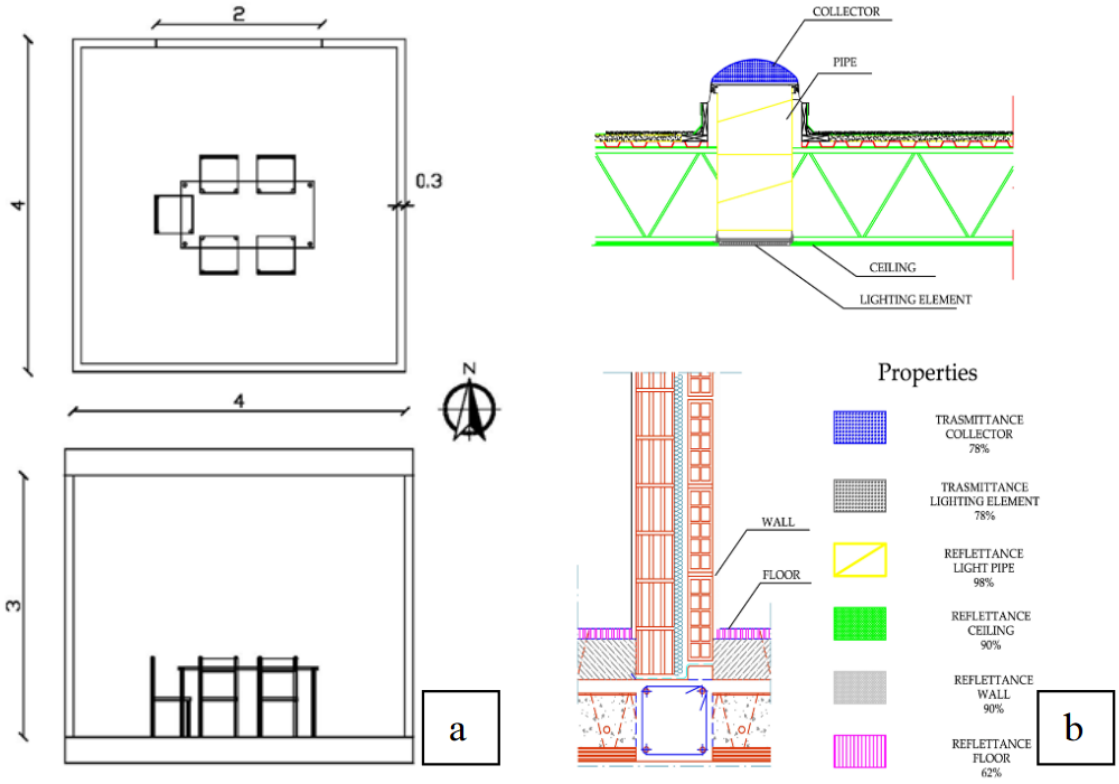


Figure 2.07 Wall Section (Reprinted From "*Sizing Analysis of Interior LIghting Using Tubular Daylighting Devices*", by Baglivo, 2022, Energy Procedia)

For this test, a room was created that was to have the two daylighting option applied to it. Simulations with the software Daysim were run to assess the luminance levels of each space as well as daylight factors and other useful indicators. Post process, it can be "observed that the contribution of daylight is highest in the cases where the application of the skylights is considered." (Baglivo, 2022). This being said, a look at Figure 2.08 shows that while skylights have the highest daylight factor percentage, the ratio of the light level inside a structure to the

light level outside the structure, solar tubes do not fall far behind, still proving to impact the amount of daylight within the space.

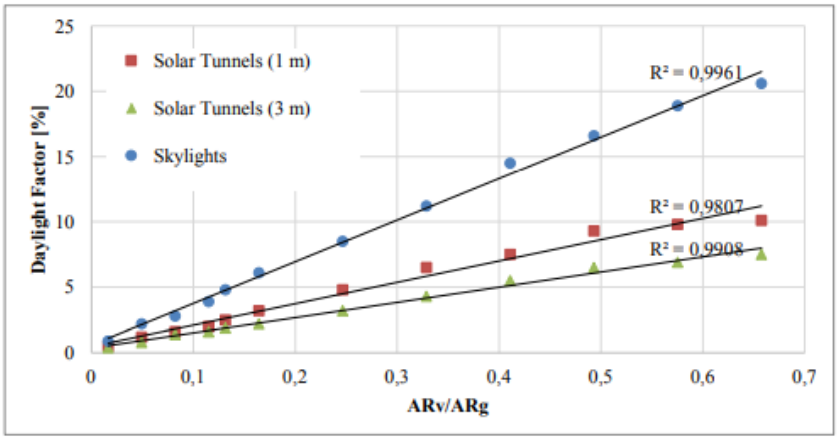


Figure 2.08 Calculations Chart (Reprinted From "*Sizing Analysis of Interior LIghting Using Tubular Daylighting Devices*", by Baglivo, 2022, Energy Procedia)

Additionally, a test regarding the performance of artificial skylights against both daylight through fenestrations as well as LED lighting and their effect on the user of the space was conducted by Construction Technologies Institute of National Research Council of Italy. This test played a key role in lighting design research, as ensuring the comfort of the indoor environment with regard to the functionality of the people in the space is a priority. In this study, a monitoring system was placed in three different rooms where participants would spend entire work sessions in each lighting option (See Figure 2.09). Analyzing the visual and non visual effects that each lighting option had on the participants, the diffused lighting that comes from artificial skylights resulted in the best lighting conditions (Bellazzi, 2021).

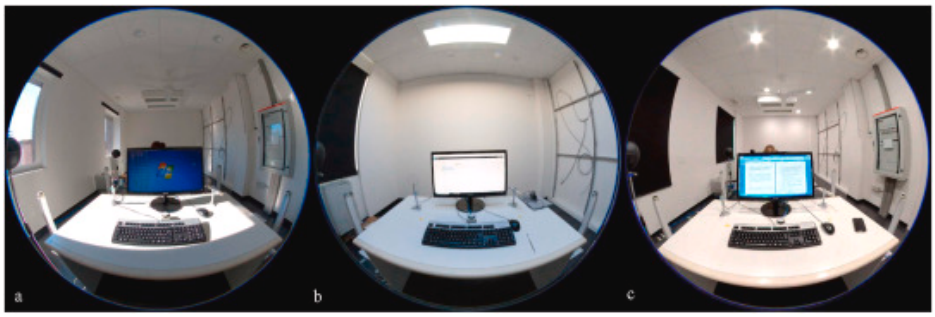


Figure 2.09 Daylight (left), Artificial Skylights (middle), and LED Lighting (right) in each room (Bellazzi, 2021)

As visible in the image above, glare is prominent in the LED room as well as the daylighted room whereas the room with the artificial skylight is glare free (Bellazzi, 2021). This was a key component of occupant comfort.

F. Conclusions

This chapter focuses on the conditions of the Ridgedale Mill, the benefits of skylights and daylighting, manufacturer information, applications, technical information, and performance data. The following chapter explains the methods that were used in order to inform the design decisions for the proposed renovation.

IV. Chapter 3: Methodology

A. Intro

The research methods for this thesis are presented within this chapter, as well as used to develop the design and function of the adaptive reuse for the Dixie Mercerizing Mill. Interviews, reviews of journal articles and research papers, site visits, interviews over the phone or video conferencing software, and historical research from the Chattanooga Public Library were all used to gather information regarding the Dixie Mercerizing Mill, traditional skylights, artificial skylights, solar tubes, the relationships between natural daylight on the users of the space, the interior and exterior environment, and the operational costs of each form of lighting. Regarding this information, a lighting simulation measured the levels of footcandles within the commercial space using traditional skylights, artificial skylights, and solar tubes. A simple comparison of functionality and cost was created between each option to find the best option for natural lighting within the commercial space of the Ridegdale Mill's proposed reuse plan.

B. Methods

The first method used to gather information regarding the Ridgedale Mill was a site visit where a short interview with the owners informed the designers on the intended use and various background information. A visit to the Chattanooga Public Library to gather historical data as well as research regarding the design style and construction of the building through original building documents and historically accurate texts was documented as well. Online databases and architectural journals with respect to the history of the building as well as the method of adaptive reuse and how it affects sustainability was used. Field professionals in the architecture, interior design, and engineering fields were interviewed where information concerning the current state of the building and the future plans for the building was collected. Case studies have

also been reviewed where the application of skylights and skylight alternatives was evaluated and could act as possible applications to the Ridgedale Mill. A simple lighting simulation using AGI, a REVIT Plugin, was used to best show the actual lighting conditions of the proposed commercial space with regard to traditional skylights, artificial skylights, and solar tubes. Prior to any simulations, the space was outfitted within Revit to accurately portray the results of the simulation. To do so, it is important to note the documentation of the floor plan of the space to take note of existing conditions. Next, selections of material finishes for the floors, ceilings, and walls were specified while noting each material's light reflectance value. Once this criteria had been met, the selection of specific skylights and skylight alternatives was documented to ensure accurate measures of light. A base simulation with only the artificial light, also with specifics selected, and the current daylighting levels was run to provide a control for the other simulations. Rerunning the AGI test with each option were documented, and foot candle levels were compared. After the simulation, a simple analysis of overall costs informed by further research and the results of the lighting simulation informed the design. Currently, only the work lounge is to be analyzed. This space is an ideal candidate for this simulation as the users of the space benefit heavily from the effects of natural light, especially with regard to enhanced productivity (Williams, 2020) and overall morale. The entire space was not measured. The main coworking space in the open floor area was the subject matter of the study, and the positioning of the daylighting options was zoned to have an effect only on that section of the work lounge. Additionally, the time of 12 PM was used for each simulation of daylighting options to ensure that the time of day with the most overhead light was measured. With roof applied products, having an overhead sun will show the highest amount of natural daylight that is gained in the space with each option. An All Perez Weather station was also referenced in Revit during the

initial setup of the simulation to ensure that the weather conditions were the same throughout all simulations. The date of September 23rd, 2022 was also referenced in revit to get accurate weather and visibility data for the simulation. See Figure 3.0 for a visual representation of methodology.

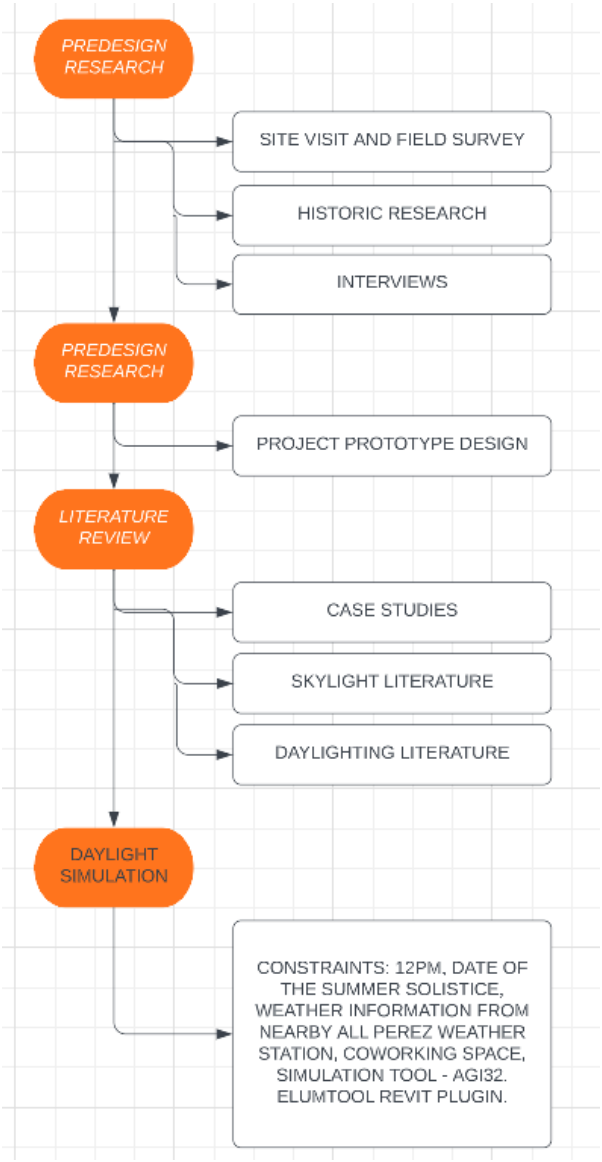


Figure 3.0 Methodology Flow Chart

C. Conclusions

The methodology behind addressing the research questions that are presented in this thesis are explained in this section. Documentation and research of existing information through credible online sources and text informs the analysis of case studies and application techniques for skylights and skylight alternatives.

IV. Chapter 4: Findings

A. Introduction

This chapter discusses the findings regarding the current lighting conditions within the coworking space in the commercial side of the site. Also documented are lighting simulations, run with AGI, for traditional skylights, artificial skylights, and solar tubes in the coworking space. Results of the lighting simulation are explained and documented as well as estimated pricing options for each daylighting option.

B. Project Type Design

It is important to note the conditions of the space that is to be measured. To do so, Figures 4.00 through 4.02 and Table 4.00 and 4.02 have been provided for information regarding specific products, materials, and existing conditions such as existing windows. Please note that the north arrow orientation is the same on every floor plan as seen below.

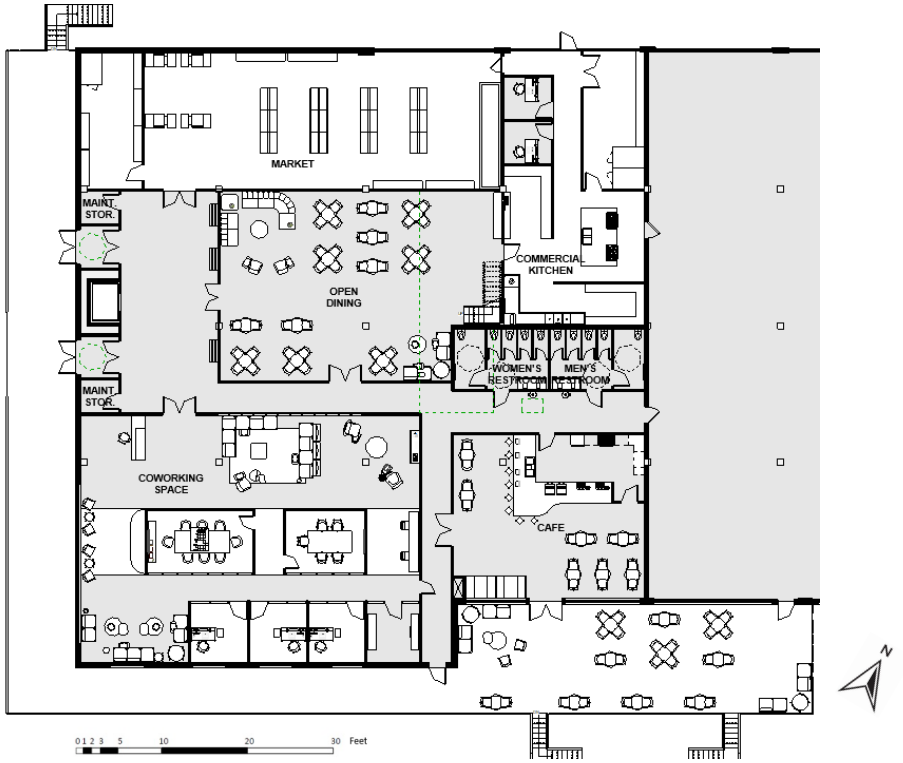


Figure 4.00 Proposed Overall Floor Plan with North Arrow (Wood, 2023)

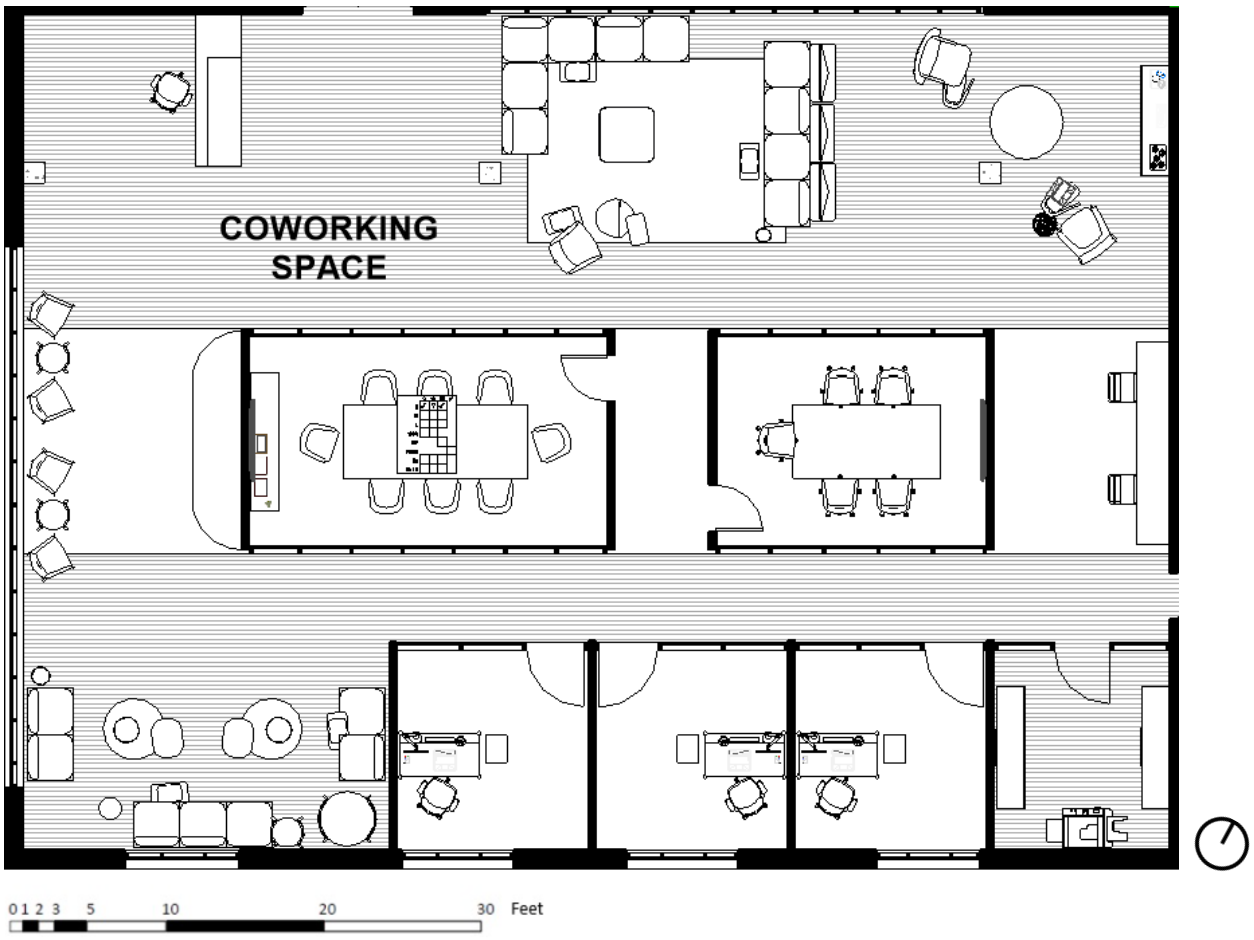
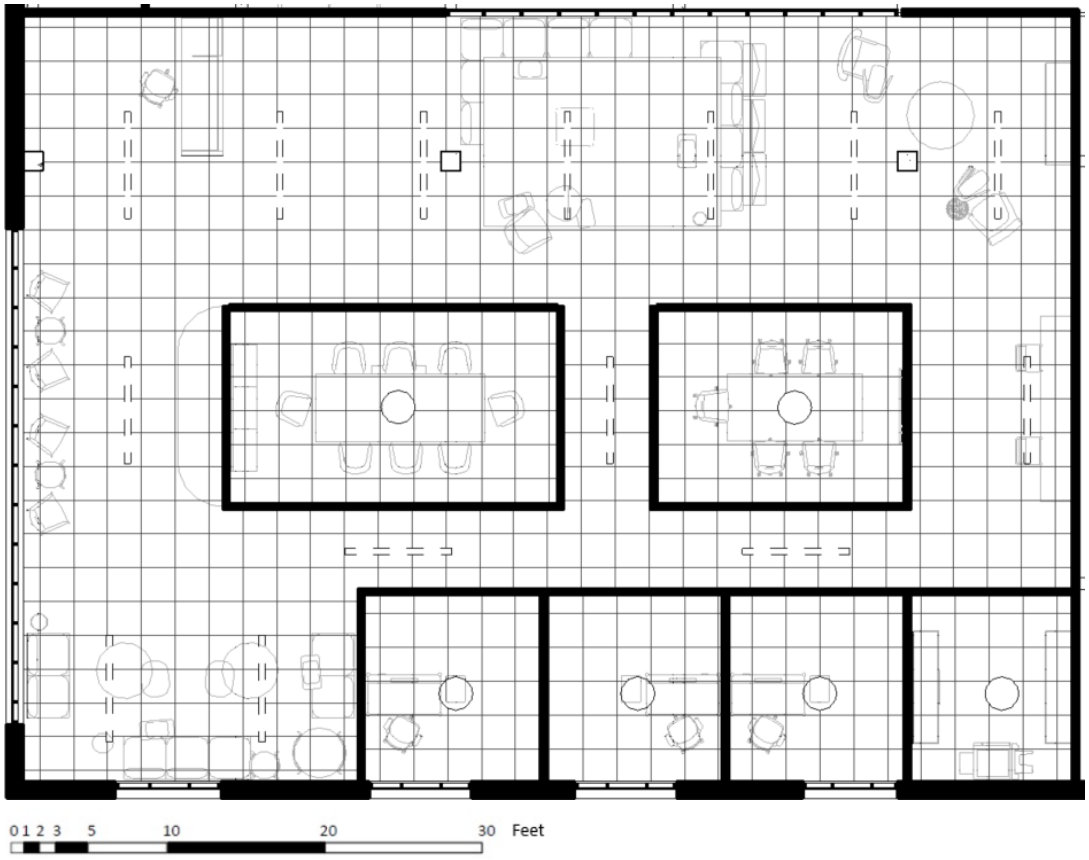


