

How Natural Light Is Transitioned Through A Healthcare Setting

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Master of Architecture
in
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How Natural Light is Transitioned Through a Healthcare Setting

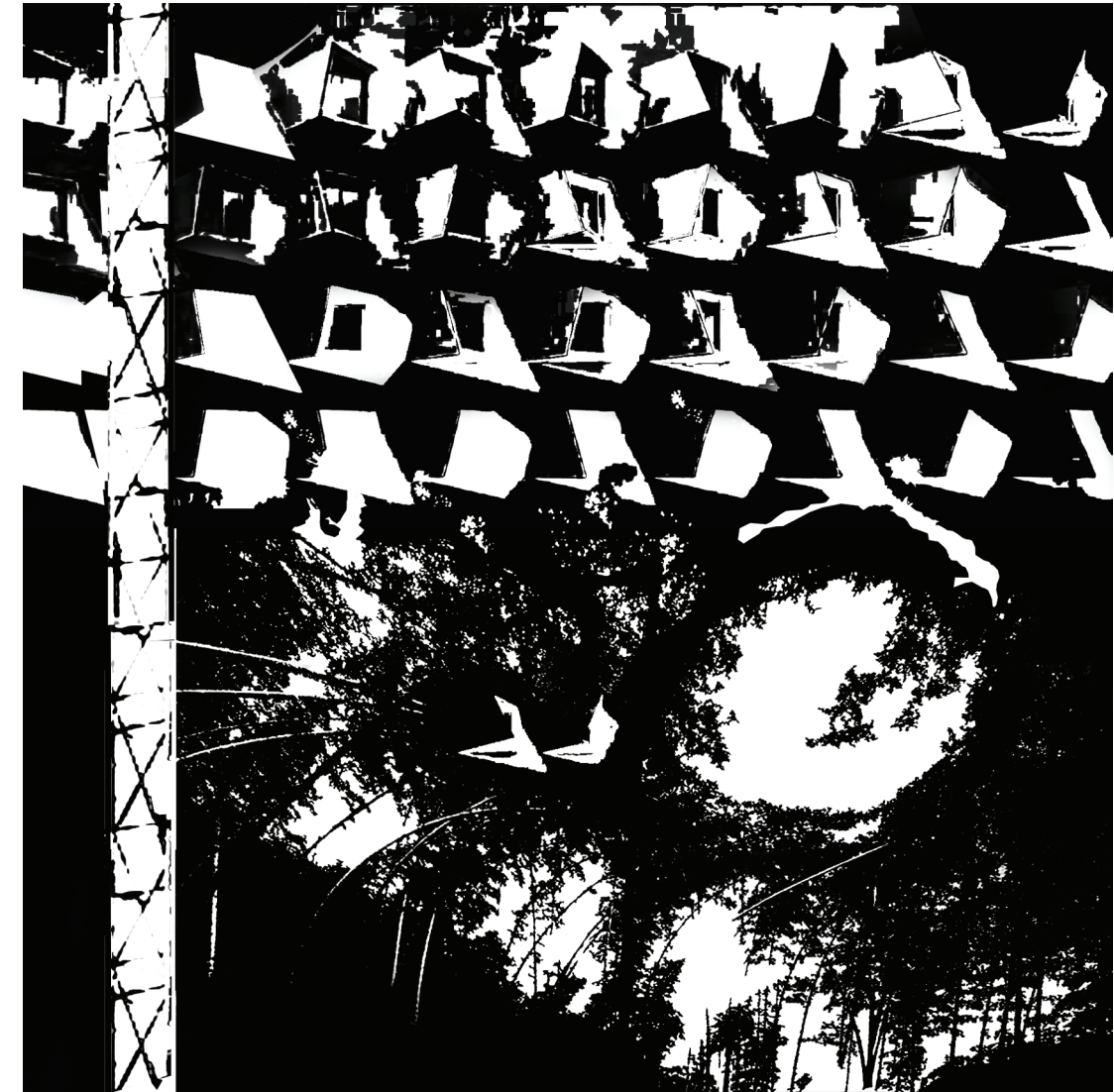
Ehab Al Hourani

Abstract

Healthcare workers' overall performance and patients' well-being are crucial to wellness design and the overall productivity of the working environment. The purpose of this thesis is to narrate how natural light- a key aspect of biophilic design- can give great health outcomes and enhance the placemaking of a healthcare setting.

Hence, this dissertation attempts to deal with placemaking and formation as an inside-outside dialogue that connects users to nature by implementing the idea of transitioning natural light through space and structure. In doing so, lighting explorations were conducted as series of physical models and case studies to help understand and analyze various effects of light at different times of the day.

These explorations narrate a story about the journey of the medical worker and the patient throughout the setting of the apertures, walls, path, and canopy. Also, in response to the topography, a south-facing aperture wants to be framed, while a north-facing aperture can be an open wall, a smooth polished continuous wall and path can act as a canvas when the filtered light falls on it, while rough fragmented walls rise from earth acting as structural walls, and a cluster of trees can act as a natural canopy to provide shelter from the sun, while a steel canopy can shelter other areas from the rain or sun.



The dialogue between nature and the built environment can be seen through the transition of light and shadow.

How Natural Light is Transitioned Through a Healthcare Setting

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General Audience Abstract

Biophilia, the innate human instinct to connect with nature, is a foundational concept to biophilic architecture. This concept seeks to enhance the well-being of users when in a human-made environment, by incorporating vital aspects of nature in a building. Therefore, applying a biophilic-based design approach to a high stressed place like a hospital can be worthwhile in numerous of ways to patients, their family and healthcare workers.

The thesis addresses the aspects of Biophilia and looks deeper into the effects and benefits of natural light in a healthcare setting.

Acknowledgment

Firstly, all praises to Allah.

Secondly, My Father and Mother, Faisal and Suzanne, thank you for your unwavering support throughout my education and beyond. It is an honor to be your son.

Also, thank you to my advisors professor Jim Jones, professor Aki Ishida and professor Ronald Gibbons for everything you taught me over the past year and for making me a better architect.

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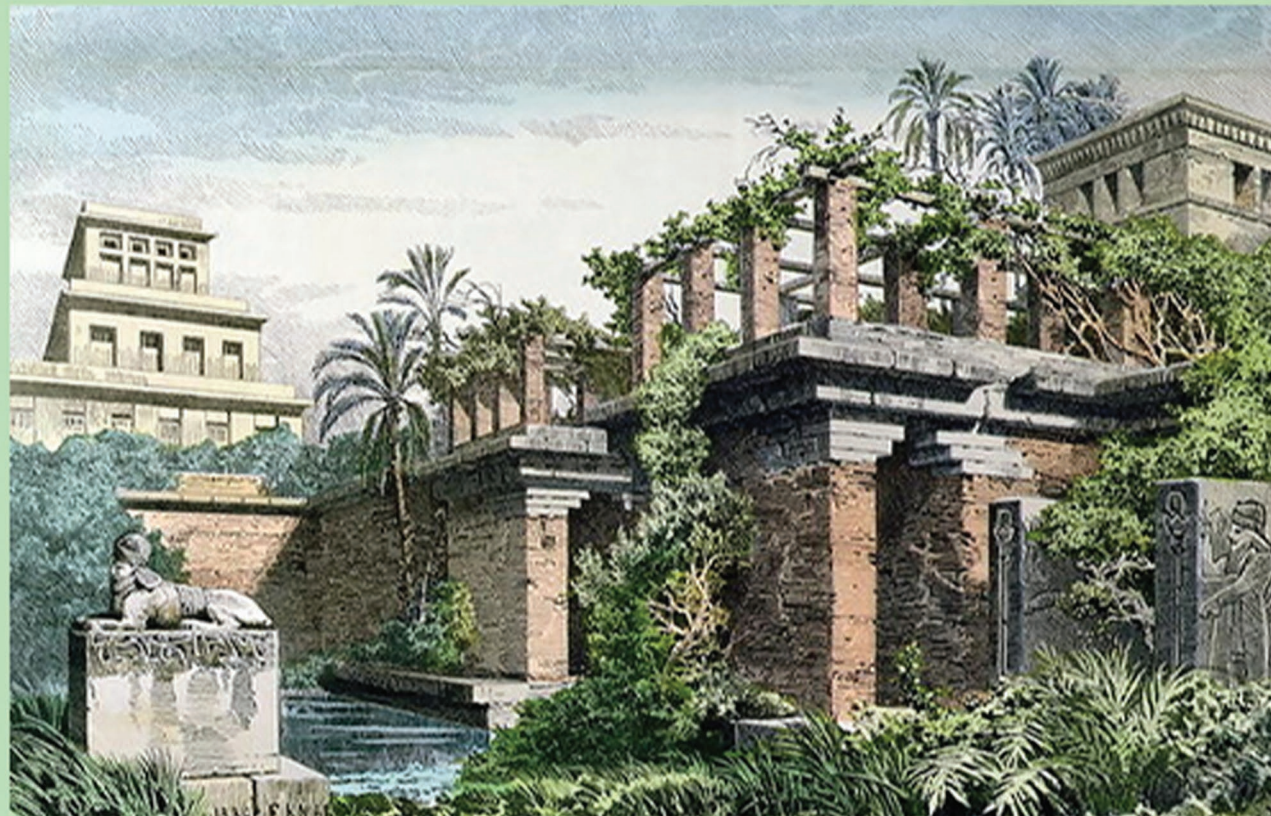
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Biophilia

The term Biophilia means love of life. The biophilia concept implies that we are drawn to be connected to nature and emotionally attracted to other living organisms as a response to our genetic makeup.