Figure 4.01 Proposed Work Lounge Floor Plan (Wood, 2023)



4.02 Proposed Work Lounge Reflected Ceiling Plan Featuring Only Artificial Lighting(Wood, 2023)

Name	Brand	Installation Type	Lumens	Watts	CCT	CRI	Notes	Floor Plan Symbol (Not to Scale)
Vaulta Linear	Corelite	Suspended	5951	43.4	3500K	80	14 in plan.	
Sense Drum Trio	Shaper	Canopy Mount	3172	38.8	3500K	80	6 in plan.	

Table 4.01 Artificial Luminaire Schedule for Simulation (See Appendix B - C for References.)

Application	Material and Spec Name	Brand	Light Reflectance Value	Image	Notes
Floor	Pine Hardwood (Stained) ((F1)) - Oak Sevede	Khars Group	29%		
Floor	Carpet Tile (F2) - Layout in Elevations	Interface Carpet Tile	36.5%		
Ceiling	Ceiling Panels (C1) - Ultima Health Zone Performance	Armstrong Ceiling & Wall Solutions	86%		2’x 4’
Wall	Paint 1 (W1) - White Winged Dove	Benjamin Moore	75.3%		Paint has been applied to brick on the interior of exterior walls.
Wall	Paint 1 (W2) - Dellwood Sand	Benjamin Moore	36.05%		
Wall	Wallpaper 1 (W4) - Highrise in Quartzite	Koroseal	68.3%		
Wall	Wallpaper 2 (W5) - Arco in Hana	Koroseal	28.6%		

Table 4.00 Light Reflectance Value Material Information for Specifications within Simulation

(See Appendix A for References.)

Type	Name	Brand	Size	Notes
Traditional Skylight	SkyMax	Wasco	48” x 96”	6
Artificial Skylight	Cadiant Dynamic Skylight	Cree Lighting	23’7 x 23’7	12
Solar Tube	SolaMaster	Solatube	26” x 26”	12

Table 4.02 Daylighting Options Specifications (See Appendix B for References.)

With the information provided above, the lighting simulation is as accurate as possible. Inputting accurate photometric information and light reflectance value numbers ensures that the light within the simulation behaves as it would in a real environment. Within the ElumTools program, actual .ies files were input to ensure accurate lighting information with regard to the artificial lighting selections.

B. Application to Research Questions

Question 1: To answer research question 1, “What are the current conditions of the Dixie Mercerizing Mill with regard to the addition of skylights”, an interview with Alex Reyland from HK Architects was conducted. When asked about what measures would need to be taken to incorporate a traditional skylight into the building, Reyland said “The structure is a cast in place concrete structure with a concrete slab that is all heavily reinforced, so it's really just about maintaining, you know, don’t stick a skylight through the middle of a beam or anything... (A. Reyland, personal communication, October 28, 2022). This cemented the fact that the building is structurally sound and is able to have additional construction done to add skylights to various spaces. When next asked about what the best approach would be to the addition of skylights,

Reyland stated that “the commercial building...traditional skylights make a lot more sense there. It’s a really deep space, and there’s that existing infill building that further blocks any natural light” (A. Reyland, personal communication, October 28, 2022). This information supports the idea of implementing skylights for their effects on both the users of the space as well as the effect on energy costs.

Question 2: To answer the research questions proposed in this project, namely “Which daylighting option provides the best balance of environmental benefit, human wellbeing, and economic viability?”, we must note the existing daylighting levels of the coworking space at 12 PM (See Figures 4.03-4.04 and Table 4.03).

Image	Footcandle Level
Red	50
Green	20
Light Blue	5
Dark Blue	0

Table 4.03 Traditional Skylights Lighting Level Legend

Figure 4.03 Existing Daylight within the Work Lounge at 12 PM Provided by Windows

With daylight coming through the existing windows, much of the space relies on artificial lighting to provide light. According to Larson Electronics (2016), “A requirement of 20 foot candles is recommended for general spaces in offices. In areas where reading and detailed tasks are carried out, 50 foot candles of lighting is sufficient.” While certain areas do meet the requirement minimum footcandle levels (Figure 4.04), over 50% of the space does not meet the necessary level of footcandles to offer comfort for the users. This could result in eye strain and generally renders the space unsuitable for the proposed use.

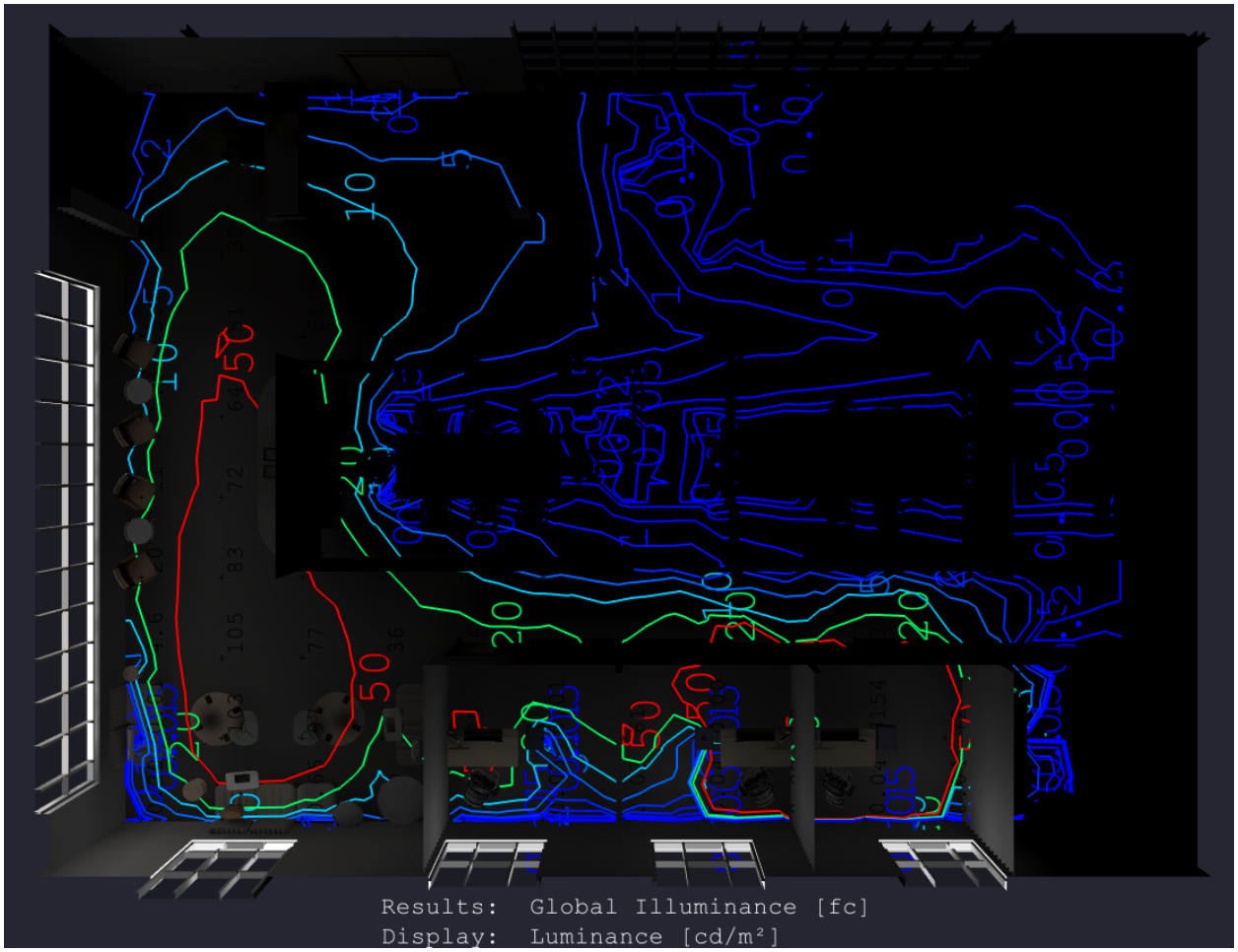


Figure 4.04 Existing Daylight within the Work Lounge at 12 PM Provided by Windows with Footcandle Averages

Noting these existing daylight footcandle levels, artificial light has been applied throughout the space to greatly improve the level of light. (See figure 4.02 for an RCP of the space). It can be seen that the space is exponentially more bright and benefits from even lighting (See figure 4.05), though the ability to achieve such light levels is dependent on the use of electricity. According to data from the Commercial Building Energy Consumption Survey, office buildings in the U.S. spend on average $1.44 per square foot on electricity annually (P3 Cost Analysts, 2022). Within the simulated space and using the estimated energy cost and use from the Commercial Building Energy Consumption Survey, it can be estimated that the 2,802 square

foot space at $1.44 per square foot would cost $4,034.88 per year to maintain comfortable lighting levels on top of other general electrical uses such as thermal comfort and additional devices such as computers or alarm systems. The opportunity to save money by applying daylighting solutions to this space is presented through the following daylighting simulations.

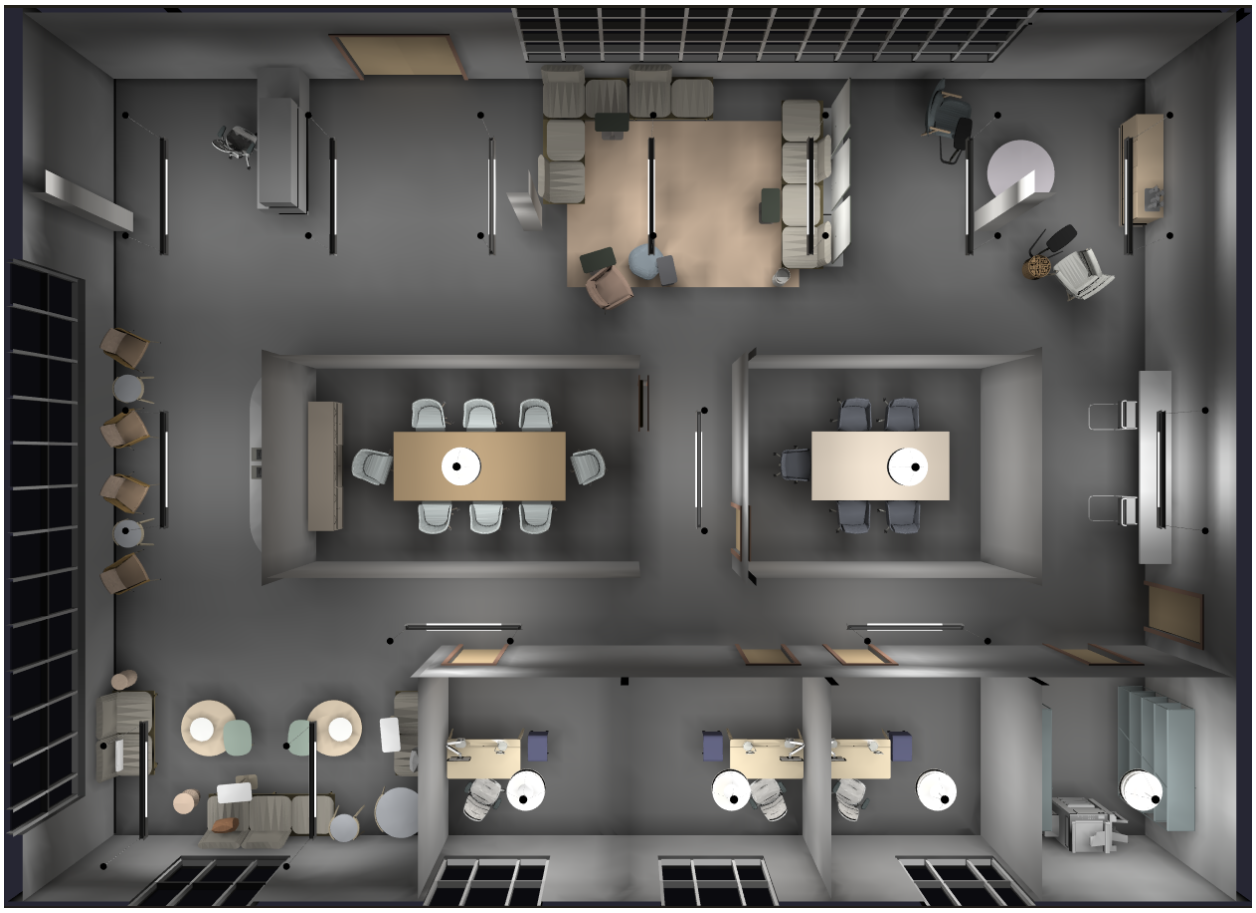


Figure 4.05 Artificial Lighting within the Work Lounge (Wood, 2023)

Additionally, further information about the footcandles within the space (See figures 4.06-4.07 and table 4.04) shows that through the application of artificial lighting, the minimum required footcandle levels are met on and around worksurfaces, though the light has the potential to have hot spots upon work surfaces and is not even throughout.

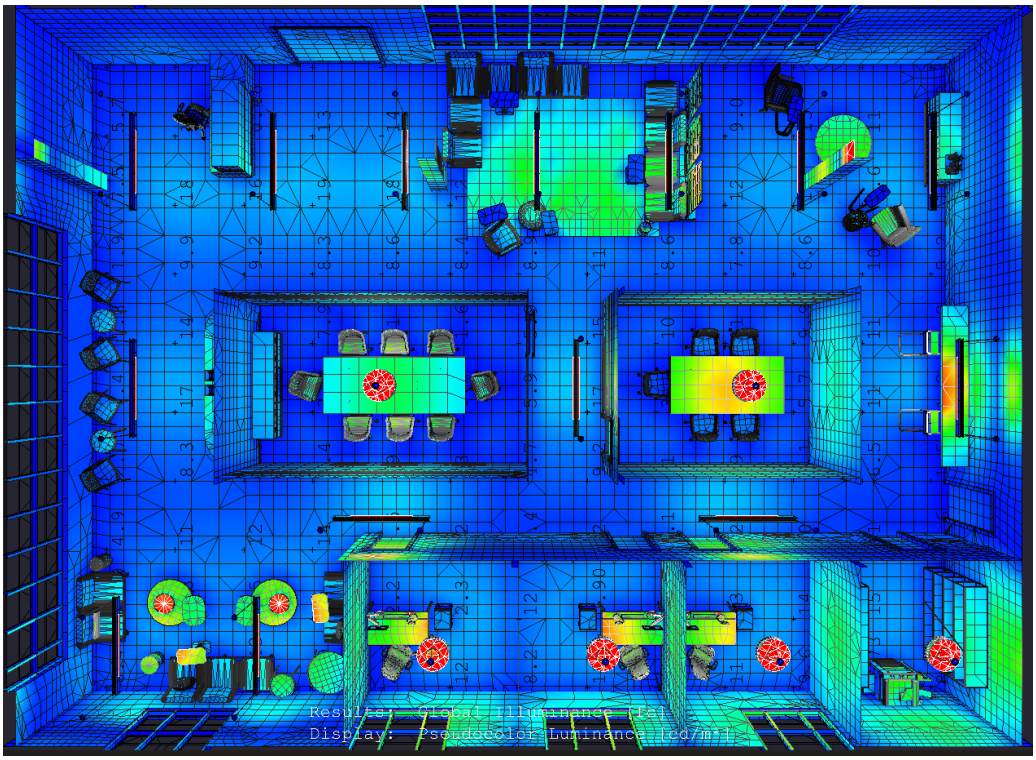


Figure 4.06 Artificial Lighting within the Work Lounge with Footcandles (Wood, 2023)

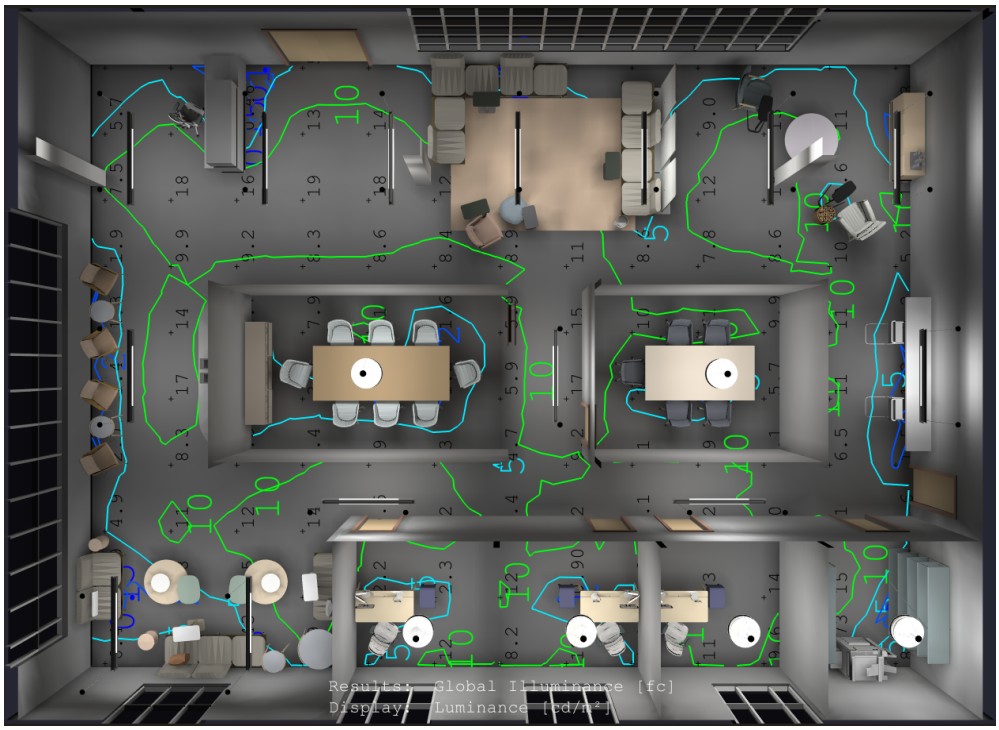


Figure 4.07 Artificial Lighting within the Work Lounge with Footcandle Averages (Wood, 2023)

Image	Footcandle Level
Green	10
Light Blue	5
Dark Blue	2

Table 4.04 Artificial Lighting Level Legend

It is also important to note various underlying costs of each daylighting option, such as maintenance and installation (See table 4.05). Please note that costs are estimates, see Appendix B for more information.

Type	Product Cost (Including tax and installation)	Maintenance Costs (Avg., yearly for all fixtures.)	Number of Fixtures	Total Cost (over 1 year)
Traditional Skylight	$1,063.30	$385	6 @ 48” x 96”	$6,763.00
Solar Tube	$750	$250	12 @ 26” x 26”	$9,250.00
Artificial Skylight	$1,000.00	$100	12 @ 23’7 x 23’7	$12,100.00

Table 4.05 Estimated Cost (Year of installation)

C. Traditional Skylights Simulation

Through the addition of daylighting products, the space will benefit from lower energy consumption as well as more even lighting distribution. First, traditional skylights were simulated within the space. Due to the need for lighting at the main entry of the space that stems from the lack of access to natural light through the existing windows in the space, the skylights

have been applied there, and this will continue to be the area of focus where daylighting options are applied. (See Figure 4.08-4.9).

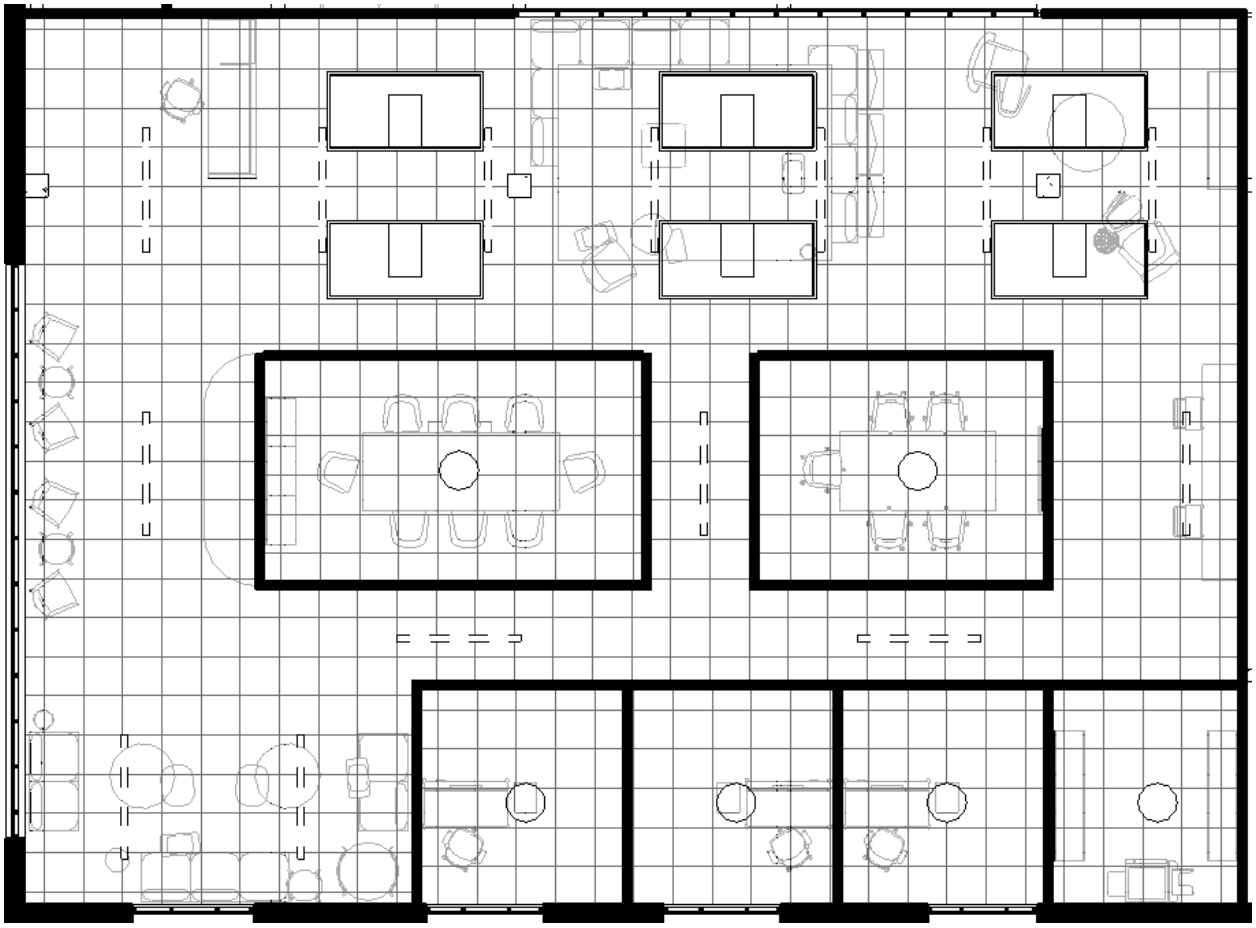


Figure 4.08 Traditional Skylights Reflected Ceiling Plan Displaying Proposed Skylight Placement (Wood, 2023)

Figure 4.09 Traditional Skylights Lighting (Wood, 2023)

Information from the simulation also provides useful numerical values regarding the foot candle averages within the space with just the skylights being recorded. While the main dark spots gained a lot of light, they still are not quite meeting the minimum number of footcandles at a minimum (See Figure 4.10). The highest average is 10 footcandles (See Figure 4.11 and Table 4.06), which is still 10 below the minimum level for an office space. It is safe to assume that though the addition of traditional skylights does increase the passive light within the space, it would still need additional lighting to maintain a healthy and functional amount of footcandles. With low light in an office space, eye strain is a heightened risk factor. It is important to note that

with the application of traditional skylights, the use of artificial lights would still be needed to ensure that adequate lighting levels are met and maintained to ensure the wellbeing of the users.

It can be concluded that while traditional skylights do add to the ambient lighting throughout the work day at a lower cost than both solar tubes and artificial skylights, the low footcandles within the space would result in continued use of electricity at all times. Due to this, the yearly cost after the application of traditional skylights at $6,763.00 added to the yearly energy consumption cost of $4,034.88 would mean a yearly cost of $10,797.88. While not the most expensive option, there would be minimal energy savings, meaning that the yearly cost of electricity would fail to fall. In the years following the initial application, the cost of the yearly maintenance at $385.00 and yearly energy consumption at $4,034.88 would equal $4,428.88 per year.

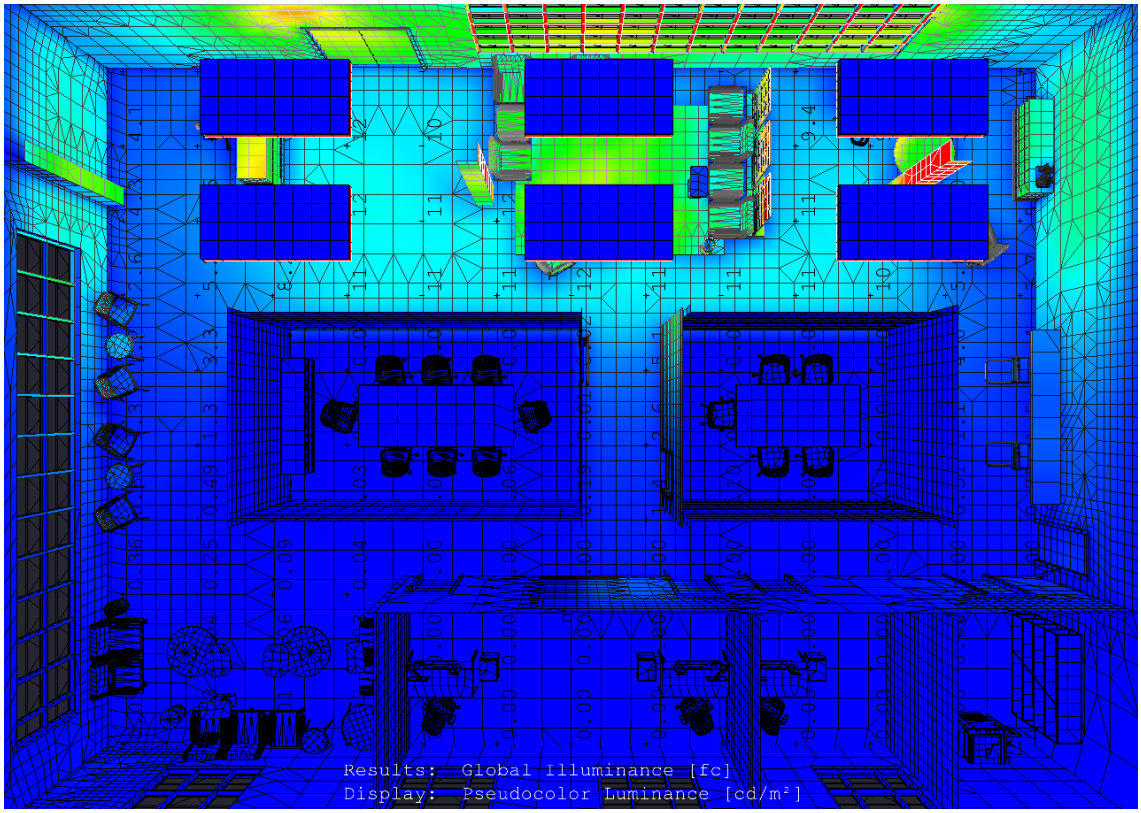


Figure 4.10 Traditional Skylights Lighting with Footcandles (Wood, 2023)

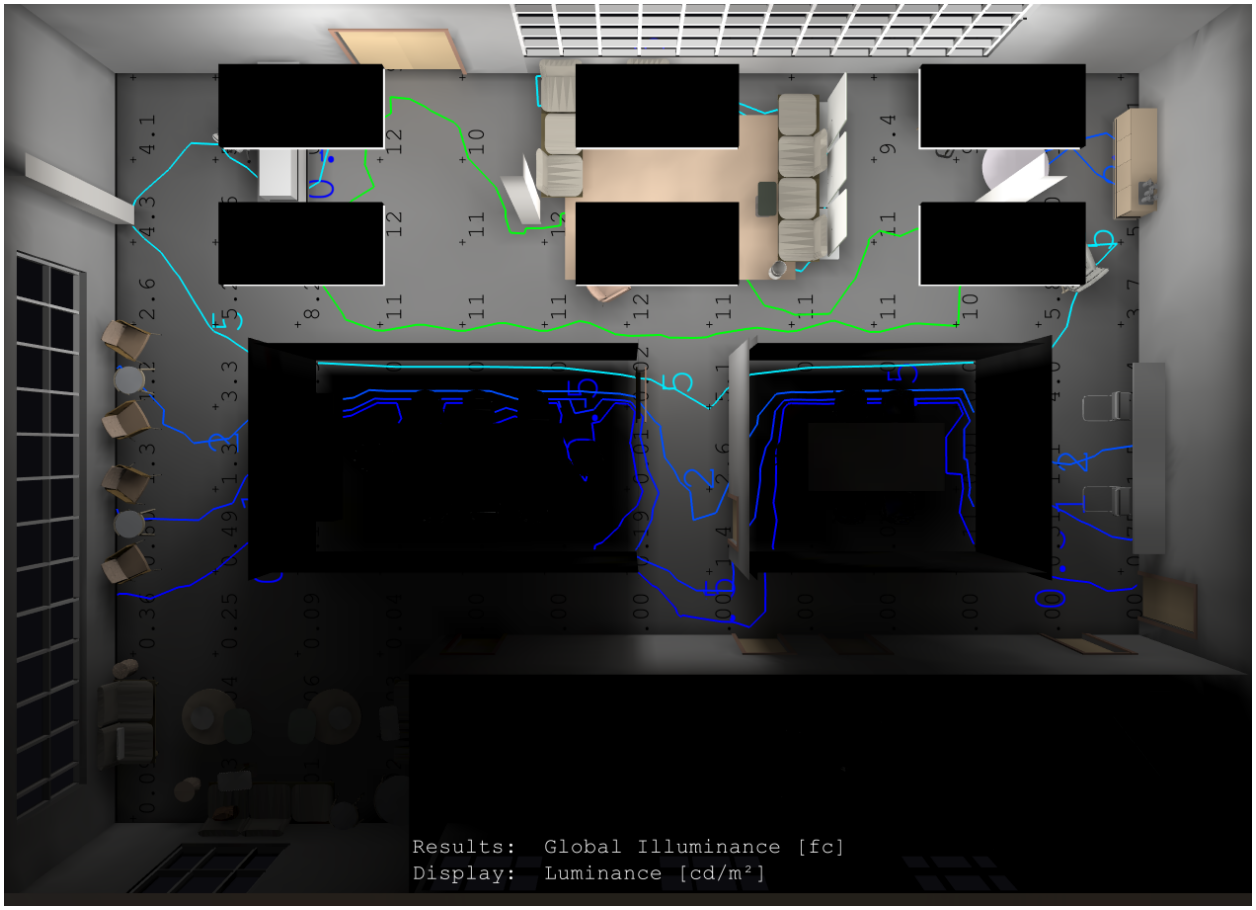


Figure 4.11 Traditional Skylights Lighting with Footcandle Averages (Wood, 2023)

Image	Footcandle Level
Green	10
Light Blue	5
Dark Blue	2

Table 4.06 Artificial Lighting Level Legend

Overall, the addition of traditional skylights to the spaces does increase the general lighting within the space, but does not raise the lighting levels to the minimum level required for an office space. While still providing some benefits to the users such as an increase in productivity and morale, the low lighting level would keep the benefits at a minimal level and

does not optimize the space. Additionally, the continuous need for electricity throughout the space even with the skylights combats the sustainability benefits of skylights. While providing the opportunity to reduce energy consumption and energy output, it does not optimize the space enough to warrant such environmental benefits.

D. Solar Tubes Simulation

Solar tubes are an increasingly popular daylighting option due to their affordable pricing and their ability to increase energy savings. When applied to the work lounge, 12 units are able to adequately light the space. (See Figure 4.12 - 4.13).

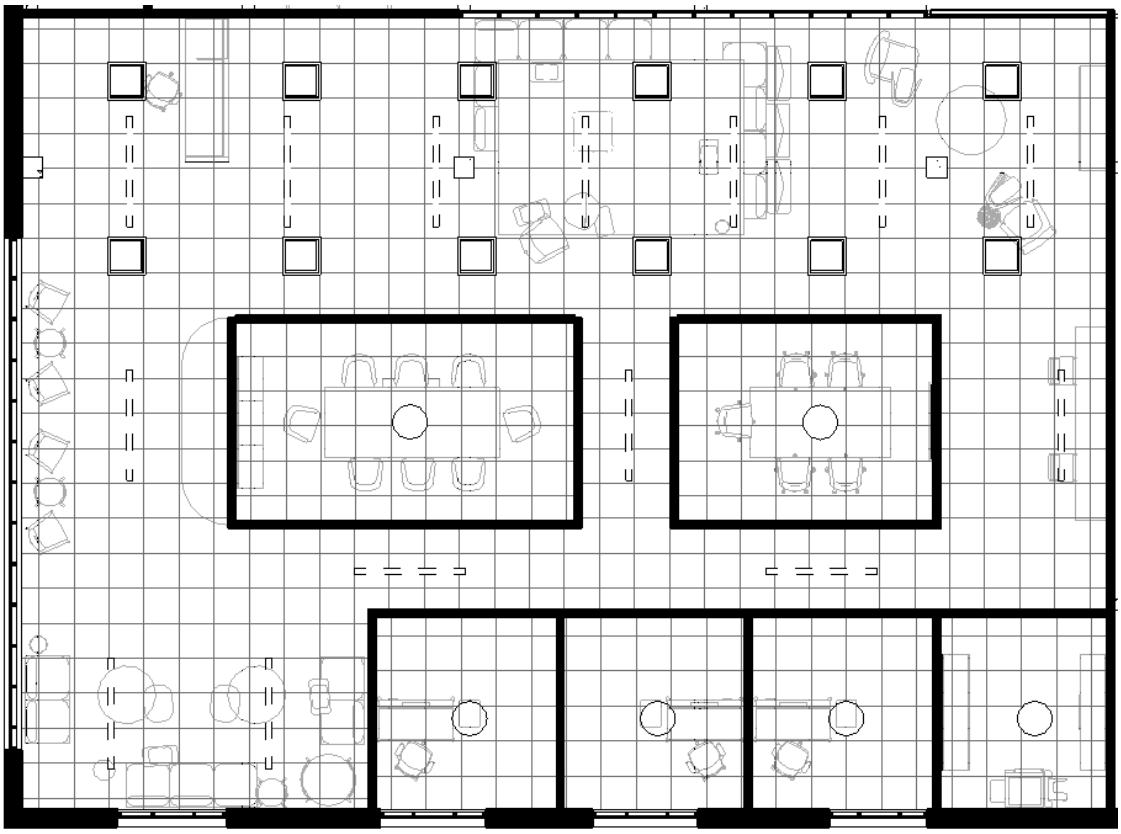


Figure 4.12 Solar Tubes Reflected Ceiling Plan Displaying Proposed Solar Tube Placement (Wood, 2023)

Figure 4.13 Solar Tubes Lighting (Wood, 2023)

Additional information from the simulation shows that with the addition of solar tubes, the average footcandle level in the space is 20 in the main co-operative working spaces (See Figures 4.14 and 4.15 table Table 4.07). Due to this level of footcandles, it can be assumed that the space is lit at an acceptable level, meaning that the need for artificial lighting throughout the day is lowered. While not able to be completely turned off, the artificial lights within the space at certain times of the day and especially during sunny days will not be required to meet the minimum required footcandle levels in the space.