The origin of Biophilia:



Hanging Gardens of Babylon - Martin Hewmskreck

“Nature is something within which we flourish, so having it be more a part of our lives is critical, especially when we live and work in built environments.” - University of Rochester Professor Richard Ryan

“Deviation from nature is deviation from happiness” - Samuel Johnson

Biophilic design

The three pillar concepts of biophilic design are:



Nature in the space



Nature of the space



Natural analogues

Nature in the space

Bringing natural elements into the built environment.

■ Visual connection with nature



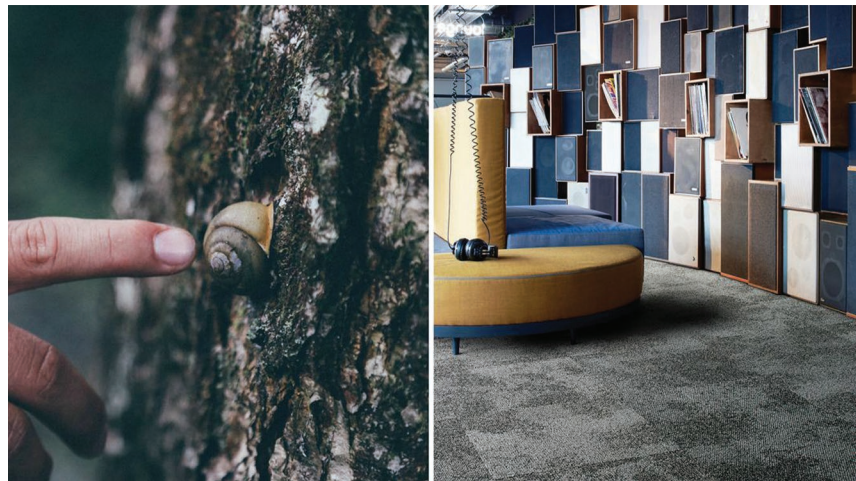
Image by Art Aqua - Interface, Net effect

■ Connection with natural systems



Images by Interface

■ Non-visual connection with nature



Photography by Interface, composure

■ Non-Rhythmic sensory stimuli



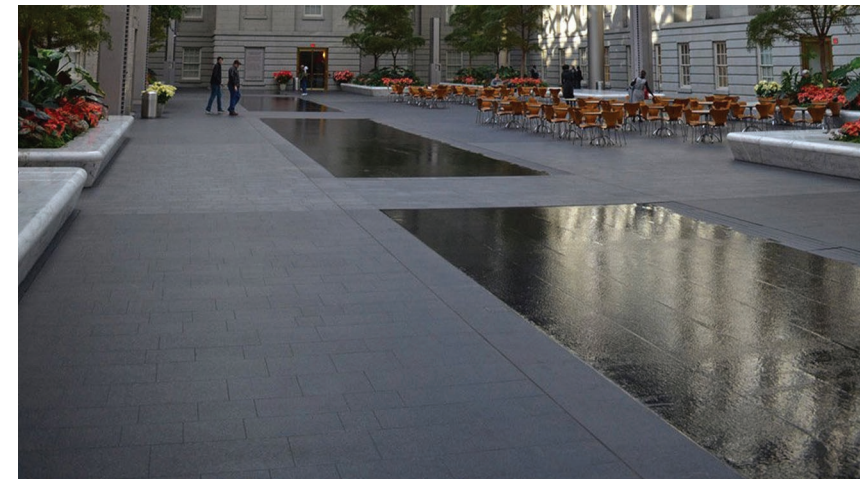
Image by Interface, net effect - Ulemiste Shopping Centre - Photographed by Oleg Harchenko

■ Dynamic & Diffuse light



Images by interface

■ Presence of water



The Robert and Arlene Kogod Courtyard in the Smithsonian American Art Museum, Washington, DC

Natural analogues

Objects, materials, colours, shapes, sequences and patterns found in nature.

■ Biomorphic forms & Patterns



Image by Art Aqua - Interface, urban retreat

■ Material connection to nature



Images by Interface, urban retreat

■ Complextity & Order



Images by Interface, equal measure

“It has sometimes been said that we find nowhere in nature an analogue of the difference between happens and is, on the one hand, and ought, on the other hand.” - Wolfgang Kohler

Nature of the space

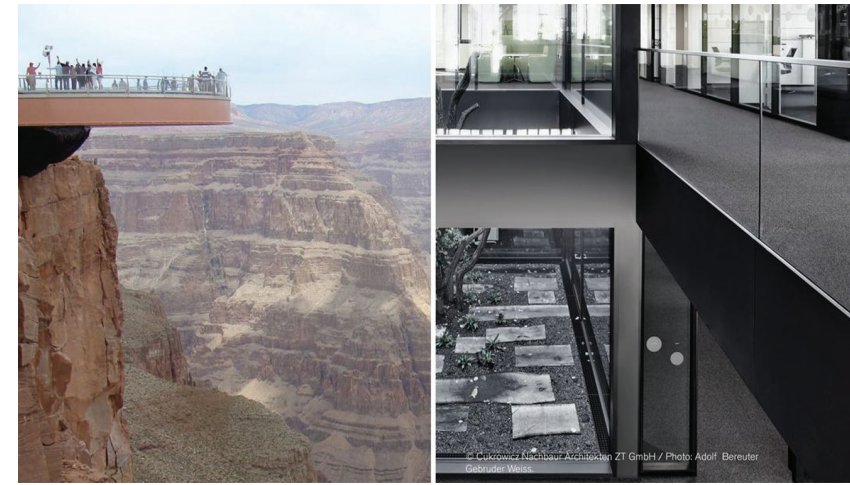
The assurance of more knowledge as the individual explores deeper into the built environment.

■ Refuge



OffX coWorking building - Image by Andreas Rudolph.

■ Risk/Peril



Cukrowcz Nachbaur Architekten ZT GmbH - Image by Adolf Bereuter Gebrüder Weiss.

■ Prospect



Bohl data service building - Image by BOS Büro- und Objekteinrichtungen GmbH.

■ Mystery



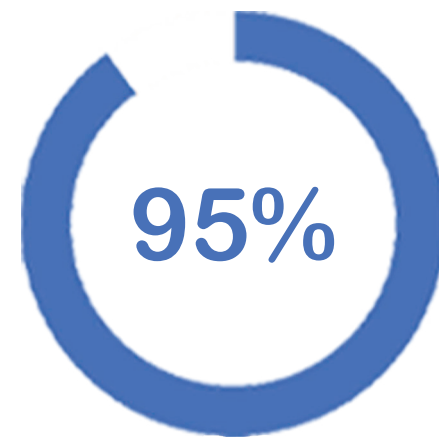
SCA, urban retreat - Image by Interface.

How does a biophilic design impact wellness in a healthcare setting?

While a hospital is a high stressed place for patients, their family, and health-care workers, studies show that nature heals us when we expose ourselves to it. By reducing our blood pressure, increasing heart rate, impacting the production of stress hormones, and muscle tension. Also, it gives us that moment to breath and find peace in the chaos we encounter and improves our mood, well-being, and vitality. Other studies and serveys show the folowing **facts & statistics:**



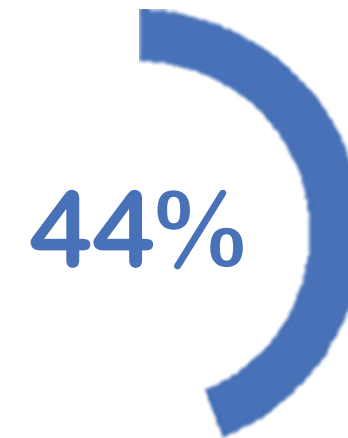
The need for pain-reduction medication can be lowered by %22.



An overwhelming 95% of all people visting inpatients, surveyed across four independent hospitals, reported feeling more relaxed, rejuvenated, and positive.

10-15 MINUTES

Only 10-15 minutes in nature, can improve our health.



A survey shows that 44% of people say that their stress has increased in the last 5 years.



Post-operative recovery times can be reduced by 8.5%



In the United States, 83% of the population live in urban areas.

**\$228
MILLION/YEAR**

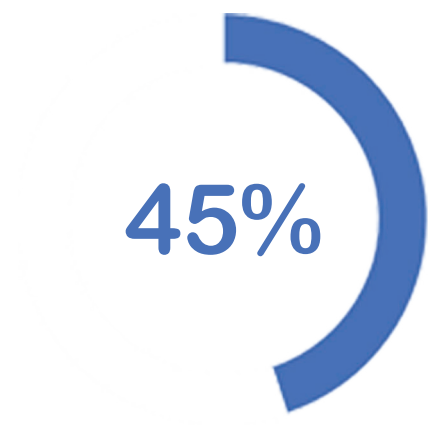
Exposure to nature could be used as a way to minimize symptoms of ADD and ADHD in children. This could result in reduced consumption of ADD and ADHD medication. A 10% reduction in spending on this medication amounts to around \$228 Million/Year.