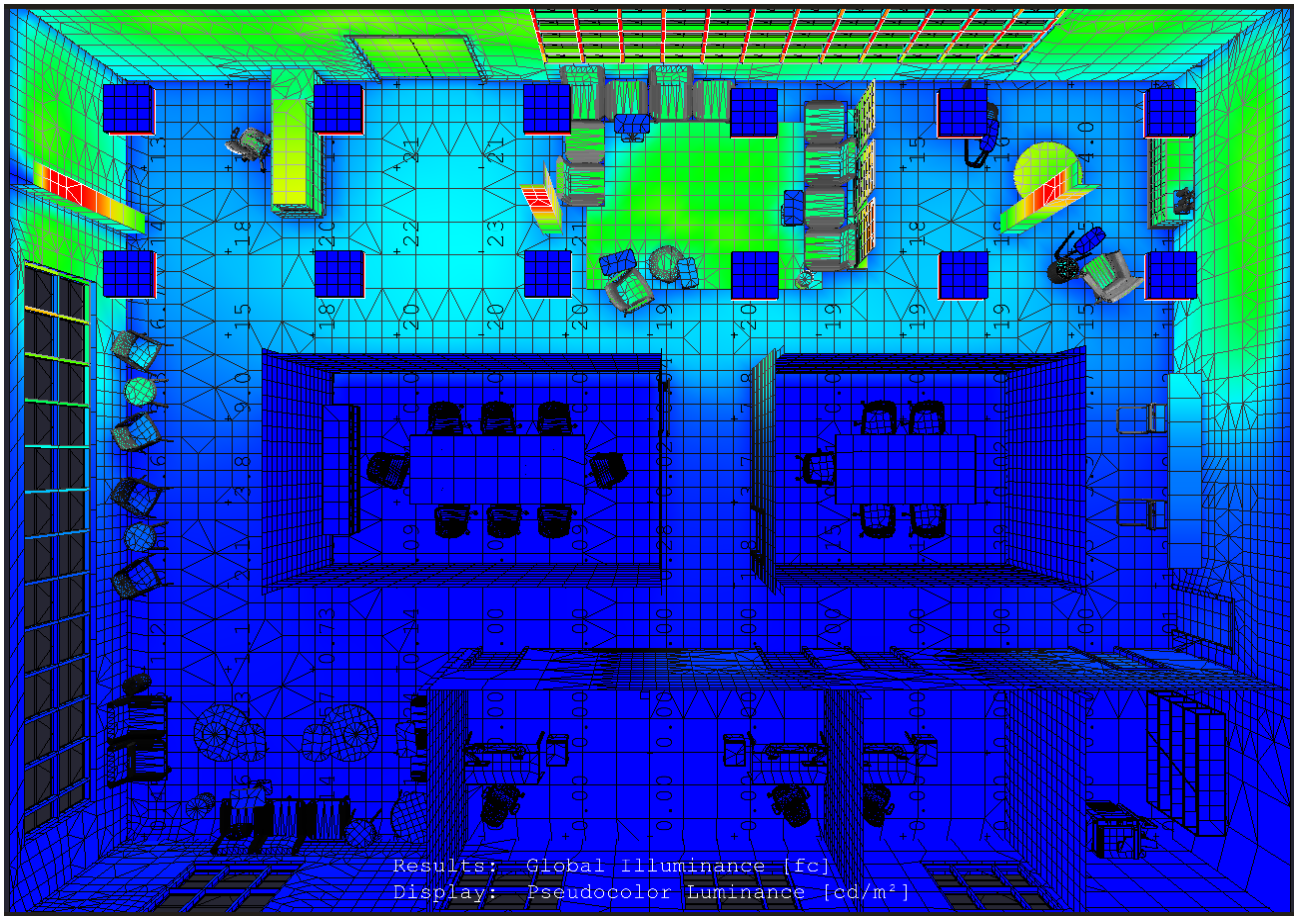


Figure 4.14 Solar Tubes Lighting with Footcandles (Wood, 2023)

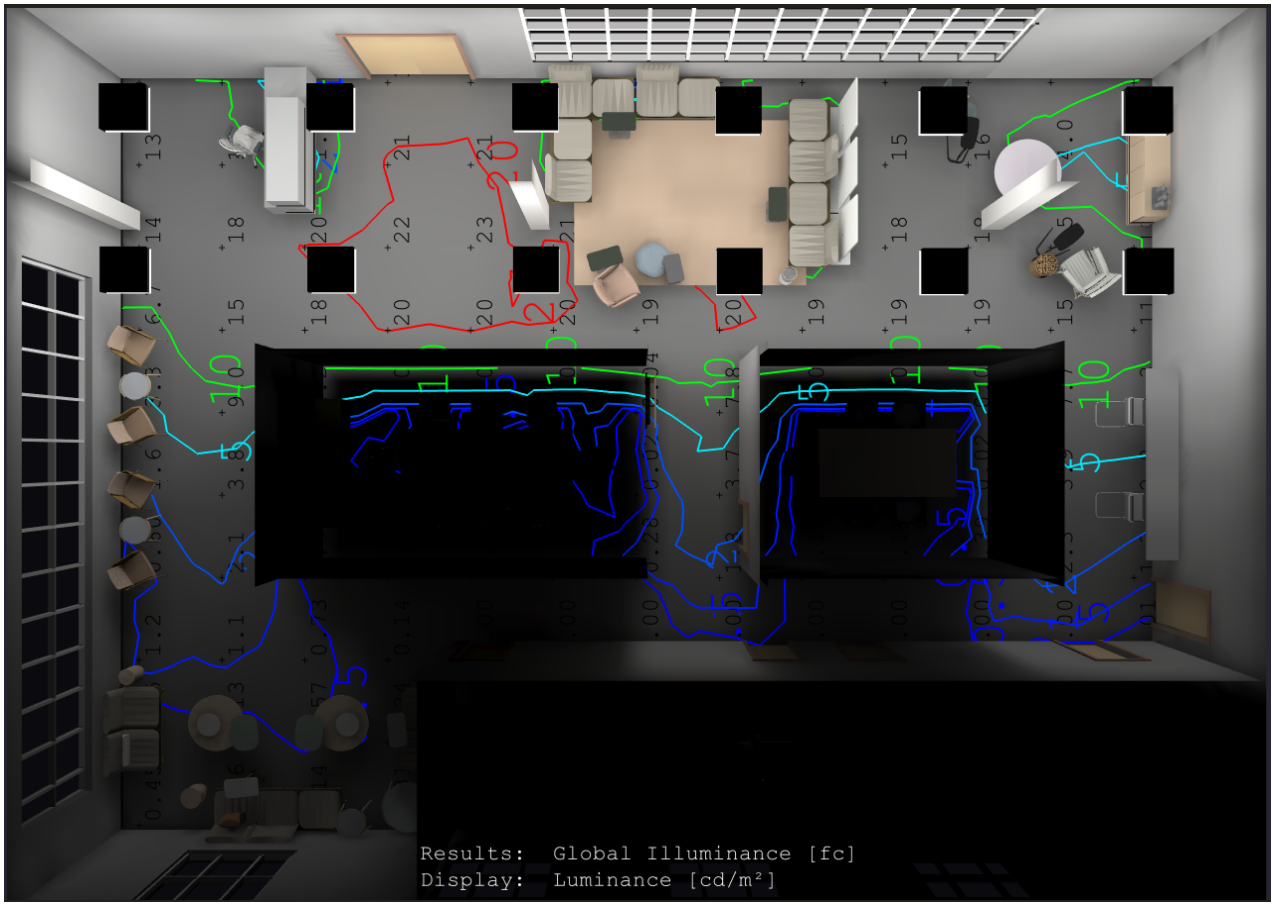


Figure 4.15 Solar Tubes Lighting with Footcandle Averages (Wood, 2023)

Image	Footcandle Level
Red	20
Green	10
Light Blue	5
Dark Blue	2

Table 4.07 Artificial Lighting Level Legend

It can be noted that with the application of solar tubes, some savings can be achieved with regard to energy savings. With an estimated 210 sunny days in Chattanooga per year (National Climatic Data Center, 2023), a simple equation can be used to calculate an estimate of

energy savings. First, the overall cost of the application of skylights is estimated at $9,250.00. Taking the energy consumption cost of $4,043.88 per year and dividing it by 350 days (a full working year with 2 weeks vacation) gives us roughly $11.55 in costs per day for energy consumption. Next, multiplying $11.55 by 210 (sunny days in Chattanooga per year) is approximately $2,425.50. Taking the 210 days of full sun that Chattanooga gets per year and subtracting the $2,425.50 from the $4,043.88 lowers the yearly energy consumption cost to $1,618.38. In the first year of application, the cost would be roughly $9,250.00 plus $1,618.38, equaling $10,868.38. In the following years, maintenance and energy consumption costs would come to $1,868.38 per year. While the initial cost of install is more expensive than traditional skylights, the overall energy savings is much lower than the previous option.

Overall, the addition of solar tubes into this space is extremely beneficial. While increasing the overall lighting level to be at or above the minimum required level, the need for continuous electrical lighting throughout the day is unnecessary, resulting in lower energy consumption levels and a lower energy output. This also lowers the overall amount of natural gas, nuclear energy, or fossil fuels that are needed to maintain the functions of the space, positively affecting levels of pollution for the surrounding environment by lowering them. The environmental benefits of solar tubes also outweighs the benefits of traditional and artificial skylights due to the sheer ability to let in more light. The ability to completely turn off artificial lighting for a large portion of the space can decrease the carbon footprint of the proposed building. Due to the fact that solar tubes let in more natural light than its counterpart -- traditional skylights -- more tangible and visible benefits for the users of the space are seen through increased productivity, morale, and mental and physical wellbeing.

E. Artificial Skylights Simulation

Artificial skylights are another popular daylighting option in today's design. While not really natural light, these technologically advanced devices can mimic natural daylight. Due to this, the users of the space still benefit from things such as regulated circadian rhythms, increased morale, and increased production. With the work lounge, 12 artificial skylights were used to increase the amount of daylight within the space. (See Figure 4.16 - 4.17).

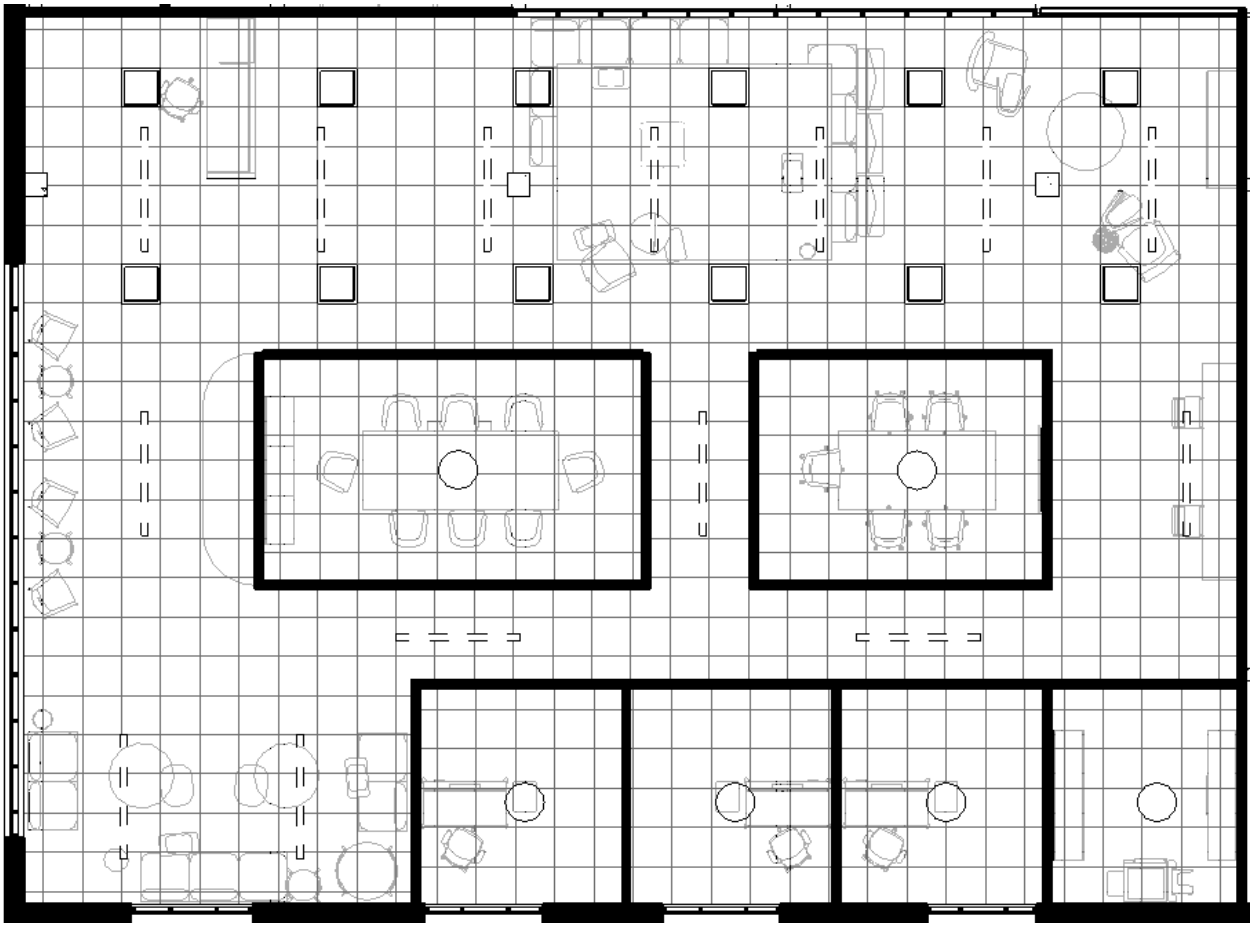


Figure 4.16 Artificial Skylight Reflected Ceiling Plan Displaying Proposed Skylight Placement (Wood, 2023)

Figure 4.17 Artificial Skylight Lighting (Wood, 2023)

As seen in Figures 4.18 and 4.19 and Table 4.08, the artificial skylights do provide an abundance of additional light, meeting minimum requirements of foot levels within the main collaborative section of the simulated space. However, because artificial skylights do not allow for a truly electricity free light source, the energy consumption is not lessened.

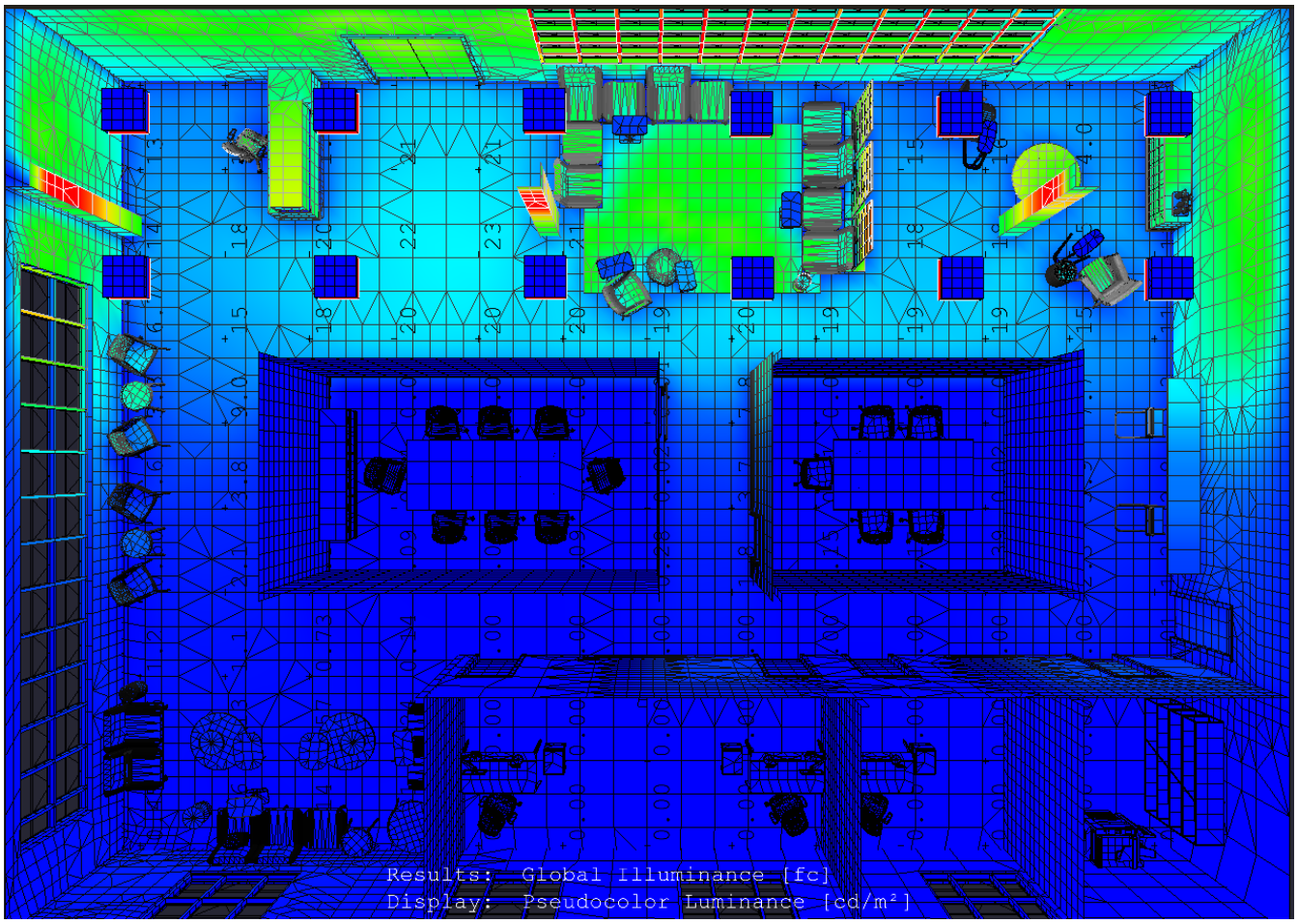


Figure 4.18 Artificial Skylight Lighting with Footcandles (Wood, 2023)

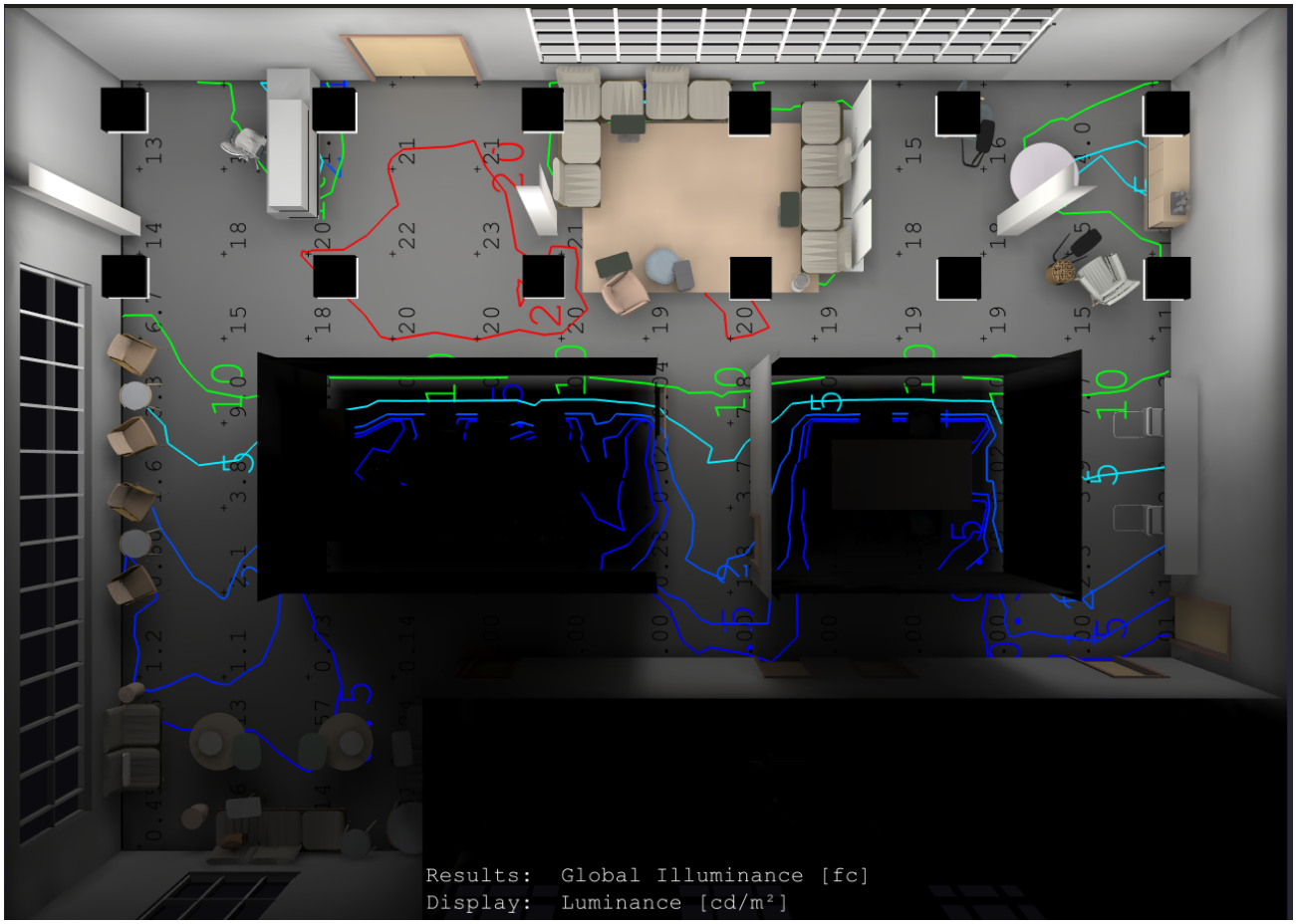


Figure 4.19 Artificial Skylight Lighting with Footcandle Averages(Wood, 2023)

Image	Footcandle Level
Red	20
Green	10
Light Blue	5
Dark Blue	2

Table 4.08 Artificial Lighting Level Legend

At a price of $12,100.00 for the install and maintenance of 12 artificial skylights, the overall cost of the first year including energy consumption costs at $4,043.88 comes to $16,143.88. A higher first year cost than the other options, and due to the fact that these do rely

on electricity to run, the yearly energy consumption price would remain the same. In the years following the install, the yearly operational costs of the work lounge would come to $4,143.88 including maintenance and electricity.

Overall, the introduction of artificial skylights into the space fails to lower the need for electrical lighting. Due to this, there are no cost or sustainability benefits with regard to environmental health. Artificial skylights do however increase the general lighting to be at a desirable amount, meeting the minimum requirement of 20 foot candles for the area of focus. Due to this and the nature of the artificial light, daylighting benefits can be assumed to positively affect the users of the space. Additionally, artificial skylights have a minimal construction and installation cost with regard to how it affects the building envelope. The ability to be installed without penetrating through the roof of the building significantly decreased construction costs at the time of installation. This allows artificial skylights to be a more feasible option for existing projects. On top of being easily installed, artificial skylights and their simple and non-invasive construction means lowered construction waste, lowered construction material, and less carbon emissions released.

F. Conclusions

This chapter documented the findings of each daylighting simulations with regard to effect on users, estimated yearly operating costs and installation costs, and overall effect on the lighting within the space. The findings further inform the most balanced daylighting option for the work lounge and confirm that solar tubes are the best option. Based on Table 4.09, an understanding of average costs again presents solar tubes as the best option with regard to energy savings. Additionally, the environmental benefits of solar tubes outweighs the benefits of

traditional and artificial skylights due to the sheer ability to let in more light. The ability to completely turn off or at least dim artificial lighting for large portions of the space can decrease the carbon footprint of the surrounding environment. The lower installation cost also means a lower construction costs, again positively affecting the carbon footprint of the building.

Type	Product Cost (Including tax and installation)	Maintenance Costs (Avg., yearly for all fixtures.)	Number of Fixtures	Yearly Energy Consumption of Work Lounge	Total Cost (over 1 year)	Total Yearly Cost after 1st Year
Traditional Skylight	$1,063.30	$385.00	6 @ 48” x 96”	$4,043.88	$10,797.88	$10,797.88
Solar Tube	$750	$250.00	12 @ 26” x 26”	$4,043.88	$13,293.88	$1,868.38
Artificial Skylight	$1,000.00	$100.00	12 @ 23’7 x 23’7	$4,043.88	$16,143.88	$16,143.88

Table 4.09 Breakdown of Costs and Savings

As stated above, solar tubes are the only viable option when it comes to sustainability. Traditional skylights are unable to bring in enough light to minimize energy usage, meaning that there would be little to no effect on the interior environment, on the amount of energy and light used and discarded, and low savings. Artificial skylights suffered from the same issues; the continuous use of energy to function kept them from lowering the building’s carbon footprint and did not result in energy savings of any kind. Solar tubes have a higher initial cost at installation, but bring in enough light to lower the need for artificial lighting throughout the space. Due to this, the following years would have high energy savings, a lowered carbon footprint and lessened pollution output, and a greater effect on the users within the space.

Chapter 5: Discussions and Conclusions

A. Introduction

The findings of this thesis presented three daylighting solutions that will increase the interior environment's appeal and health with regard to the users of the space and the overall efficiency of the space. Within this chapter, a final decision on the most appropriate daylighting option is discussed.

B. Discussions

a. Benefits of Chosen Method

The chosen method of a simulation was beneficial to this project because it studied a variable, daylight, where the benefits of the variable are dependent upon how well daylight is able to enter and fill a space. Due to this, the simulation was able to provide accurate information regarding the light levels of daylight within the work lounge, allowing for more concrete conclusions with regard to the effect of the conclusion on the future users of the space. This method could be applied to other projects to provide information about lighting levels within a space and could inform the designers and architects of the best solution to any daylighting issues or concerns.

b. Future Impacts

For this project, the results inform future designers of the functionality of the specified products as well as the general benefits of each daylighting option. Additionally, the simulation provided an example of how spaces can transform through lighting design and how the functionality of interiors can be dictated by the amount of natural light that enters the space. It also provided a collection of data regarding the physical and mental benefits of natural lighting

in interiors, information on the application of the specified daylighting options, and physical results of each applied method for future review and study.

C. Conclusions

This thesis explored the effects of daylighting a space and why it is important to both the users and the environment. Proposing three types of daylighting solutions, traditional skylights, solar tubes, and artificial skylights, allowed for a simulation to be run to best test each option within the proposed space. Through this simulation, it can be concluded that solar tubes are the most balanced daylighting option for this space. This conclusion can be used to provide an informed recommendation for how to properly daylight a space with regard to human health and wellbeing and energy efficiency.

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Appendix A: Finish Tearsheets

SEVEDE

PRODUCT DETAILS	
Article Number	151NCSEK05KW240
EAN Code	7393969039000
Surface Treatment	Oil This floor should be oiled immediately after installation.
Design features	Beveled 4-sided, Brushed, Light smoked, Handscraped
Dimensions	7 3/8 x 95 1/4 "
Weight per Package	48.5 lbs
Area per Package	29.1 sqft
Area per pallet	1317.5 sqft
Package info	Packages may contain start and stop boards.

DETAIL DESCRIPTION

All naturally occuring wood colour variations allowed, from light to dark brown. Sapwood may occur. The product includes very large sound and black knots and cracks. Knots and cracks will be present in all sizes and numbers.

COLOR CHANGE

Stained product - noticable color change over time.

FACTS	
Wood Species	White Oak
Design	1-strip
Grading	Dynamic
Range	Kährs Supreme
Collection	Småland Collection
Resandable	2 times
Natural/Stained	Stained
Brinell Value	3,7
Joint	Woodloc® 5S
Floor heating	Yes
	30 years
Wear-layer material	Hardwood
Wear Layer Thickness	1/8"
Core material	Pine/Spruce lamella
Backside material	Veneer
Thickness	5/8"
Installation method	Floating, Glue-Down

TECHNICAL PROPERTIES		
Moisture content	EN13183	7%±2%
Minimun Mean Density kg/m³		>500 kg/m³
Reaction To Fire	EN13501-1	Dfl-s1
Formaldehyde Emission	EN717-1	E1
Content PCP	CEN/TR14823	≤ 5 x 10-6n
Breaking Strength N/mm²	EN1533	NPD
Thermal Conductivity	EN12664	0,14 W/mK
Thermal Resistance R-Value		.11 (m2K/W)
Biological Durability	EN350-2	Class 1
CARB2		Compliant
Slipperiness	CEN/TS15676	NPD

Other products in this collection


Oak Klinta


Kinda


Sevede


Ydre


Möre


Vista


Vedbo


Handbörd


Tveta


Finnveden


Aspeland

CERTIFICATES

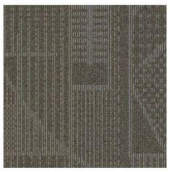
Descriptions & Imagery

All samples, images and product description, plus photo and brochure specifications are there for the sole purpose of giving an approximate idea of the items described in them. They shall not form part of the contract or have any contractual force and should be viewed for illustrative purposes only. We cannot guarantee that your computer's display or the quality of the print will accurately reflect the colour of the products. Your product may vary slightly from the images within this literature.

Flooring 1

Layout

Interface



Product Layout **Color** Details **Collection** Architectural Plans Collection
Backing GlasBac™

Installation Method

Non Directional

All product specifications reflect averages derived from product sample testing, are subject to normal manufacturing and testing tolerances and inherent pattern variances, and may be changed without notice. For more information about these and other important attributes of the product(s) described herein, including recycled content and product warranty information, please see www.interface.com/disclaimer.

Product Specifications		
Product Number	1465402500	
Product Construction	Tufted Textured Loop	
Yarn System	Post-Consumer Content Nylon	
Yarn Manufacturer	Universal	
Dye Method	100% Solution Dyed	
Soil/Stain Protection	Protekt²®	
Preservative Protection	Intersept®	
More Product Specifications		
	Imperial	**Metric**
Tufted Yarn Weight	17.00 oz/yd²	576.40 g/m²
Machine Gauge	1/12 in	47.2 ends/10cm
Pile Height	0.14 in	3.60 mm
Pile Thickness	0.10 in	2.50 mm
Stitches	10.00 /in	39.40 ends/10cm
Pile Density	6,120.00 oz/yd³	226,928.20 g/m³
Size	19.69 in x 19.69 in	50cm x 50cm
Performance Specifications		
Flooring Radiant Panel	(ASTM E-648) Passes	
Smoke Density	(ASTM E-662) ≤ 450	
Lightfastness	(AATCC 16 - E) ≥ 4.0 @ 60 AFU's	
Static	(AATCC - 134) < 3.0 KV	
Traffic Classification	Severe	
Fiber Modification Ratio	1.7 to 1.9	
Preservative Efficacy	(AATCC 174 Parts 2&3) 99% Reduction/No Mold 7 Days (ASTM E-2471) Complete Inhibition	
Health + Environmental Specifications		
Embodied Carbon (Cradle to Gate)	4.54 Kg CO_2/M²	
Full Life Cycle Carbon Emissions	Certified Carbon Neutral Floors™	
Total Recycled Content	64.05 %	
Recycled Content (Pre Consumer)	62.79 %	
Recycled Content (Post Consumer)	1.26 %	
Indoor Air Quality	Green Label Plus #GLP0820 CDPH 01350	
Material Compostion	Free of Added Heavy Metals, Formaldehyde, Fluorinated Chemicals (PFAS), and Halogenated Flame Retardants.	
Disclosure of Environmental Impacts	Environmental Product Declaration	
Disclosure of Product Ingredients	Health Product Declaration	
Environmental Certifications	Certificate of Conformity	
LEED v4	Contributes to multiple IEQ and MR credits	

End of Life	Carpet to Carpet Recycling through ReEntry®
Technical Information	
Installation	Interface Installation Guidelines
Maintenance	Recommended Interface Maintenance Guidelines
Reclamation	Recyclable through ReEntry® - Call 1.888.733.6873 (U.S.) / 1.866.398.3191 (Canada)
Warranty	15 Year Standard Carpet Warranty
Installation Method	Non Directional
Manufacturing Location	ISO 9001 & 14001 Certified facilities in Troup County, Georgia, United States

ULTIMA® Health Zone™
ULTIMA® Health Zone™ High NRC

Square Lay-in
fine texture

TOTAL ACOUSTICS®
Sound Absorption (NRC) + Sound Blocking (CAC)

SUSTAIN®
High Performance Sustainable Ceiling Systems

CAD/Revit® drawings at:
armstrongceilings.com/cadrevit

▲ Ultima® Health Zone™ Square Lay-in panels with Prelude® XL® 15/16" suspension system

Perfect for office, education, and healthcare spaces

Fine texture mineral fiber ceiling; combines exceptional acoustical performance, sustainability, and functionality attributes in one go anywhere ceiling panel that is especially durable and aesthetically pleasing for every healthy space.

KEY SELECTION ATTRIBUTES

- Get total noise control and floor plan versatility with Total Acoustics® ceiling panels: NRC + CAC = Total Acoustics Performance
- Meets or exceeds USDA/FSIS, FGI, HIPAA and ANSI S12.60 guidelines
- Anti-Bacterial/Mold/Mildew – BioBlock® Plus performance resists the growth of odor and stain-producing bacteria as well as mold and mildew on the ceiling tile surface
- Exceptional durability and cleanability – impact-, scratch-, and soil-resistant
- CleanAssure™ – safe for use with disinfectant cleaners
- Clean + Simple – Ultima® panels are part of the Sustain® portfolio and are free of Red List chemicals for better indoor air quality
- Clean Room Performance up to ISO Class 5 (Class 100) using gasketed Clean Room™ suspension systems
- Long-lasting water-repellency; washable and scrubbable
- Energy-saving, high light-reflective finish
- 30-Year Limited System Warranty against visible sag, mold, mildew, and bacterial growth

TYPICAL APPLICATIONS

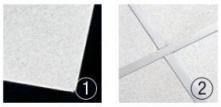
Healthcare:
- Patient rooms
- Treatment rooms
- Nurses' stations
- Emergency rooms
- Corridors
- Lavatories and restrooms
- Kitchen/food prep areas

Education
Office
Clean Rooms (item 1935)

COLOR

White (WH)

DETAILS



1. Ultima® Health Zone™ Square Lay-in
2. Ultima® Health Zone™ High NRC Square Lay-in panels with Clean Room™ 15/16" suspension system

TechLine 877 276-7876
armstrongceilings.com/healthzone

Armstrong® CEILING & WALL SOLUTIONS

ULTIMA® Health Zone™
ULTIMA® Health Zone™ High NRC

Square Lay-in
fine texture

USDA CERTIFIED BIOBASED PRODUCT PRODUCT 95%+

SUSTAIN® High Performance Sustainable Ceiling Systems

GREENGUARD Gold Certified (details below)

Declare.

LEED® WELL™ LBC

UP TO 76% RECYCLED CONTENT

Calculate sustainability with Green Genie™ armstrongceilings.com/greengenie

energy management · construction waste mgmt · regional materials ▲ · design for flexibility · EPD · recyclable/ product/ producer resp · biobased materials · recycled content · sourcing of raw materials · material ingredient reporting · low emitting/ materials · lighting quality · acoustics

▲ LOCATION DEPENDENT

VISUAL SELECTION

PERFORMANCE SELECTION

Dots represent high level of performance. $$$$

armstrongceilings.com/suspdwgs	Susp. Dwg.	Item No.	Dimensions (Inches)	UL Classified Acoustics NRC + CAC =	Total Acoustics[1]	Articulation Class AC	Fire Performance	Light Reflect	Bio-Block+ Anti-Bacterial/ Mold/ Mildew	Humi-Guard+ Sag Resistant	Certified Low VOC Emissions	CleanAssure™ Disinfectable Panels: Fog & Spray	Wipe	DURABILITY: Water Repel	Wash	Scrub	Impact	Scratch	Soil	Recycle Program	30-Yr Warranty
ULTIMA® Health Zone™ High NRC 15/16" Square Lay-in	1, 6	1445	24 x 24 x 7/8"	0.80 • 35 •	BEST	170 •	Class A	0.86 •	+	•	•	•	•	•	•	•	•	•	•	•	•
		1448*	24 x 48 x 7/8"	0.80 • 35 •	BEST	170 •	Class A	0.86 •	+	•	•	•	•	•	•	•	•	•	•	•	•
ULTIMA Health Zone 15/16" Square Lay-in	1, 6	1935	24 x 24 x 3/4"	0.70 • 38 •	BETTER	N/A	Class A	0.86 •	+	•	•	•	•	•	•	•	•	•	•	•	•
		1938*	24 x 48 x 3/4"	0.70 • 38 •	BETTER	N/A	Class A	0.86 •	+	•	•	•	•	•	•	•	•	•	•	•	•
Made-to-Order Sizes ULTIMA Health Zone		1 Ctn Min FASTSIZE 3 WEEKS order to ship	3/4" or 7/8" Thick – 15/16" Square Lay-in Width: 4" – 6", 6-1/2" – 30", 30-1/2" – 48" Length: 12" – 72", 12" – 72", 4" – 30"	N/A	N/A	N/A	N/A	Class A	0.86 •	+	•	•	•	•	•	•	•	•	•	•	•	•

Visit the product page online and see "Configure an Item" to verify capabilities.
Questions? email Techline@armstrongceilings.com

[1] Total Acoustics® ceiling panels have an ideal combination of sound absorption and sound blocking in one product.
GOOD (NRC 0.60-0.65; CAC 35+) **BETTER** (NRC 0.70-0.75; CAC 35+) **BEST** (NRC 0.80+; CAC 35+)
* Item does not have painted edges

SUSPENSION SYSTEMS

15/16"

Prelude® · Clean Room™ (Steel or Aluminum)

PHYSICAL DATA

Material
Wet-formed mineral fiber with DuraBrite® acoustically transparent water-repellent membrane

Surface Finish
DuraBrite with factory-applied latex paint

Fire Performance
Class A: ASTM E84 and CAN/ULC S102 surface burning characteristics. Flame Spread Index of 25 or less. Smoke Developed Index of 50 or less (UL® labeled).

ASTM E1264 Classification
Type IV, Form 2, Pattern E; Fire Class A

Humidity/Sag Resistance
HumiGuard® Plus ceiling panels are recommended for areas subject to high humidity, up to, but not including, standing water and outdoor applications.