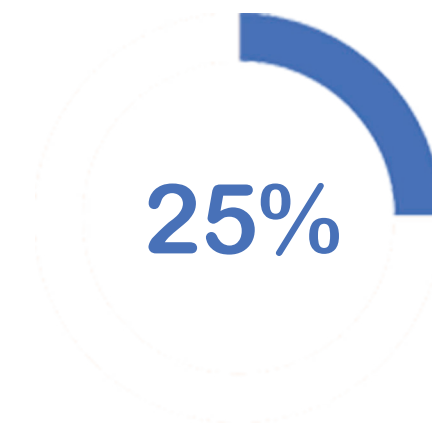
People spend 90% of their time indoors.

**112
TIMES**

Today, productivity costs are 112 times greater than energy costs in a work place.



45% of global office workers have no daylight access.



Test scores increased by 25% in classrooms that have daylight.

Day light, Human body & Health

The implementation of the circadian lighting and windowlights is a key aspect in biophilic healthcare design. The incorporation of daylight windows in a space regardless of its proximity to the outdoors can benefit patients, their family, and healthcare workers.

■ Artificial light



Image by Lowercase.design 2019

Since the eye remains the main gateway to the waves of the light spectrum, the daylight is as vital as air and water for human beings. Hence, our brain has a biological clock, which needs daylight to adjust itself. Therefore, a lack of natural light has dangerous consequences.

“In the morning, light appears mostly in green-blue tones, while it is rather reddish in the afternoon. Brains are perfectly regulated on this natural cycle. When the eyes register a blue-green light, the brain ‘knows’ that it is the morning.” - Locke & Latham, 1990.

■ Day light



Image by Lowercase.design 2019

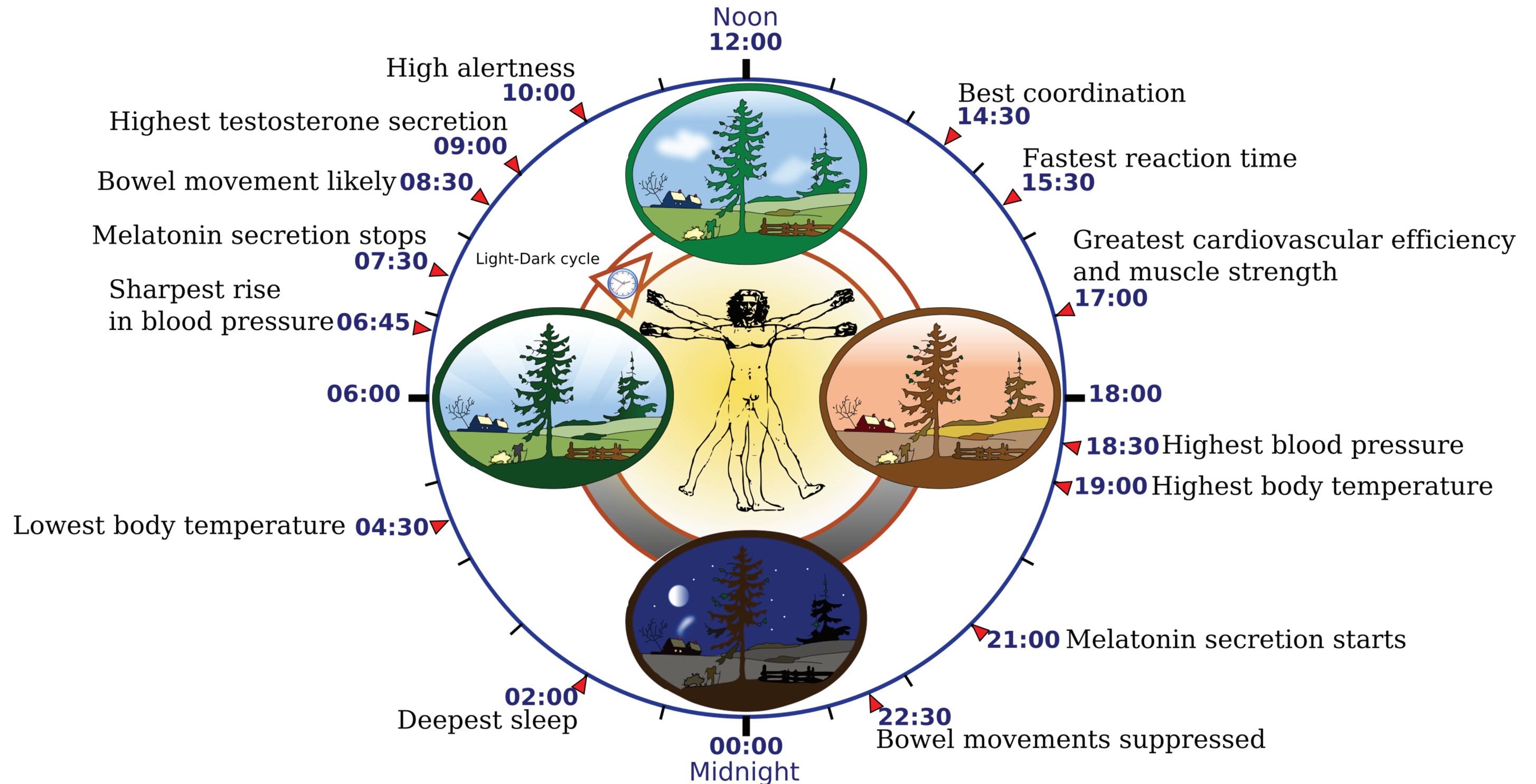
Physically		Psychologically	
Vitamin D	Cancer Possibility	Mood	Depression
Visual System	Abnormal Bone Formation	Mental Performance	Stress
Circadian Rhythms	–	Alertness	Sadness
Sleep Quality	–	Brain Activity	Violent Behavior

Natural Light and Productivity : Analyzing the Impacts of Daylighting on Students ' and Workers ' Health and Alertness - N. Shishegar, M. Boubekri

Circadian Rhythm

A circadian rhythm, is a natural, internal process that regulates the sleep-wake cycle and repeats roughly every 24 hours. It can refer to any process that originates within an organism (is endogenous) and responds to the environment (entrained by the environment).

“In the morning, light appears mostly in green-blue tones, while it is rather reddish in the afternoon. Brains are perfectly regulated on this natural cycle. When the eyes register a blue-green light, the brain ‘knows’ that it is the morning.” - Locke & Latham, 1990.



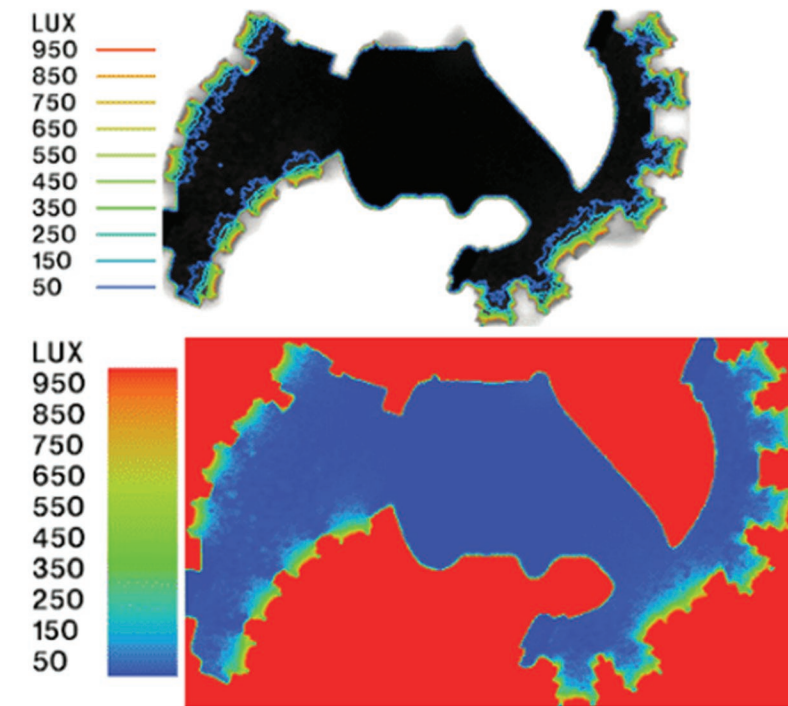
The work was done with Inkscape by Yassine Mrabet. Informations were provided from "The Body Clock Guide to Better Health" by Michael Smolensky and Lynne Lamberg; Henry Holt and Company, Publishers (2000).

Case study analysis



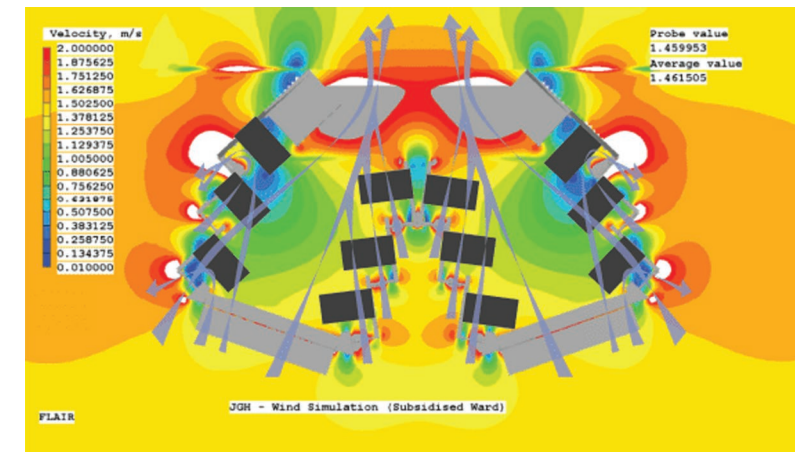
Ng Teng Fong General Hospital & Jurong Community Hospital, Image by HOK group.

Daylight



Ng Teng Fong General Hospital & Jurong Community Hospital, Diagram by HOK group.

Natural Ventilation

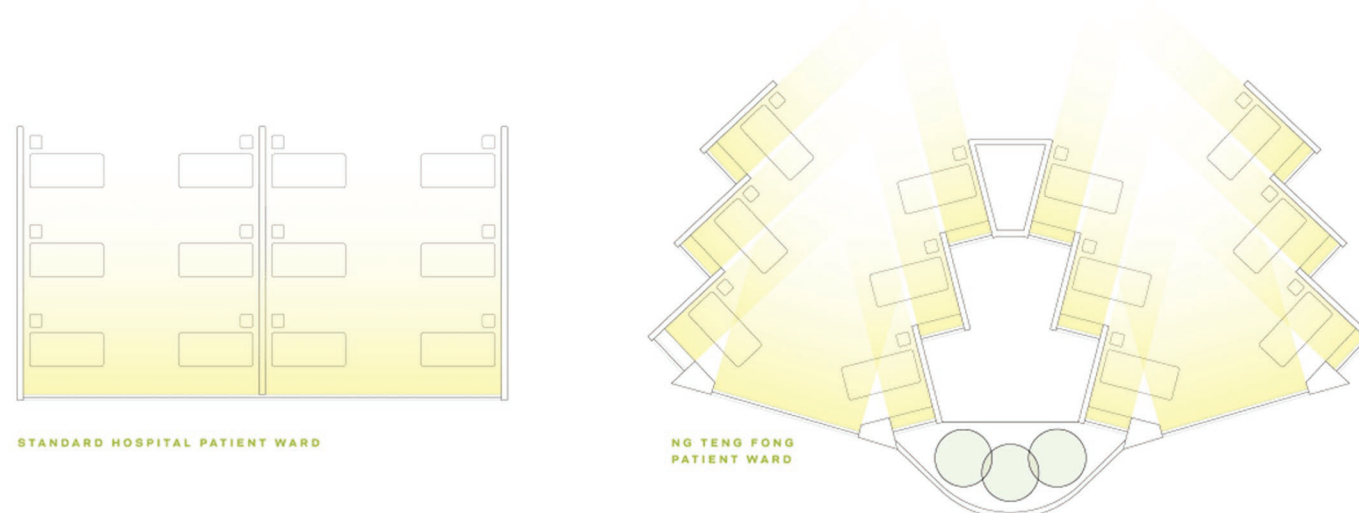


Ng Teng Fong General Hospital & Jurong Community Hospital, Diagram by HOK group.

Exterior Shading



Ng Teng Fong General Hospital & Jurong Community Hospital, Exterior image by HOK group.



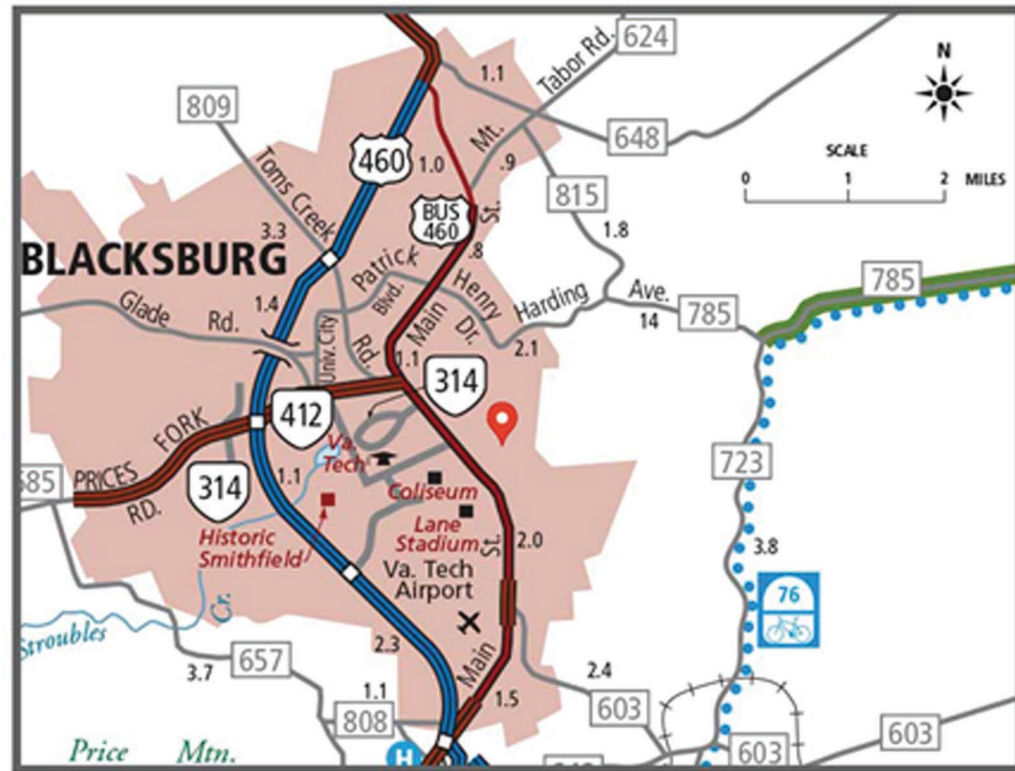
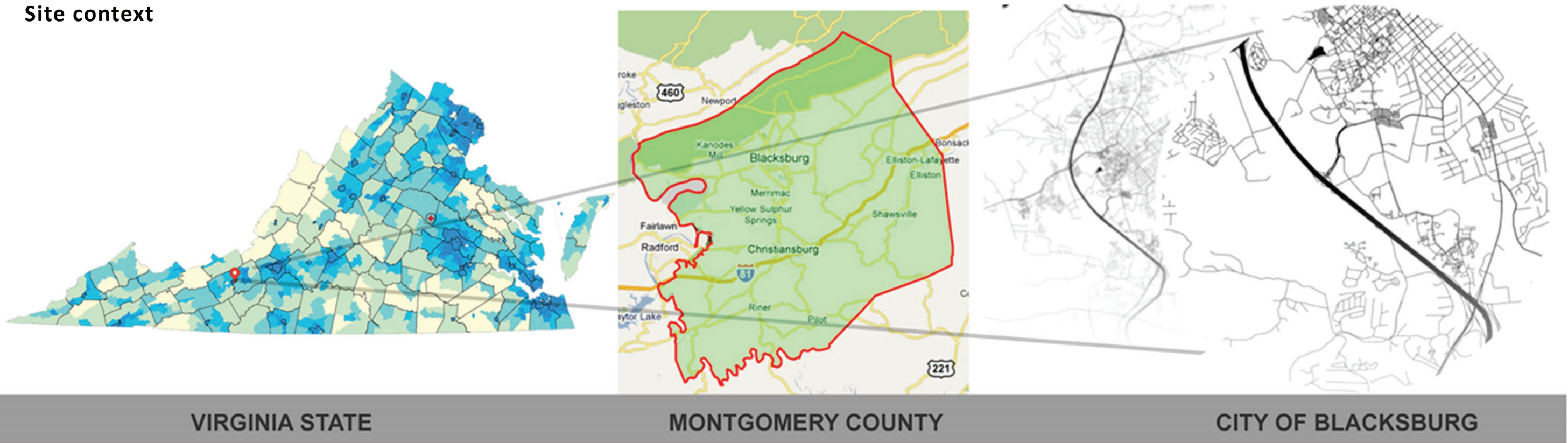
Ng Teng Fong General Hospital & Jurong Community Hospital, Diagram by HOK group.

Introduction

Visting hospitals can often cause high levels of stress, affecting patients' quality of life and the healthcare provider's outcome. Stress is a highly subjective experience that can prompt an acute onset of physical, emotional, and mental strain, which may affect a patient's ability to heal and cope (Papa-thanasiou, Tsaras, Neroliatsiou, & Roupa, 2015). Therefore, adjusting the placemaking of a hospital by incorporating elements of nature into the design can generally improve the healthcare process. The incorporation of nature into the placemaking of a hospital can be achieved by implementing a biophilic-based architecture that is more considerate when it comes to the overall performance of the healthcare process.