Anti-Bacterial/Mold/Mildew
Ceiling tiles with BioBlock® Plus performance resist the growth of odor and stain-producing bacteria as well as mold and mildew on the ceiling tile surface.

VOC Emissions
GREENGUARD Gold Certified
PRODUCT CERTIFIED FOR LOW CHEMICAL EMISSIONS UL.COM/GG UL 2818
Third-party certified compliant with California Department of Public Health CDPH/EHLB/Standard Method Version 1.2, 2017. This standard is the guideline for low emissions in LEED®, WELL Building Standard™, Living Building Challenge® (LBC), CalGreen Title 24, ANSI/ASHRAE/USGBC/IES Standard 189; ANSI/GBI Green Building Assessment Protocol.

GREENGUARD GOLD

Acoustical Performance
CAC testing conducted using Prelude suspension system.

Primary (Embodied) Energy
See all LCA information on our EPDs.

High Recycled Content
Contains greater than 50% total recycled content. Total recycled content based on product composition of post-consumer and pre-consumer (post-industrial) recycled content per FTC guidelines.

Insulation Value
R Factor – 2.9 (BTU units)
R Factor – 0.445 (Watts units)

Cleaning and Disinfecting
Cleaning and CDC recommended disinfecting options available on armstrongceilings.com/cleaning

30-Year Performance Guarantee & Warranty
When installed with Armstrong® Suspension System. Details at armstrongceilings.com/warranty

Weight; Square Feet/Carton
1448, 1938 – 1.08 lbs/SF; 48 SF/ctn
1445 – 1.0 lbs/SF; 40 SF/ctn
1935 – 1.0 lbs/SF; 48 SF/ctn

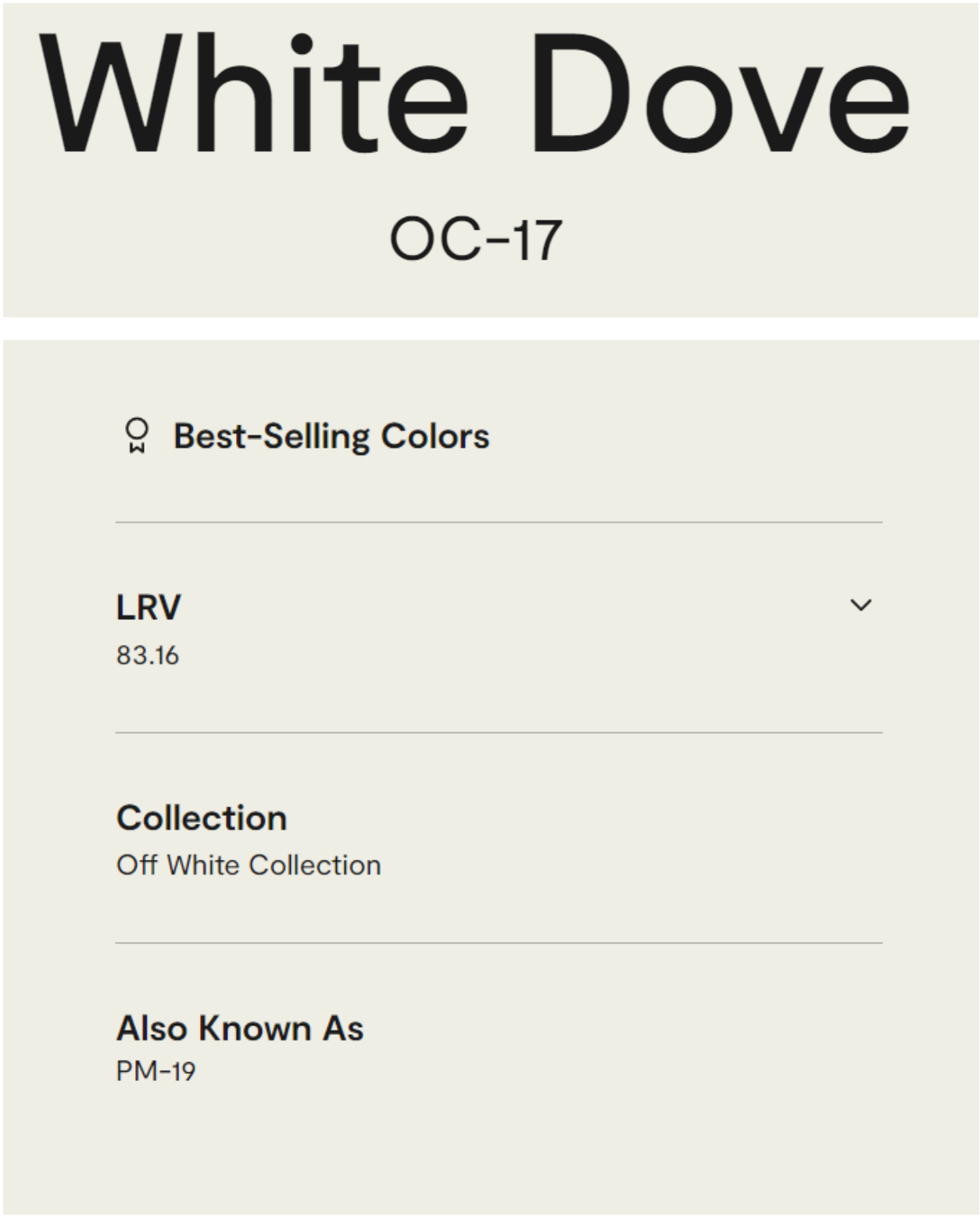
Minimum Order Quantity
1 carton

TechLine / 1 877 276-7876
armstrongceilings.com/healthzone

BPCS-4066-1122

Armstrong® CEILING & WALL SOLUTIONS

MINERAL FIBER – Standard


White Dove
OC-17
Best-Selling Colors
LRV
83.16
Collection
Off White Collection
Also Known As
PM-19

Paint 1


Dellwood Sand
1019
LRV
36.05
Collection
Benjamin Moore Classics®
Also Known As
CC-364, TH-280

Paint 2

koroseal | STACY GARCIA NEW YORK

HIGHRISE
Fact Sheet

9 Colorways:	SG06-01 Alabaster SG06-02 Aluminum SG06-03 Cement SG06-04 Steel SG06-05 Silt	SG06-06 Sandstone SG06-07 Jade SG06-08 Blue Kyanite SG06-09 Quartzite	
Total Weight	20 oz. ply (618 g. plm.) 13.3 oz. psy (451 g psm.)	**Vertical Repeat**	18 in.
Roll Width	52-54 in. (132-137 cm.)	**Horizontal Repeat**	52 in.
Backing	Woven (Osnaburg)	**Nominal Pattern Width**	51 in.
Tensile (Minimum)	50 x 55 lb_f (222 x 245 N)	**Match Information**	Reverse Hang, Random Match
Tear (Minimum)	25 x 25 lb_f (111 x 111 N)	**WA Spec.**	WA-101, Type II
Federal Spec.	CCC-W-408D, Type II	**ASTM F-793**	Category V, Type II
Fire Testing	NFPA 101® Life Safety Code® NFPA 255 (ASTM E-84, CAN S102M) Tunnel Test[1] - Class A Rating - Flame Spread - 10 - Smoke Developed - 5 NFPA 286 Corner Burn Test[2] - Meets requirements for Flame Spread, Smoke Developed, & Flashover 1 When applied to GRC board with A-848-B adhesive 2 When applied to 5/8" Type-X-Gypsum board with A-848-B adhesive		
CE Certification	EU classification in accordance with EN 15102:2007 + A1:2011		
Indoor Air Quality	California 01350 – Meets emission requirements for schools and offices		

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48-47-SG06-07/2021

Wallpaper 1

koroseal

ARCO
Fact Sheet

8 Colorways:	RA21-01 Étretat RA21-02 Wales RA21-03 Malta RA21-04 Rome	RA21-05 Sydney RA21-06 Hana RA21-07 Moab* RA21-08 Cabo*	
	*These decorative metallic wallcoverings should only be cleaned with mild ingredients such as soap, detergent, and water. Stronger, more alkaline household cleaners have the potential to damage the surface of the material along with excessive scrubbing.		
Total Weight	20 oz. ply (618 g. plm.) 13.3 oz. psy (451 g psm.)	**Vertical Repeat**	24 in.
Roll Width	52-54 in. (132-137 cm.)	**Horizontal Repeat**	52 in.
Backing	Non-Woven	**Nominal Pattern Width**	51 in.
Tensile (Minimum)	50 x 55 lb_f (222 x 245 N)	**Match Information**	Non-Reverse Hang, Straight Match
Tear (Minimum)	25 x 25 lb_f (111 x 111 N)	**WA Spec.**	WA-101, Type II
Federal Spec.	CCC-W-408D, Type II	**ASTM F-793**	Category V, Type II
Fire Testing	NFPA 101® Life Safety Code® NFPA 255 (ASTM E-84, CAN S102M) Tunnel Test[1] - Class A Rating - Flame Spread - 10 - Smoke Developed - 5 NFPA 286 Corner Burn Test[2] - Meets requirements for Flame Spread, Smoke Developed, & Flashover 1 When applied to GRC board with A-848-B adhesive 2 When applied to 5/8" Type-X-Gypsum board with A-848-B adhesive		
CE Certification	EU classification in accordance with EN 15102:2007 + A1:2011		
Indoor Air Quality	California 01350 – Meets emission requirements for schools and offices		

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63-47-RA21-03/2022

Wallpaper 2

Appendix B: Product Specifications

SKYMAX LARGE SPAN GLASS UNITS

Maximized Daylighting and Thermal Performance – Energy Efficient Single Light up to 35 Square Feet!

SkyMax doubles the square footage of standard size flat glass unit skylights without loss of thermal efficiency.

SkyMax combines the thermal performance of our smaller vinyl frame unit skylights with the structural benefits of our larger aluminum framed structural skylights.

SkyMax's one piece extruded vinyl curb incorporates a condensation channel, eliminating the need for weep holes. This, combined with high-end glazing options, maximizes its thermal performance.

The SkyMax's vinyl frame is structurally reinforced with aluminum, allowing large single light spans.

- Single Light Up to 35 Square Feet – Ten Feet at Longest Dimension
- Meets Most Local Energy Codes and Can Meet IECC in All Climate Zones*
    - WDMA Hallmark Certification
    - NFRC Certification
    - Florida Product Approval
    - IAPMO-ES Certified
- 10 Year Warranty
- For Flat or Sloped Roof 1° – 60° (1/4:12 – 20:12)

		4896	5199
Frame Width	(W-in.)	48	51
Frame Height	(H-in.)	96	99
Daylight Area	(Sq. Feet)	29.06	32

Custom sizes are available up to 35 square feet, 10 feet at longest dimension.

GLAZING OPTIONS

1-1/16″ Solarban 70XL (2)/Argon/Clear HS Laminated is standard. Custom glazing is available, contact your local sales representative for more information.

FINISH

Capstock Finish:

- PVC – White Interior, VELUX Cool Grey Exterior

Retainer Finish:

- VELUX Cool Grey Polyester Powder Coat (Standard)
- FEVE or Polyester Powder Coat, PVDF, Anodized (more information)
- Copper Clad
- Mill

Traditional Skylight

SOLATUBE

Model: Solatube 330 DS-O Open Ceiling
(21 in./530 mm Daylighting System)

Project: Departmental Thesis

Location: 1101 South Watkins Street

Type: Commercial

Product Specifications Appear in CSI Division 08, Section 08 62 23. For budgeting and quotations use only. Qty: 12

Model	Capture Zone				Transfer Zone		Delivery Zone		
S330DS-O	DA	PB	C14	T24	E1	A1	L2	D1	I
1	2	2a	3	3a	4	4a	5	5a	6

1 Model

330 DS-O SolaMaster® Solatube 330 DS-O (21 in./530 mm Daylighting System) Open Ceiling

Capture Zone

2 Dome

DA Dome Acrylic (Meets UFC-ATFP)
DP Dome Polycarbonate (FM Only*+)

2a Dome Options (Leave blank if not desired)

B Security Bar
SK Dome Security Kit
PB Dome Edge Protection Band (Required for FM*+)
SS Secondary Diffuser
FG Rooftop Fire Glazing
Required for High Fire Zones

3 Flashings

F4 4 in. (102 mm) Self Mounted 

F8 8 in. (203 mm) Self Mounted (FM Approved*+) 

F11 11 in. (279 mm) Self Mounted (FM Approved*+) 

FC Curb Cap (FM Approved*+) 

C12** Metal Insulated Curb 26 in. x 26 in. x 12 in. (673 mm x 673 mm x 305 mm) 

C14** Metal Insulated Curb 26 in. x 26 in. x 14 in. (673 mm x 673 mm x 355.5 mm) 

C16** Metal Insulated Curb 26 in. x 26 in. x 16 in. (673 mm x 673 mm x 406.5 mm) 

C20** Metal Insulated Curb 26 in. x 26 in. x 20 in. (673 mm x 673 mm x 508 mm) 

CXX** Metal Insulated Curb 26 in. x 26 in. x XX in. (673 mm x 673 mm x XX mm)
XX: Custom curb height determined by bidding contractor 

*+ Only product that is FM approved. Must use Dome Polycarbonate (DP). It is required that a Dome Edge Protection Band (PB) is used with FM approved flashings.

** Curbs designed for single-ply roofing, lightweight fill or tapered insulation low slope roof types.

3a Flashing Options (Leave blank if not desired)

T12* Roof Flashing Turret Extension 12 in./305 mm
T24* Roof Flashing Turret Extension 24 in./610 mm
T36* Roof Flashing Turret Extension 36 in./914 mm
T48* Roof Flashing Turret Extension 48 in./1219 mm

MCF Membrane Counter Flashing (use with F8 or F11)
FI Flashing Insulator
CI Curb Insulator
CCI Curb Cap Insulation

* Specify additional extension tubes in #4

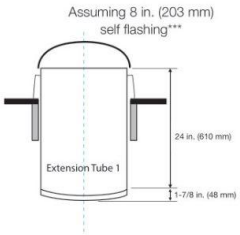
Transfer Zone

4 Extension Tubes Required*

Run measured from top of flashing to diffuser along centerline of tubing using 24" lengths. See 4a for optional 48" length.

E1** One Extension Tube – Max Run = 24 in. (610 mm)
E2** Two Extension Tubes – Max Run = 46 in. (1169 mm)
E3** Three Extension Tubes – Max Run = 68 in. (1728 mm)
E4** Four Extension Tubes – Max Run = 90 in. (2286 mm)
E5** Five Extension Tubes – Max Run = 112 in. (2845 mm)
E6** Six Extension Tubes – Max Run = 134 in. (3404 mm)
E7** Seven Extension Tubes – Max Run = 156 in. (3963 mm)
E8** Eight Extension Tubes – Max Run = 178 in. (4522 mm)
E9** Nine Extension Tubes – Max Run = 200 in. (5080 mm)
E10** Ten Extension Tubes – Max Run = 222 in. (5639 mm)
EXX** Total Run Length to be Determined by Bidding Contractor

*At least one 24 in. (610 mm) or 48 in. (1219 mm) extension tube required for diffuser
**Compatible with dome ring to be used as a top tube or extension tube
***Total tube run will vary depending on flashing used



4a Product Options (Leave blank if not desired)

A1 One 0-90 Degree Extension Tube (Angle Adapter)
A2 Two 0-90 Degree Extension Tubes (Angle Adapter)
E Wire Suspension Kit (50 ft./15 m)
EL Optional 48 in. (1219 mm) Extension Tube (Substitute one 48 in./1219 mm for two 24 in./610 mm above)
TIP Thermal Insulation Panel

R Trim Ring
AK 16 in. (406 mm) Top Tube Angle Adapter and 16 in. (406 mm) Bottom Tube Angle Adapter
TA 16 in. (406 mm) Top Tube Angle Adapter
BA 16 in. (406 mm) Bottom Tube Angle Adapter

Delivery Zone

5 Diffuser Lens

L2 Prismatic Diffuser 

L5 Optiview Wide
L6 Optiview Superwide
L7 Optiview Narrow 

5a Options (Leave blank if not desired)

D1 0-10V Daylight Dimmer™ **LED** 75W 100-277V, 1.1A, 50/60Hz

6 Measurement Standard

M Metric **I** Imperial

Accessories (Order separately)

S1 Low voltage 0-10V switch (white) required to operate Solatube 0-10V Daylight Dimmers. Only one switch is required per forty-eight (48) synchronously controlled dimmers. (For 'D1' only) Note: For use when no controls have been specified and customer is looking for an off-the-shelf solution. If different controls have been specified please source those from others.
TR20 UL Listed Class 2 Transformer 24 VAC, Rated 20 VA (For 'D1' only)
TR96 UL Listed Class 2 Transformer 24 VAC, Rated 96 VA (For 'D1' only)

Example

S330 DS-O-DA-F8-E2-L2-D1-M
SolaMaster Series® 330 DS-O (21 in./530 mm Daylighting System), Acrylic Dome, 8 in. (203 mm) High Self Mounted Flashing, Two Extension Tubes, Prismatic Diffuser and 0-10V Daylight Dimmer. For metric installations.

Solar Tube

Cadiant™ Dynamic Skylight

Cadiant™ Experience 2' x 2' Architectural LED Dynamic Skylight

Rev. Date: V4 08/29/2022

Product Description

Cree Lighting's Cadiant™ dynamic skylight brings the outdoors in, recreating the sensation of being under a natural sky for an interior lighting experience that's as smart as it is visually stunning. For architects, lighting designers and specifiers seeking the visual impact and human benefits of a real skylight — but without the associated high costs or construction limitations — the Cadiant™ experience is an exciting, dynamic lighting solution that delivers the sensation and human benefits of bringing the outdoors in to any interior space

Applications: Commercial office, healthcare, education, retail

Performance Summary

- Utilizes Cree TrueWhite® Technology
- **Adjustable Lumen Levels:** 200-3,200
- **Input Power:** 6-50 watts
- **Efficacy:** Up to 67 LPW
- **CRI:** 90+ CRI
- **R9:** > 65
- **CCT:** Adjustable from 3000K to 6500K
- **Input Voltage:** 120-277 VAC
- **L_{70} Lifetime:** > 100,000 hours at 35°C
- **Limited Warranty[1]:** 5 years on luminaire; up to 5 years for SmartCast® accessories; 1 year for luminaire accessories
- **Mounting:** Designed for use in most ceiling grids including standard 1 ½", 9/16", 15/16" and hard ceiling
- **Weight:** 34 lbs. (15.4kg)
- **Controls:** SmartCast® Technology dimming to 5% with East to West Sun Feature
- Assembled in the USA by Cree Lighting from US and imported parts

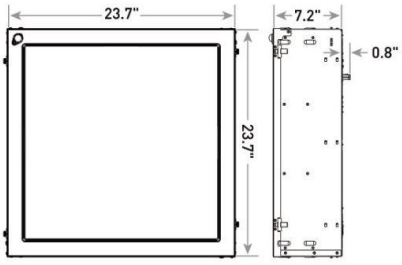
[1] See http://creelighting.com/warranty for warranty terms. For SmartCast accessories, consult SmartCast spec sheets for details on warranty terms.