Daylight, a key aspect of biophilic design, is critical to human functioning in that it allows us to see things and perform activities. But it is also important because it affects human beings psychologically and physiologically. Several studies have documented the importance of light in reducing depression, decreasing fatigue, improving alertness, modulating circadian rhythms, and treating conditions such as hyperbilirubinemia among infants (Ulrich, Zim-ring, Joseph, Quan, & Choudhary, 2004). Therefore, lighting explorations were conducted in this thesis to achieve the best possible layout of the apertures, and to attain an optimal transition of daylight through the spaces and structures of the hospital.

Site context

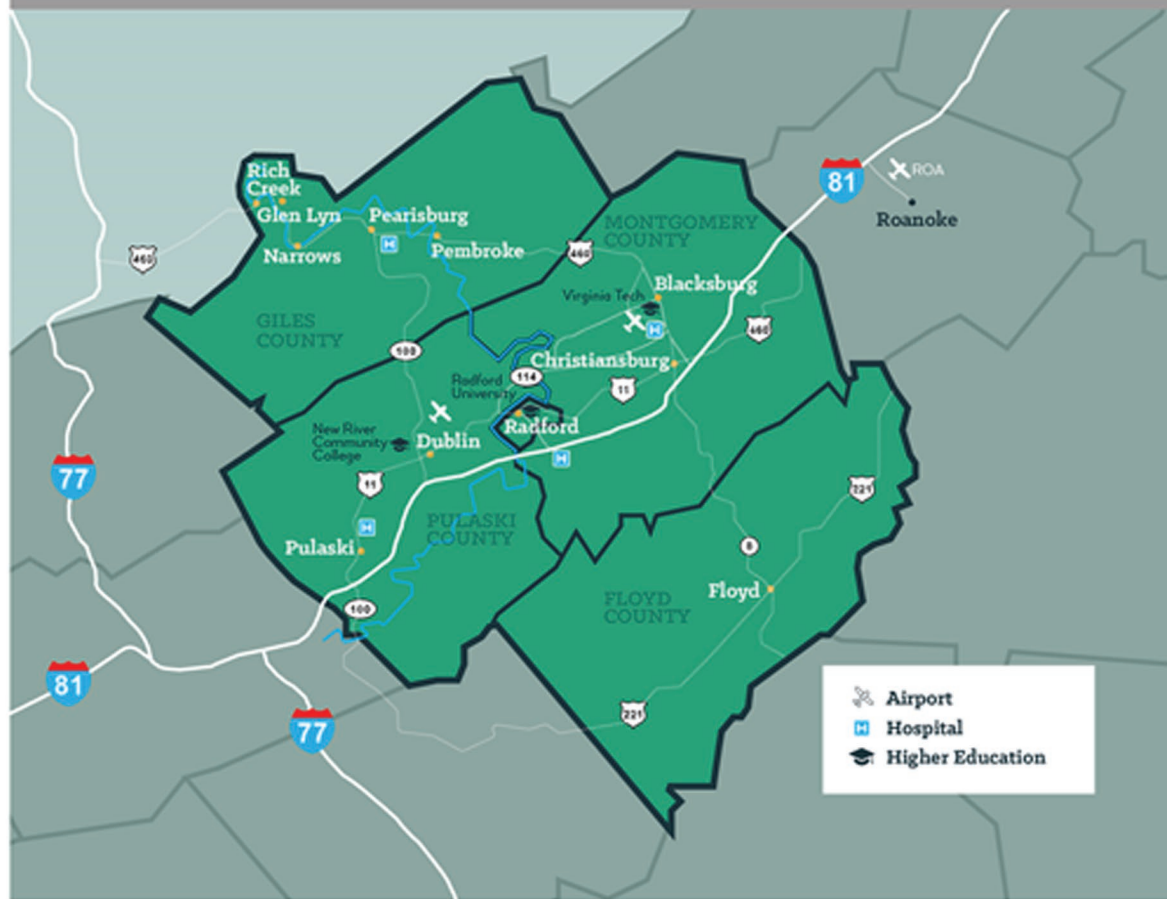


The plot is 0.9 miles away from U.S. route 460.



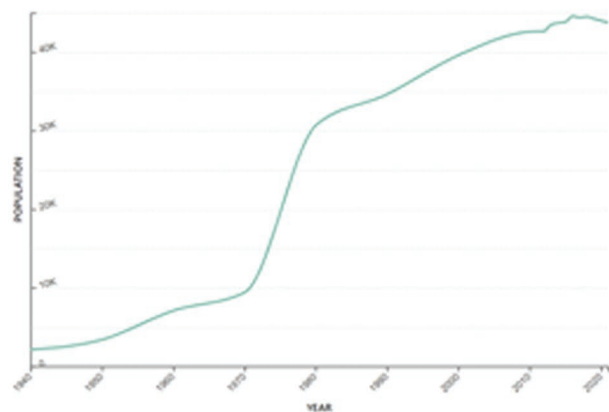
Foxridge neighborhood.

WHY THIS PROJECT ON THIS PLOT?