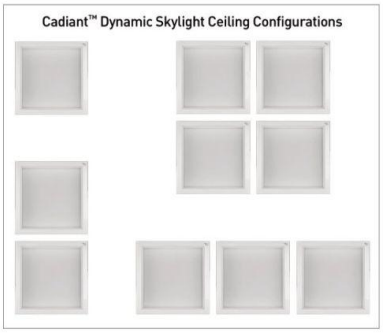
Cadiant™
Dynamic Skylight

SmartCast®
Touchscreen Control

Smartcast®
Wireless Gateway with WiFi

***SmartCast Touchscreen & SmartCast Wireless Gateway Sold Separately**





Cadiant™ Accessories

Field-Installed

SmartCast® Technology Configuration Tool
CCT-CWC-1
- One required per project when CMA control is selected

SmartCast® Technology Face Plates
CFP-1-WH
- Matching Cree Lighting face plate, 1-gang, white
CFP-2-WH
- Matching Cree Lighting face plate, 2-gang, white
CFP-3-WH
- Matching Cree Lighting face plate, 3-gang, white

SmartCast® Technology Wireless Dimmer
CSC-CWD-UNVN-WH (neutral wire required)
CSC-CWD-UNV-WH (no neutral required)

SmartCast® Technology Wireless Switch
CSC-CWS-UNVN-WH (neutral wire required)
CSC-CWS-UNV-WH (no neutral required)

SmartCast® Technology Adjustable CCT Wireless Dimmer
CCD-CWC-WH
- 3000K-5000K adjustable CCT

SmartCast® Technology Wireless Plug Load Controller
CPLC-JB-CWC

SmartCast® Touchscreen Control
CSC-TS-A-BK

SmartCast® Wireless Gateway with Wi-Fi
CSC-GW-CWC-W
- Required with SmartCast Touchscreen Control

SmartCast® Wall Plug Power Supply
CSC-WPS-120V
- For use with SmartCast Wireless Gateway with Wi-Fi

SmartCast® Ceiling Plug Power Supply
CSC-CPS-120V
- For use with SmartCast Wireless Gateway with Wi-Fi

SmartCast® 10V Zone Controller
CSC-ZC-10V-CWC
- Intelligent sensing and control of 0-10V luminaires

SmartCast® 5-Button Wireless Scene Controller
CSC-SC-5B-CWC-WH (w/o text)
CSC-SC-5S-CWC-WH (w/scene text)
CSC-SC-5C-CWC-WH (w/CCT text)
CSC-SC-5X-CWC-WH (w/custom text)

Drywall Grid Adapter
DGA22-WHT

Ordering Information

Example: CDNT-AL-ACK-CMA

CDNT	AL	ACK		CMA
Product	**Lumen Package**	**CCT**	**Voltage**	**Control**
CDNT	**AL** Adjustable Lumens 200 - 3,200 Lumens	**ACK** Adjustable Color 3000K - 6500K	**Blank** 120 - 277 Volt	**CMA SmartCast® Technology** - Integral motion and ambient sensors and wireless communication - Dimming to 5%

SMARTCAST® TECHNOLOGY

CREE TRUE WHITE TECHNOLOGY

UL CERTIFIED

RoHS COMPLIANT

LEDs MAGAZINE SAPPHIRE AWARDS 2020 WINNER

CREE LIGHTING®

US: creelighting.com (800) 236-6800
Canada: creelighting-canada.com (800) 473-1234

Cadiant™ Experience 2' x 2' Architectural LED Dynamic Skylight

Product Specifications

SMARTCAST® TECHNOLOGY

SmartCast® Technology is the most intuitive and easiest to install intelligent light solution on the market. SmartCast® Technology delivers up to 70% energy savings at up to half the cost of other solutions. Luminaires combine best-in-class light with onboard sensors and intelligence to deliver a better light experience. Extreme energy productivity, code compliance and a better light experience without any extra design, installation or setup work.

CREE TRUEWHITE® TECHNOLOGY

A revolutionary way to generate high-quality white light, Cree TrueWhite® Technology is a patented approach that delivers an exclusive combination of 90+ CRI, beautiful light characteristics and lifelong color consistency, all while maintaining high luminous efficacy – a true no compromise solution.

CONSTRUCTION & MATERIALS

- Durable 22 ga. galvanized steel housing provides strength and uniformity
- 5" (127mm) regress gives the impression of a true sky while fitting into most recessed applications
- Luminaire is post-painted for enhanced matte finish
- Includes four t-bar clips and tabs for mounting support wires (by others)
- Luminaire sides and ends are hemmed in for safe, easy handling
- Not for installation within 3" (76mm) of insulation
- **Weight:** 34.0 lbs. (15.4kg)

OPTICAL SYSTEM

- Unique luminaire design creates perfect balance of both horizontal and vertical illumination
- Optimized smooth acrylic lens eliminates pixelation and delivers a low-glare, diffused light distribution
- Dynamic lighting profile provides variation in lumen output and CCT throughout the day
- Soft blue-sky w/east to west sun panels which simulates the natural dawn to dusk arc of the sun

ELECTRICAL SYSTEM

- **Input Voltage:** 120-277V, 50/60Hz
- **Input Power:** Stays constant over life
- **Power Factor:** > 90% at full load
- **Total Harmonic Distortion:** < 20% at full load
- **Operating Temperature Range:** 0°C - + 35°C (32°F - + 95°F)

REGULATORY & VOLUNTARY QUALIFICATIONS

- cULus Listed
- Suitable for damp locations
- Designed for indoor use only
- Requires minimum 90°C supply conductors
- Not intended for use in environments containing airborne corrosive agents such as chemical solvents, cleaners, or cutting fluids
- RoHS compliant. Consult factory for additional details
- Meets FCC Part 15, Subpart B, Class A limits for conducted and radiated emissions
- Assembled in the USA by Cree Lighting from US and imported parts
- Meets Buy American requirements within ARRA
- ⚠ **CA RESIDENTS WARNING:** Cancer and Reproductive Harm – www.p65warnings.ca.gov

SmartCast® Technology

INTEGRAL MOTION SENSOR

- Passive infrared (PIR)
- **Coverage area:** 100 sq. ft. (30.5m²) at 10 ft. (3.0m) mounting height
- Not intended to be mounted higher than 12 ft. (3.7m)
- **Operation:**
  - Grouped with a wall control: Luminaire will operate in vacancy mode (manual-on/auto-off)
  - Not grouped with a wall control: Luminaire will operate in occupancy mode (auto-on/auto-off)
- Configuration Tool required to initiate OneButton™ Setup

AMBIENT LIGHT SENSOR

- Sensor response matches response of human eye
- Not intended to be mounted higher than 12 ft. (3.7m)
- Luminaires operate at full intensity until OneButton™ Setup is initiated by the Configuration Tool
- Daylight harvesting calibration performed automatically during OneButton™ Setup

INTEGRAL WIRELESS COMMUNICATION

- 2.4GHz wireless mesh technology with AES 128-bit encryption
- Self assigns to quietest channel during OneButton™ Setup
- **Range:**
  - 30 ft. (9.1m) in typical commercial applications
  - 300 ft. (91.4m) open air without obstructions
- **Network:** 250 devices max.
- **Space:** 100 devices max. per group
- FCC and IC certified

LUMINAIRE

- Luminaires operate at full intensity until OneButton™ Setup is initiated by the Configuration Tool
- 10-year power fail memory of settings
- **NOTE:** SmartCast luminaires must be installed on unswitched AC power. Constant power is required to maintain all luminaires on the SmartCast network. If wall control or manual dimming is required, a SmartCast wall control dimmer must be used for manual on, off, and dimming.

DEPLOYMENT

- Please refer to the SmartCast® Technology Deployment Guide

Cadiant™ Dynamic Skylight Ambient Adjusted Lumen Maintenance[1]

Ambient	Initial LMF	25K hr Reported[2] LMF	50K hr Estimated[3] LMF	75K hr Estimated[3] LMF	100K hr Estimated[3] LMF
0°C (32°F)	1.05	0.97	0.90	0.83	0.77
5°C (41°F)	1.04	0.97	0.89	0.82	0.76
10°C (50°F)	1.03	0.96	0.88	0.82	0.76
15°C (59°F)	1.02	0.95	0.88	0.81	0.75
20°C (68°F)	1.01	0.94	0.87	0.80	0.74
25°C (77°F)	1.00	0.93	0.86	0.79	0.73
30°C (86°F)	0.99	0.92	0.85	0.79	0.73
35°C (95°F)	0.98	0.91	0.84	0.78	0.72

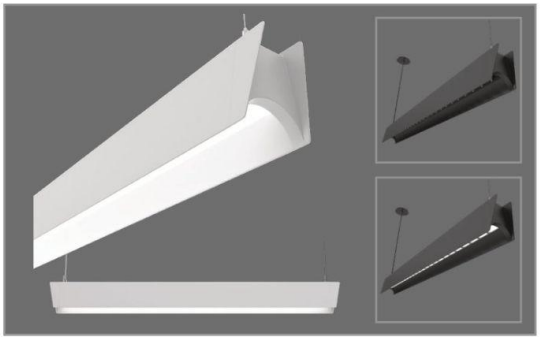
[1] Lumen maintenance values at 25°C (77°F) are calculated per IES TM-21 based on IES LM-80 report data for the LED package and in-situ luminaire testing. Luminaire ambient temperature factors (LATF) have been applied to all lumen maintenance factors.
[2] In accordance with IES TM-21, Reported values represent interpolated values based on time durations that are up to 6x the tested duration in the IES LM-80 report for the LED.
[3] Estimated values are calculated and represent time durations that exceed the 6x test duration of the LED.

CREE LIGHTING®

US: creelighting.com (800) 236-6800
Canada: creelighting-canada.com (800) 473-1234

Artificial Skylight

Project		Catalog #		Type	
Prepared by		Notes		Date	



Corelite

Vaulta

Suspended
Direct, Direct/Indirect LED

Typical Applications

• Office • Education • Healthcare • Hospitality • Retail

Interactive Menu

Product Certification

Product Features

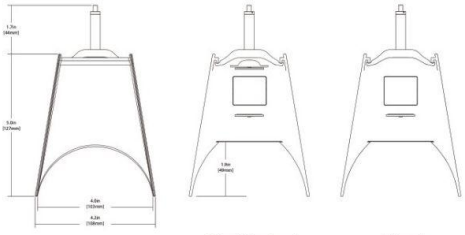
Connected Systems · powered by fifthlight · damp location

Top Product Features

- Open aperture with architectural vault style aesthetics
- Integral electrical components and circuiting options
- Seamless illumination with single-piece luminous roll lens softly lighting open aperture reflectors
- Black and white Discreet glare reducing louvered baffle options
- Batwing and Asymmetric direct distributions with light shaping lens combo
- Precision indirect batwing optic for maximizing ceiling uniformity and on-center spacing
- Wide range of direct/indirect distributions plus independent up/down circuiting
- Up to 142 lumens per watt
- Options to meet Buy American Act requirements

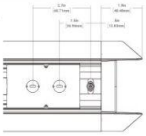
Dimensions

Cross Section Views

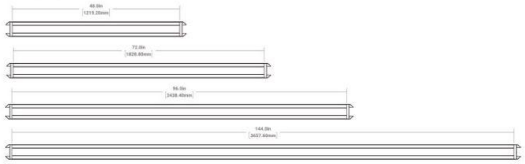


Direct/Indirect Direct

Top View



Bottom Views



Note: End caps add 1.9" at each end.

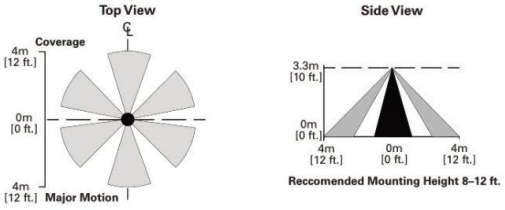
Corelite — Vaulta - Suspended

Control Systems

- WaveLinx Wireless
- WaveLinx Wired
- WaveLinx Lite
- Enlighted
- iLumin Plus
- VividTune

Connected Systems CLICK HERE

The Vaulta with Integrated Sensor technology provides automatic energy savings without sacrificing performance. The Vaulta delivers superior lighting with integrated occupancy and daylighting controls. For standalone and controlled applications, the WaveLinx Lite integral sensor provides out-of-the-box functionality with no gateways required and factory startup is not needed. When more connectivity is required, the WaveLinx Wireless sensor meets modern code and utility requirements, delivers energy and cost savings, while enabling buildings to become smart buildings. The WaveLinx Wireless Connected Lighting System combined with Trellix provides an open IoT platform and infrastructure that connects intelligent sensors leveraging the real-estate of the physical light fixture to solve higher complexity problems to deliver actionable insights through the aggregation of valuable data.
For additional information integrated sensors and connected lighting, please visit Cooper Lighting Solutions' Connected Lighting Website.



Note: Discreet Baffle configurations may have a small cutoff of coverage pattern perpendicular to the fixture.

Vaulta Suspended with Integrated Sensor - Endcap

Vaulta Suspended with Integrated Sensor - Side Mount

	Standalone	Controlled WaveLinx Lite	Connected WaveLinx Wireless	Enterprise Trellix
Occupancy	Yes	Yes	Yes	Yes
Daylighting	Yes	Yes	Yes	Yes
Gateways	–	–	1 WAC	300 WACs
Devices	–	50 per Area (1400 per site)	150 per WAC	45,000 per Core Enterprise
Software	–	WaveLinx Lite Mobile App	WaveLinx Mobile App	Trellix Core
Areas	–	28 per Site	16 per WAC	up to 4,800
Zones	–	16 per Area	16 per Area	up to 76,800
Scheduling	–	–	Local	Global
VividTune™	–	–	Yes	Yes
Plug-Load Control	–	–	Yes	Yes
Integration	–	–	–	BACnet, API
Dashboards	–	–	–	Energy, Occupancy
Configuration	–	Installer	Technician	Technician / IT

SCALABILITY

devices → areas → floors → buildings

Product Specifications

Construction
- Single-piece extruded aluminum housing
- 4" x 5" profile
- Die-formed 20 gauge cold rolled steel LED tray
- Driver accessible from above while fixture is suspended

End Caps
- Die cast aluminum end caps allow for expansion of roll lens to eliminate light leak
- Attach mechanically to the end of the fixture without exposed fasteners
- Standard end cap adds 1.9" at each end.

Lengths
- Available in 4-ft, 6-ft, 8-ft, and 12-ft sections
- Modular design eliminates the need for starter, intermediate, and end of run sections
- See table on page 4 for standard continuous row length breakdowns

Finish
- Electrostatically applied polyester powder coat paint
- White, silver, and black finishes are standard.
- RAL custom colors are available

Mounting
- Aircraft cable mounts on 4', 6', 8', or 12' centers, equal to the respective unit length
- Aircraft cable mount centers are 1/2" from ends of fixture/run
- Can be adjusted along the length of the fixture to match existing mounting points. See Installation Instructions for more details
- Minimum suspension height from ceiling to top of fixture is 5"
- Can be adjusted along the width at mounting bracket for balancing.
- All sections are continuously wired with push-in connectors for fast installation
- Fixtures can be joined for straight continuous runs using supplied alignment pins and internal cast joiners
- Refer to installation instructions for various ceiling interface details

Shielding
- **F:** Continuous lens supplied up to 100+ ft. Consult factory for more information on white and light custom color fixures with Discreet baffle's segmented optics and medium distribution that creates a nonuniform reflector effect on the inside housing.
- **BB**(Black) and **WB**(White): Injection molded, contoured, segmented baffles with for low UGR values and improved visual comfort.
- **FB, FA**: Frosted continuous flexible roll lens and light shaping lens combo creates seamless illumination along entire row length. Each lens is a single piece roll lens up to 100+ ft.

Optics
- Precision engineered acrylic TIR optics on upper and lower LED light engines for optimal light distribution and uniformity
- 110° peak candela angle in indirect distribution
- **BB, WB:** 80° beam angle direct distribution with 45° cutoff

LED and Light Engine
- LEDs are available in 3000K, 3500K, 4000K
- CRI options of either ≥80CRI or ≥90CRI
- Lumen output will be affected - please refer to the lumen adjustment factor tables
- TM21 life at 60,000 hours up to L84 and calculated L70 exceeds 121,000 hrs.
- Drivers available in 120-277V and 347V

Integrated Controls
- 0-10V dimming to 1% standard
- WaveLinx sensor compatible for IoT capability
- Enlighted sensor compatible for IoT capability
- DALI 2.0 and Lutron dimming available

Emergency Options
- Emergency circuit option operates entire downlight portion of a specified unit (4 ft, 6 ft, 8 ft, or 12 ft)
- Optional 6-watt 120-277V integral emergency battery illuminates a 4 ft. down-light section
- 90-minute backup period for code compliance
- Test switch/indicator button located on the top side of the luminaire
- For approximate delivered lumens multiply the lumens per watt of the desired fixture by the wattage of the emergency battery pack (100 lm/W x 6 = 600 lumens)
- Battery is self-testing
- UL 924 emergency/generator transfer options available

Weight
- < 3.75 lbs. per foot

Compliance
- cULus listed for damp locations
- Tested to IESNA LM-79 and LM-80
- RoHS compliant
- Stated life per TM21 standards
- Can be used for State of California Title 24 high efficacy luminaire
- DesignLights Consortium® Qualified and classified for DLC Standard (refer to www.designlights.org)

Warranty
- Five year warranty standard www.cooperlighting.com/legal

Lighting 1

Project		Catalog #		Type	
Prepared by		Notes		Date	

Shaper

Shaper Sense™ Drum - Trio

Acoustic Lighting
Pendant Luminaire
Suspended Direct/Indirect

Typical Applications
• Office • Education • Healthcare • Hospitality • Retail
• Code-Compliance Areas • Co-working

Interactive Menu

Compliance and Award Winning Family

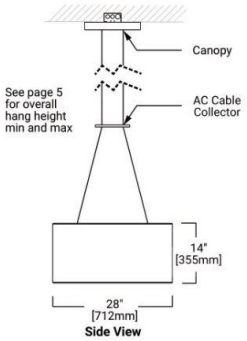
Systems | Certification | Partnerships | Awards

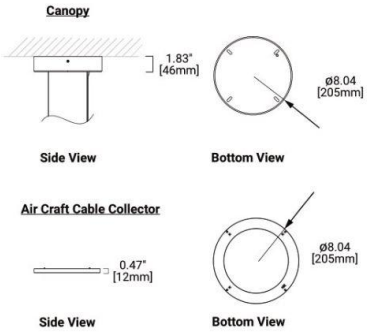
Connected Systems · Light ARchitect™ · filzfelt · PIA'20 · RoHS · BAA · GOOD DESIGN 2020

Top Product Features

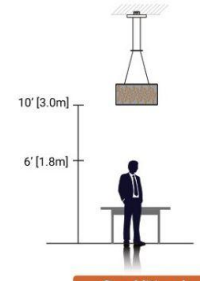
- Shaper Sense is an award winning and patented acoustic lighting product series that merges the concepts of light and sound absorption.
- Light is created by an edge-lit LED circular panel with an array of patterns that produce uniform visual distribution.
- Sound absorbing acoustic panels are designed with industry leading FilzFelt™ acoustic materials.
- Available in 96 vibrant felt colors using 100% Wool Design Felt - 100% recyclable. Select from 20 overlay patterns, 96 overlay pattern colors, 96 base layer felt colors, and 96 border edge band felt colors.
- Noise Reduction Coefficient (NRC) = 1.25, Sound Absorption Average (SAA) = 1.26.
- FilzFelt felt is steam cleanable up to 200° F / 93.3° C and acoustic sound absorption materials can be cleaned with bleach and disinfectants.
- Options to meet Buy American Act requirements

Dimensions





Scale

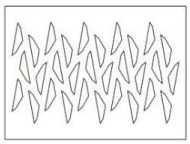


additional product diagrams

Shaper — Shaper Sense Drum - TRIO

Ordering Information - Drum TRIO Patterns

Step 1: Select overlay pattern **(in bold below)**.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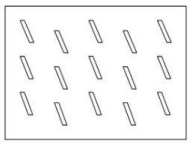
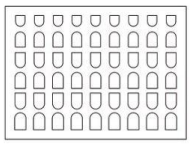
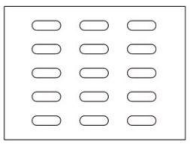
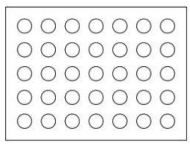
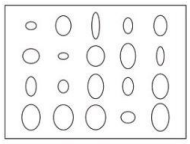
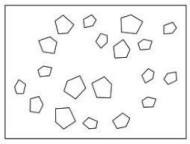

AR4 = Array 4.1

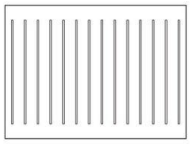

ARCH = Arch Inverted

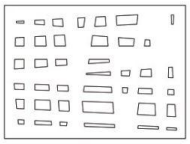

CAPS = Capsule

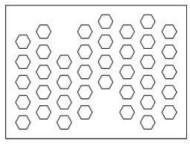

CRCL = Circle

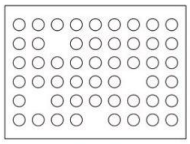

ELPS = Ellipse

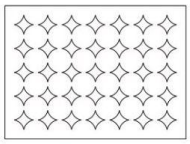

FLT = Flight

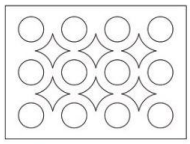

FRG = Fringe

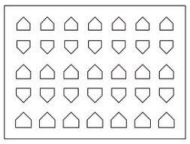

GRID = Grid

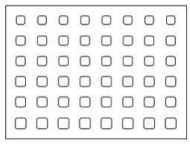

HEX = Hex

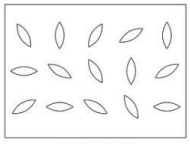

MTRX = Matrix

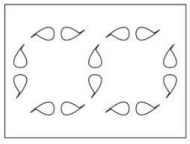

P90 = Polka 90

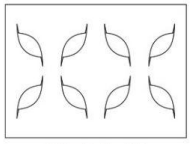

P90L = Polka 90 Light

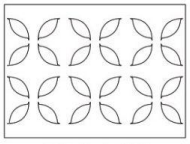

PTCH = Pitch

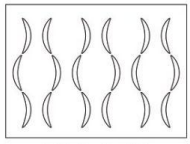

SQRE = Square Inverted


SWRL = Swirl


501 = Design 501


503 = Design 503


505 = Design 505

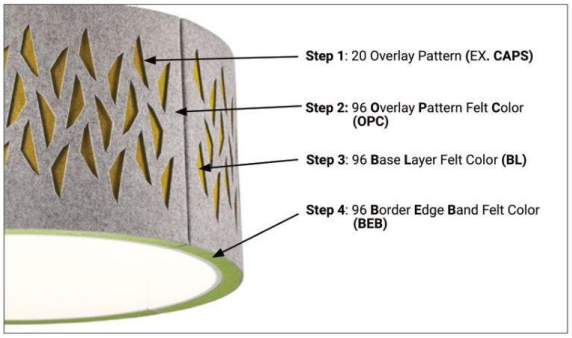

506 = Design 506

Step 2: Select pattern color - See page 4, overlay pattern color **(OPC)**.

Step 3: Select base layer **(BL)** felt color, see page 4.

Step 4: Select border edge band **(BEB)** felt color, see page 4.

Ordering Example



Appendix C: Photometric Data

Interactive Menu

Product Certification

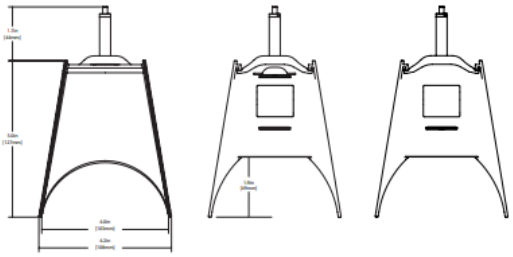
Product Features

Top Product Features

- Open aperture with architectural vault style aesthetics
- Integral electrical components and circuiting options
- Seamless illumination with single-piece luminous roll lens softly lighting open aperture reflectors
- Black and white Discreet glare reducing louvered baffle options
- Batwing and Asymmetric direct distributions with light shaping lens combo
- Precision indirect batwing optic for maximizing ceiling uniformity and on-center spacing
- Wide range of direct/indirect distributions plus independent up/down circuiting
- Up to 142 lumens per watt
- Options to meet Buy American Act requirements

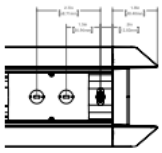
Dimensions

Cross Section Views

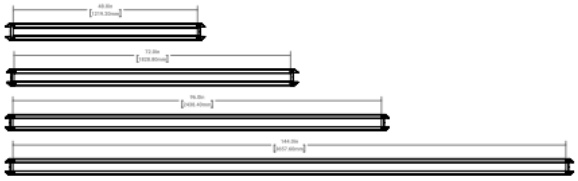


Direct/Indirect Direct

Top View



Bottom Views



Note: End caps add 1.9" at each end.

Energy and Performance Data - Frosted Lens

Vaulta Suspended Performance - 80CRI, 3500K [6]							Glare	
Lumen Package	Lumens/ft Up	Lumens/ft Down	Lumens/ft Total	W/ft Total	Lm/W	Distribution (up%/down%)	UGR [1,2,4,5,6]	MAX LUMINANCE [3,4,5,6]
0U-050D	0	493	493	3.6	137	0%/100%	21.2	5835
0U-075D	0	751	751	5.4	139	0%/100%	22.7	8883
0U-100D	0	999	999	7.3	137	0%/100%	23.7	11821
0U-125D	0	1255	1255	9.7	130	0%/100%	24.5	14841
025U-050D	257	493	750	5.7	132	34%/66%	18.5	5835
025U-075D	257	751	1008	7.5	135	25%/75%	20.7	8883
025U-100D	257	999	1256	9.4	134	20%/80%	22.1	11821
025U-125D	257	1255	1512	11.8	129	17%/83%	23.1	14841
050U-050D	495	493	989	7.3	136	50%/50%	17.1	5835
050U-075D	495	751	1246	9.1	138	40%/60%	19.5	8883
050U-100D	495	999	1495	11.0	136	33%/67%	21	11821
050U-125D	495	1255	1750	13.3	131	28%/72%	22.2	14841
075U-050D	752	493	1245	8.8	141	60%/40%	16	5835
075U-075D	752	751	1503	10.6	142	50%/50%	18.5	8883
075U-100D	752	999	1751	12.5	140	43%/57%	20.2	11821
075U-125D	752	1255	2007	14.9	135	37%/63%	21.5	14841
100U-050D	993	493	1486	10.9	137	67%/33%	15.2	5835
100U-075D	993	751	1744	12.7	138	57%/43%	17.8	8883
100U-100D	993	999	1992	14.6	137	50%/50%	19.5	11821
100U-125D	993	1255	2248	16.9	133	44%/56%	20.9	14841
125U-050D	1249	493	1743	13.2	133	72%/28%	14.6	5835
125U-075D	1249	751	2000	15.0	134	62%/38%	17.2	8883
125U-100D	1249	999	2249	16.9	133	56%/44%	19	11821
125U-125D	1249	1255	2504	19.2	130	50%/50%	20.3	14841
150U-050D	1494	493	1987	15.8	126	75%/25%	14	5835
150U-075D	1494	751	2245	17.6	128	67%/33%	16.7	8883
150U-100D	1494	999	2493	19.5	128	60%/40%	18.5	11821
150U-125D	1494	1255	2748	21.8	126	54%/46%	19.9	14841

Interactive Menu

Compliance and Award Winning Family

Systems | Certification | Partnerships | Awards

Top Product Features

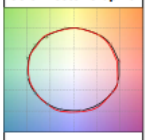
- Shaper Sense™ is an award winning and patented acoustic lighting product series that merges the concepts of light and sound absorption.
- Light is created by an edge-lit square LED panel with an array of patterns that produce uniform visual distribution.
- Sound absorbing acoustic panels are designed with industry leading FilzFelt™ acoustic materials.
- Available in 96 vibrant felt colors using 100% Wool Design Felt - 100% recyclable.
- Noise Reduction Coefficient (NRC) = 1.2, Sound Absorption Average (SAA) = 1.19. Learn more at Noise at Work, Knoll - Workplace Research.
- Select top panel felt colors and bottom panel felt colors.
- Options to meet Buy American Act requirements

Photometric Data

SHAPER SENSE - BOX @ 3000K / 90 CRI

Filename	ShSe-BOX-2-L30-90-UNV-STD.ies
Test No.	P316050
Lumcat	ShSe-BOX-2-L30-90-UNV-STD
Lumens	3172 Lm
Watts	38.8 W
LPW	95.5 Lm/W
CCT	3000K
SC (0/90/45)	3.21 / 2.21 / 2.38

Color Vector Graphic



TM-30-15

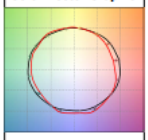
R_f	91.7
R_g	99.7

64% up 36% down

SHAPER SENSE - BOX @ 3500K / 80 CRI

Filename	ShSe-BOX-2-L35-80-UNV-STD.ies
Test No.	P316051
Lumcat	ShSe-BOX-2-L35-80-UNV-STD
Lumens	3944 Lm
Watts	38.8 W
LPW	118.8 Lm/W
CCT	3500K
SC (0/90/45)	3.21 / 2.21 / 2.38

Color Vector Graphic



TM-30-15

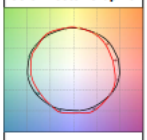
R_f	81
R_g	95.9

64% up 36% down

SHAPER SENSE - BOX @ 4000K / 80 CRI

Filename	ShSe-BOX-2-L40-80-UNV-STD.ies
Test No.	P316052
Lumcat	ShSe-BOX-2-L40-80-UNV-STD
Lumens	3873 Lm
Watts	38.8 W
LPW	116.6 Lm/W
CCT	4000K
SC (0/90/45)	3.21 / 2.21 / 2.38

Color Vector Graphic



TM-30-15

R_f	81
R_g	95.9

64% up 36% down

Lumen Maintenance

Ambient Temperature	Lumen Maintenance: TM-21 (60,000 Hours)	Theoretical L70 (Ho)
25°C	> 89%	> 60,000

Shaper — Shaper Sense Drum - TRIO

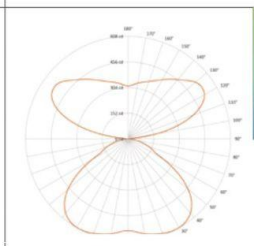
Lumen Maintenance

Ambient Temperature
25°C
Lumen Maintenance: TM-21 (60,000 Hours)
> 80%
Theoretical L70 (Hrs)
> 54,000

Photometric Data

SHAPER SENSE - DRUM TRIO - @ 3500K / 90 CRI

	Light Level 1	Light Level 2	Light Level 3
Filename	ShSe-DRUM-1-L35-90-UNV-STD.ies	ShSe-DRUM-2-L35-90-UNV-STD.ies	ShSe-DRUM-3-L35-90-UNV-STD.ies
Test No.	P402552	P402559	G3-2004-737-4
Lumcat	ShSe-DRUM-1-L35-90-UNV-STD	ShSe-DRUM-2-L35-90-UNV-STD	ShSe-DRUM-3-L35-90-UNV-STD
Lumens	4000.3 Lm	4989.9 Lm	6557.4 Lm
Input Watts	28.2 W	45.3 W	60.4 W
Efficacy	141.9 Lm/W	110.2 Lm/W	108.6 Lm/W
CCT	3500K	3500K	3500K
SC (0/90/45)	1.62 / 1.62 / 1.62	1.62 / 1.62 / 1.62	1.62 / 1.62 / 1.62



55% up 45% down

Color Vector Graphic TM-30-15

R_f	91
R_g	98
R9	67

DRUM			
Light Level-CCT-CRI	Delivered LUMENS	Power WATTS	Efficacy LPW
1-L30-80	3960	29	138
1-L35-80	4000	29	142
1-L40-80	4176	29	148
1-L30-90	3014	29	109
1-L35-90	3328	29	121
1-L40-90	3347	29	122
2-L30-80	5938	46	131
2-L35-80	5998	46	132
2-L40-80	6262	46	138
2-L30-90	4519	46	100
2-L35-90	4990	46	110
2-L40-90	5018	46	110
3-L30-80	7803	61	129
3-L35-80	7882	61	130
3-L40-80	8228	61	136
3-L30-90	5939	61	98
3-L35-90	6557	61	108
3-L40-90	6595	61	109
Color block denotes highest and lowest lumen levels			Color block denotes highest and lowest LPW levels

Cleaning recommendations and Guidelines for Light Engine

Removing Dust from Optical Panels:
Use the following recommendations:

BEST: Using aerosol dusting spray, gently blow dust from top of optical panels.
GOOD: Using CLEAN Swiffer, VERY gently brush dust from top of optical panels.
NO: DO NOT rub dust from top of fixture with cleaning cloth or dirty duster.

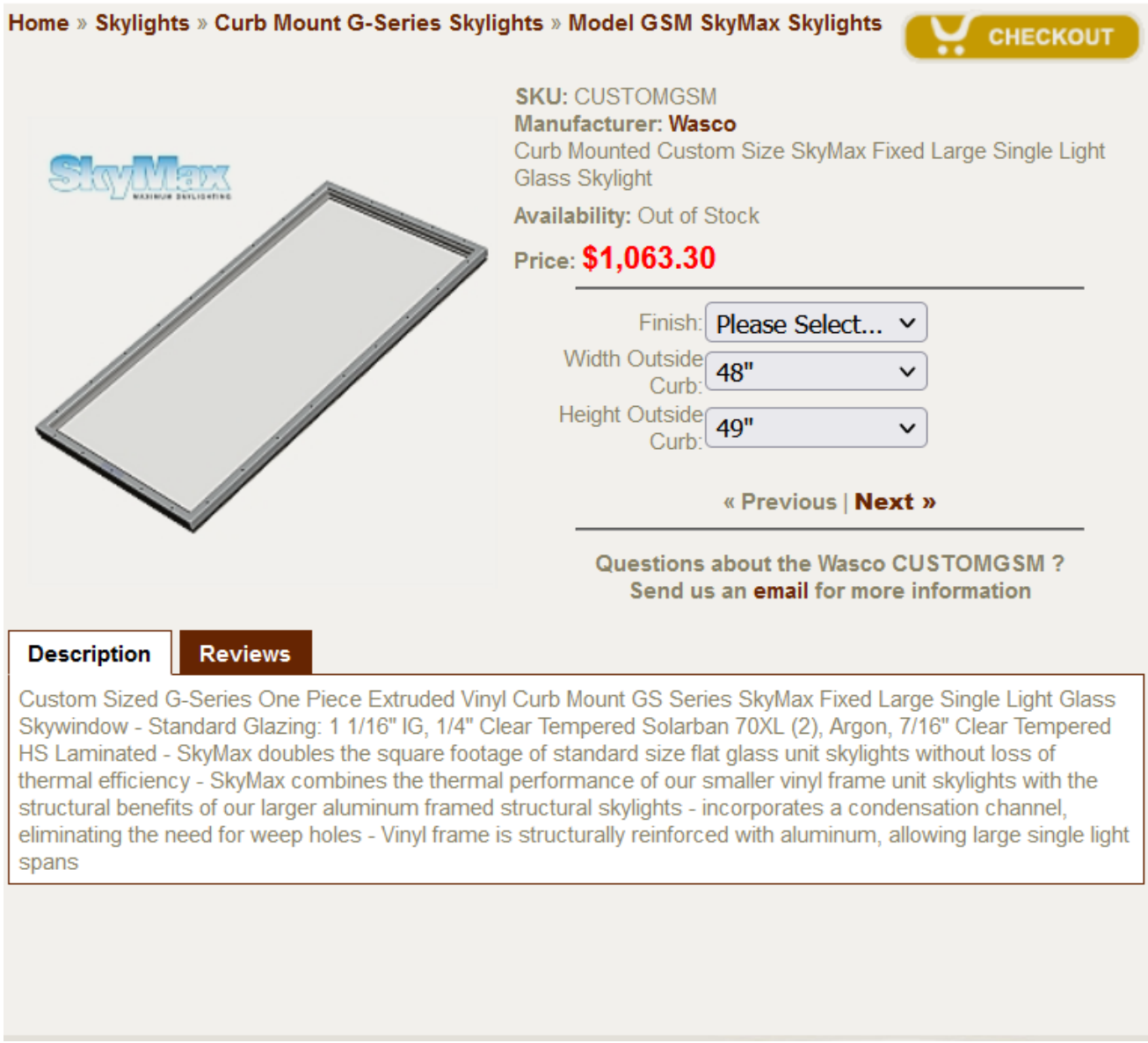
Cleaning Optical Panels:
Use the following recommendations:

A: Blend 4 parts warm water and 1 part DAWN dish soap.
B: Dampen CLEAN micro fiber cloth (or equivalent) with cleaning solution and gently wipe optical panel in single direction.
C: Gently dry optical panels with micro-fiber cloth (or equivalent).

Light Level	CCT	UGR [CIE 190:2010] (1) (4H, 8H; Reflectance: 70% Ceiling, 50% Wall, 20% Ref. Plane)		MAX INTENSITY [45-90 DEG FROM NADIR] (2) (Candela CD)		MAX LUMINANCE [45-90 DEG FROM NADIR] (2) (CD/M^2)	
		80CRI	90CRI	80CRI	90CRI	80CRI	90CRI
1	3500K	12.2	11.6	511	425	2271	1889
2	3500K	13.6	13	766	637	3405	2833
3	3500K	14.5	13.9	1006	837	4475	3723

Notes: (1) For other UGR data for room or reflective ceiling plans please see technical data on website. (2) For other CCT please see technical data on website.

Appendix D: Additional Information



Days of Sunshine Per Year in Tennessee

Number of Sunny Days

In the table below, the average number of **Sunny Days** for a city in Tennessee is the total days in a year when the sky is mostly clear. This includes the days when cloud covers up to 30% of the sky during daylight hours.

Partly Sunny Days have cloud covering from 40% to 70% of the sky during the daytime. The rest of the days are mainly overcast, with at least 80% cloud cover.

Total Days With Sun is a sum of the Sunny plus Partly Sunny days. All the numbers are annual averages, made from years of weather watching.

Annual days of sunshine

City	Sunny	Partly Sunny	Total Days With Sun
Bristol	88	112	200
Chattanooga	104	106	210
Knoxville	97	107	204
Memphis	118	96	214
Nashville	102	106	208
Oak Ridge	109	98	207