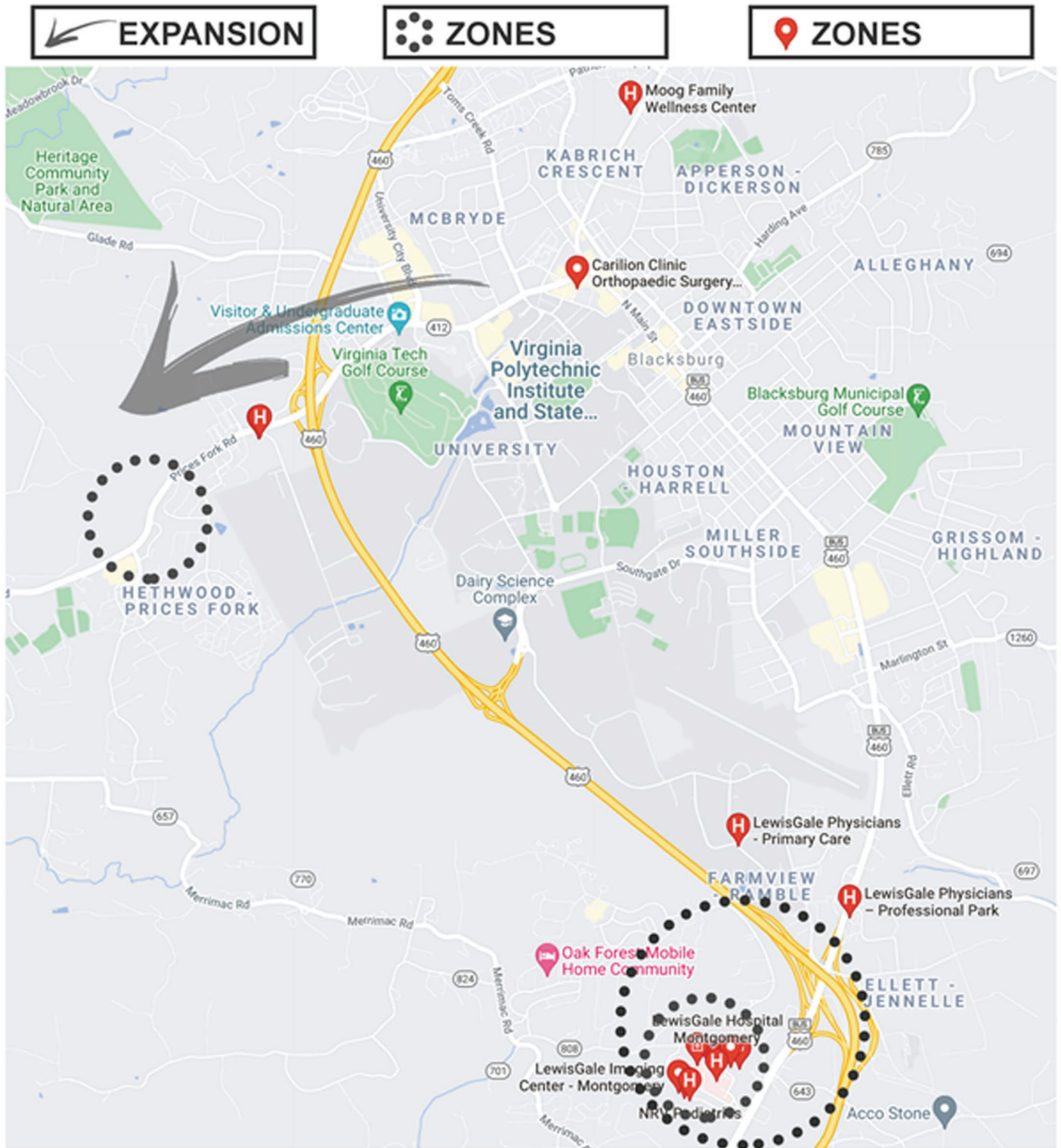
Blacksburg, Virginia Population 2021

43,735



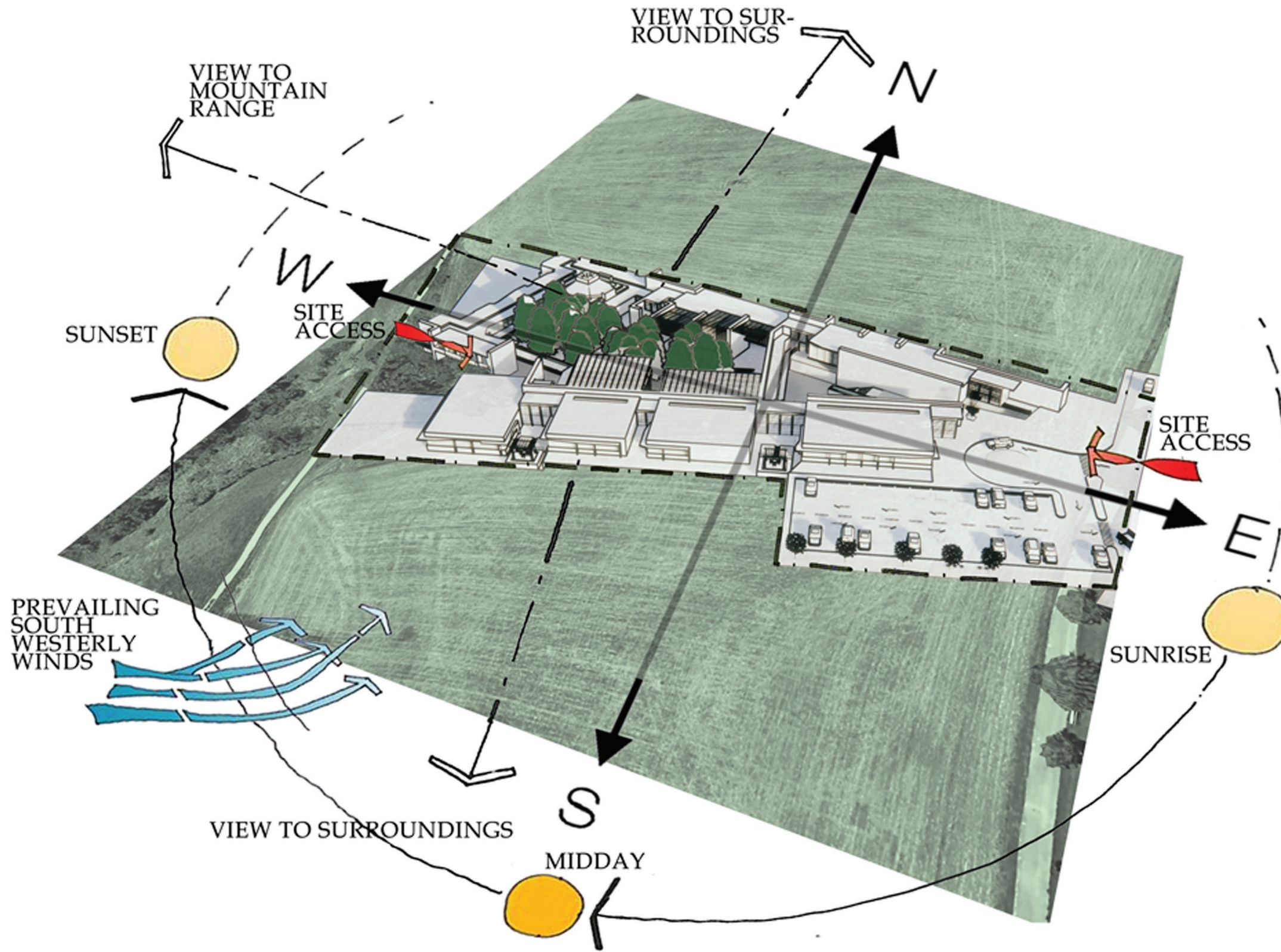
Blacksburg, Virginia population chart, US Census Bureau 2021

The city of Blacksburg is expanding beyond U.S Route 460 towards the south as the population of the city increased to approximately 44,000 in 2021.



There is only one hospital that serves Blacksburg, it is 6 miles outside the city.

Site analysis



KEY PLAN:

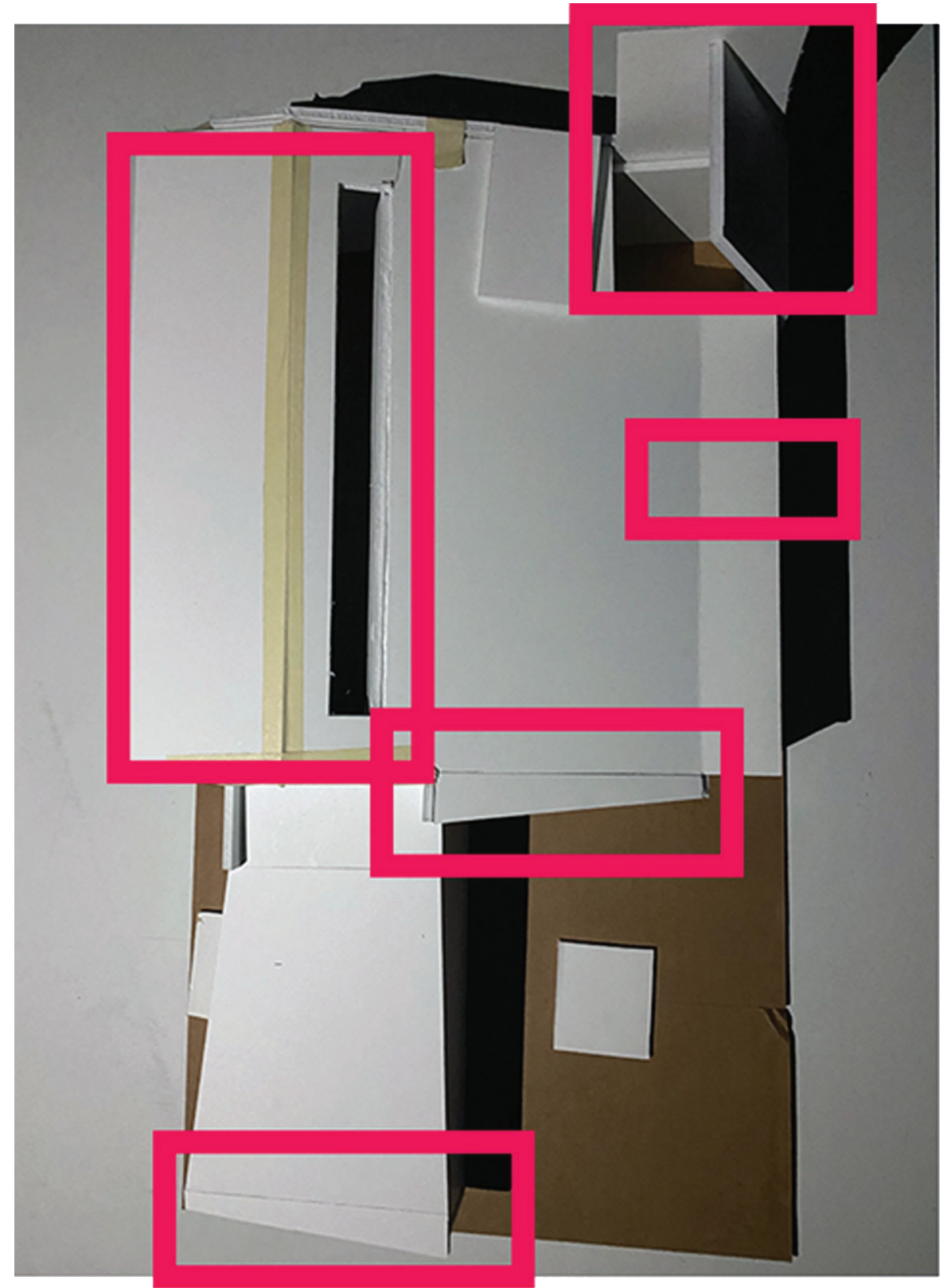


MOUNTAIN VIEW:



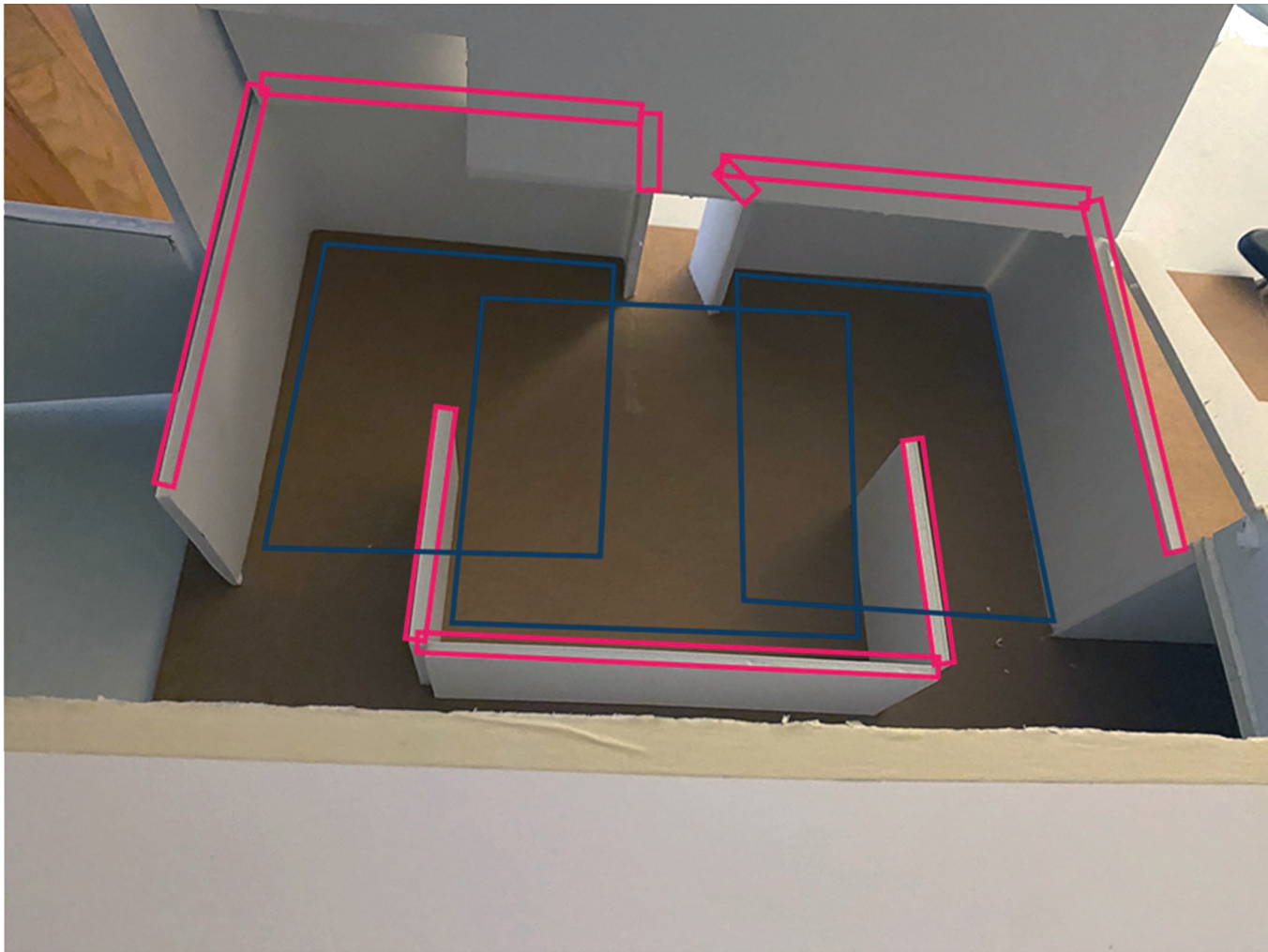
Lighting Exploration

The transition of natural light through space and structure.



Layout

The formation suggests an On-The-Go nursing station.





8:00AM



11:00AM

KEY:





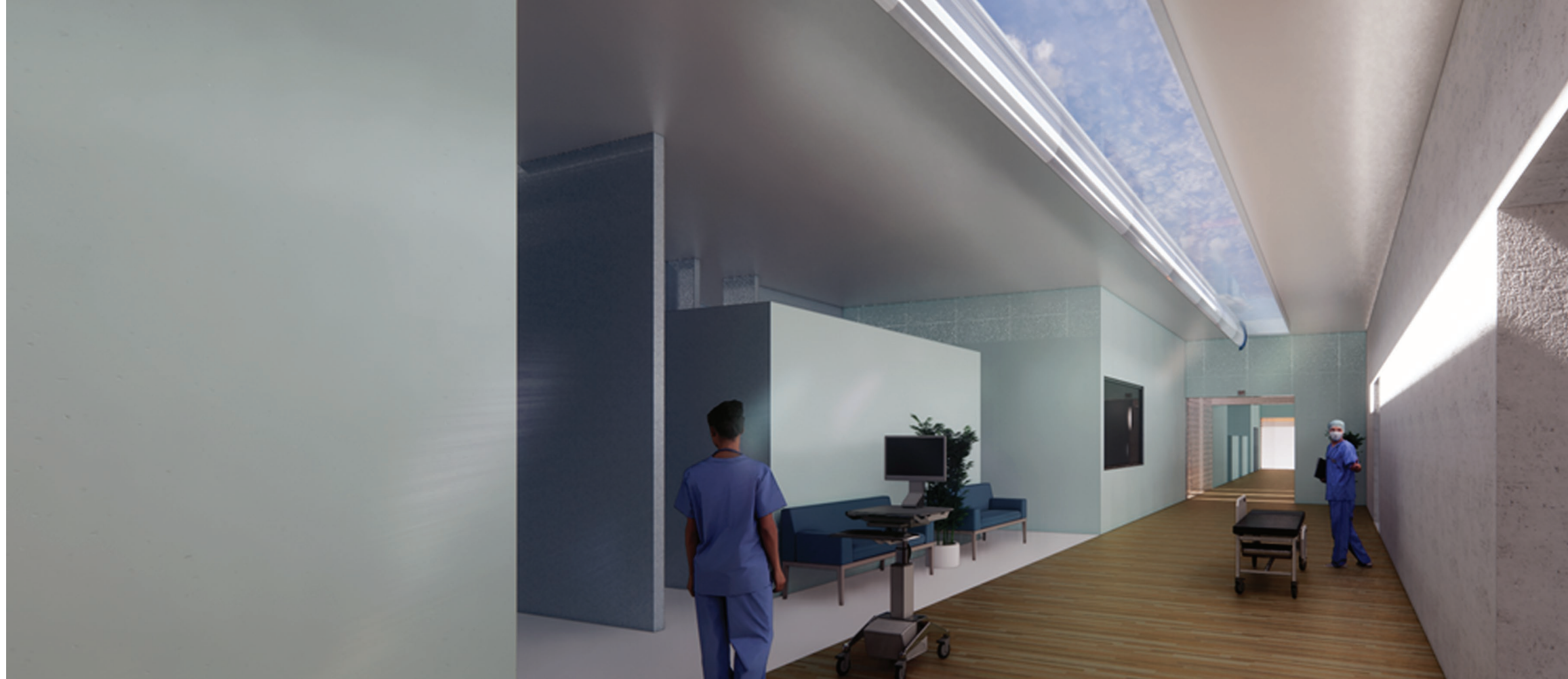
3:00PM



6:00PM

KEY:





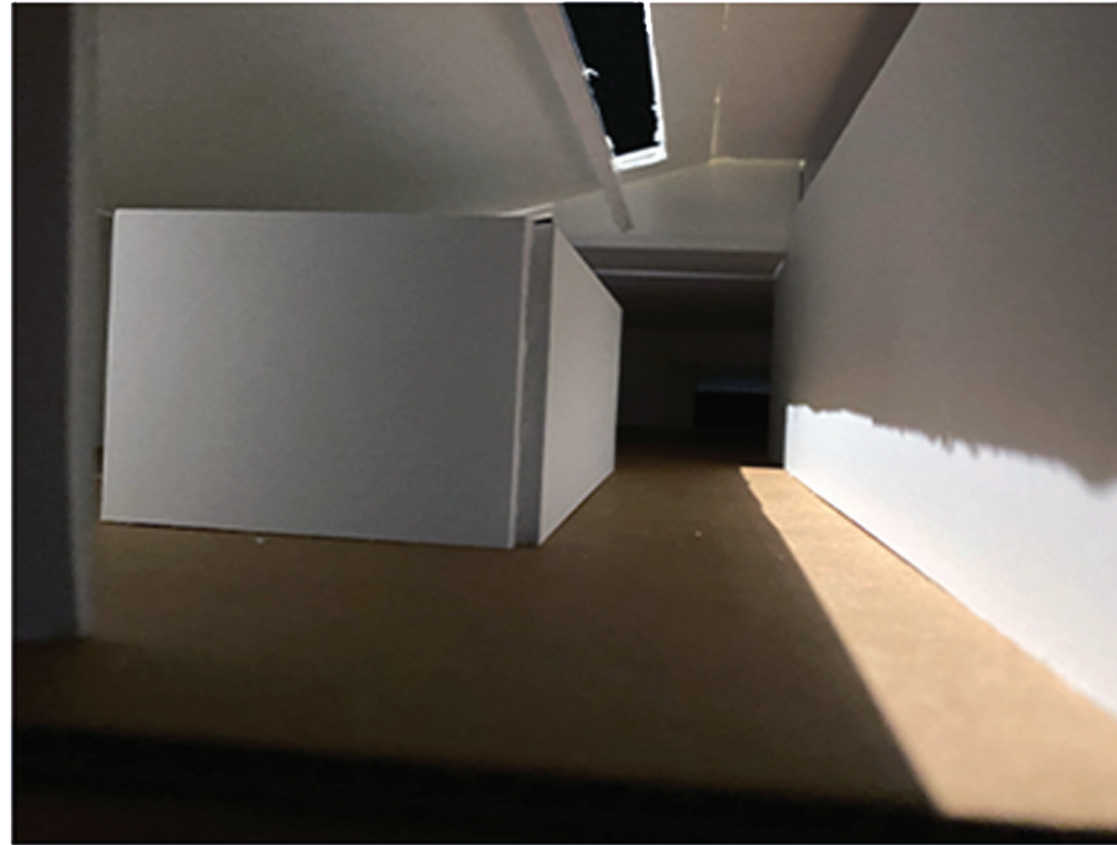
3:00PM

KEY:





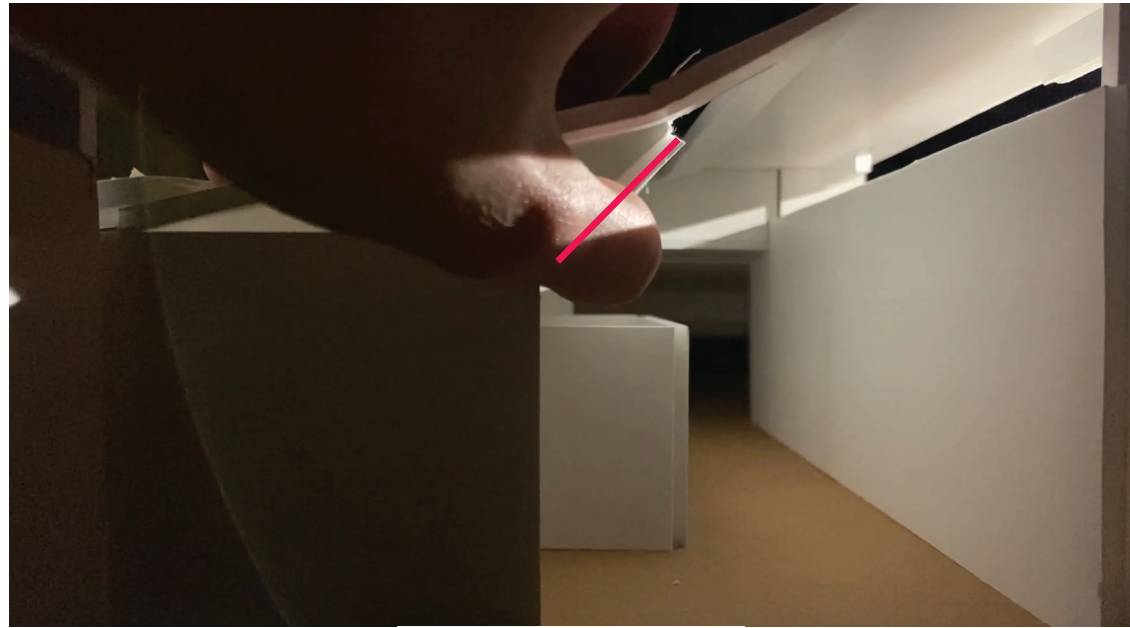
8:00AM



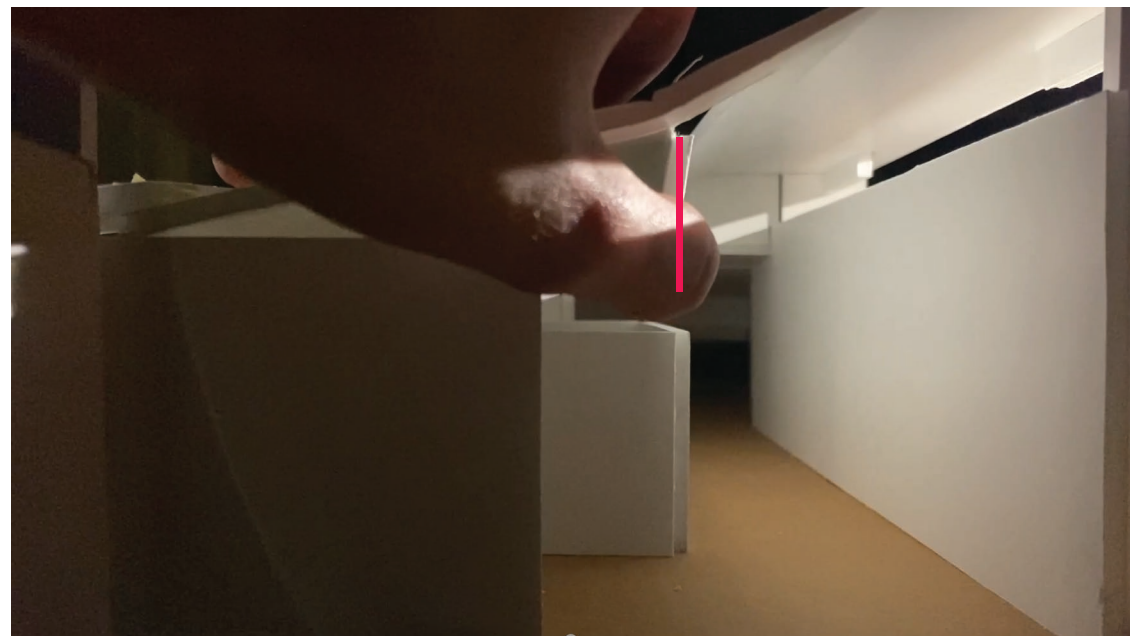
11:00AM

KEY:





270°



90°

KEY:



Response to nature

Research reveals that incorporating a painting of nature into the design of a healthcare setting can decrease stress levels.



Royal Bournemouth Hospital, Jigsaw building - Stride Treglown.



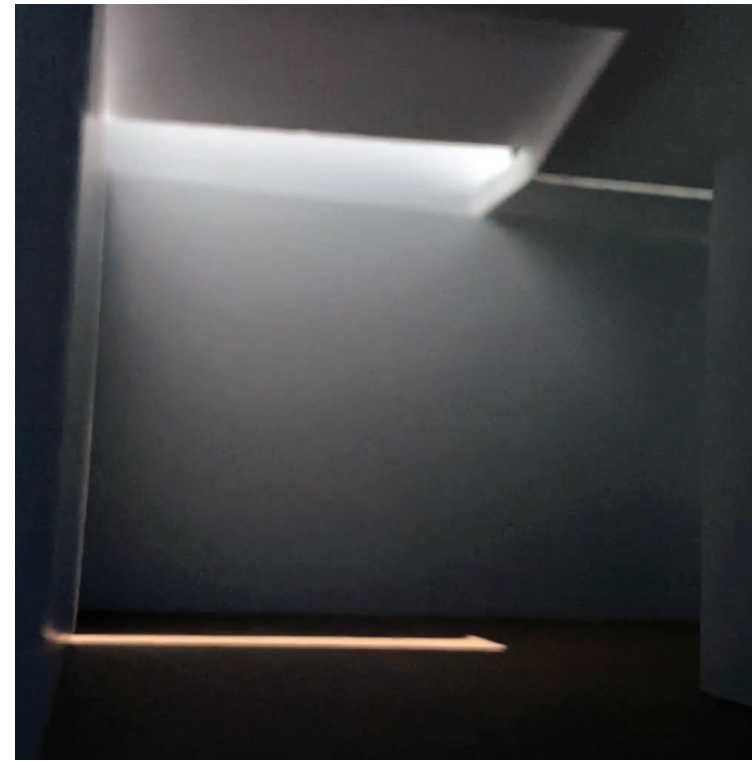
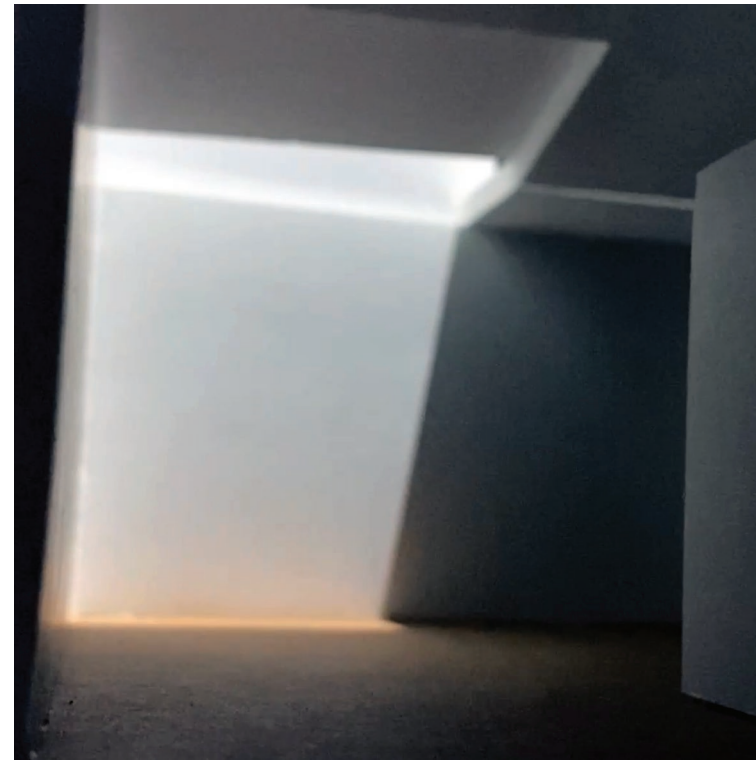
This painting of the hospital's hallway demonstrates the dynamic effects that occur when the filtered sun light is being transitioned through the space.

Wall as a canvas

After conducting different lighting explorations, this walls wants to act as natural canvas when light falls on it. This dynamic canvas changes its color tone and effects throughout the day.



The study was made in the main hallway of the hospital.



8:00AM



11:00AM

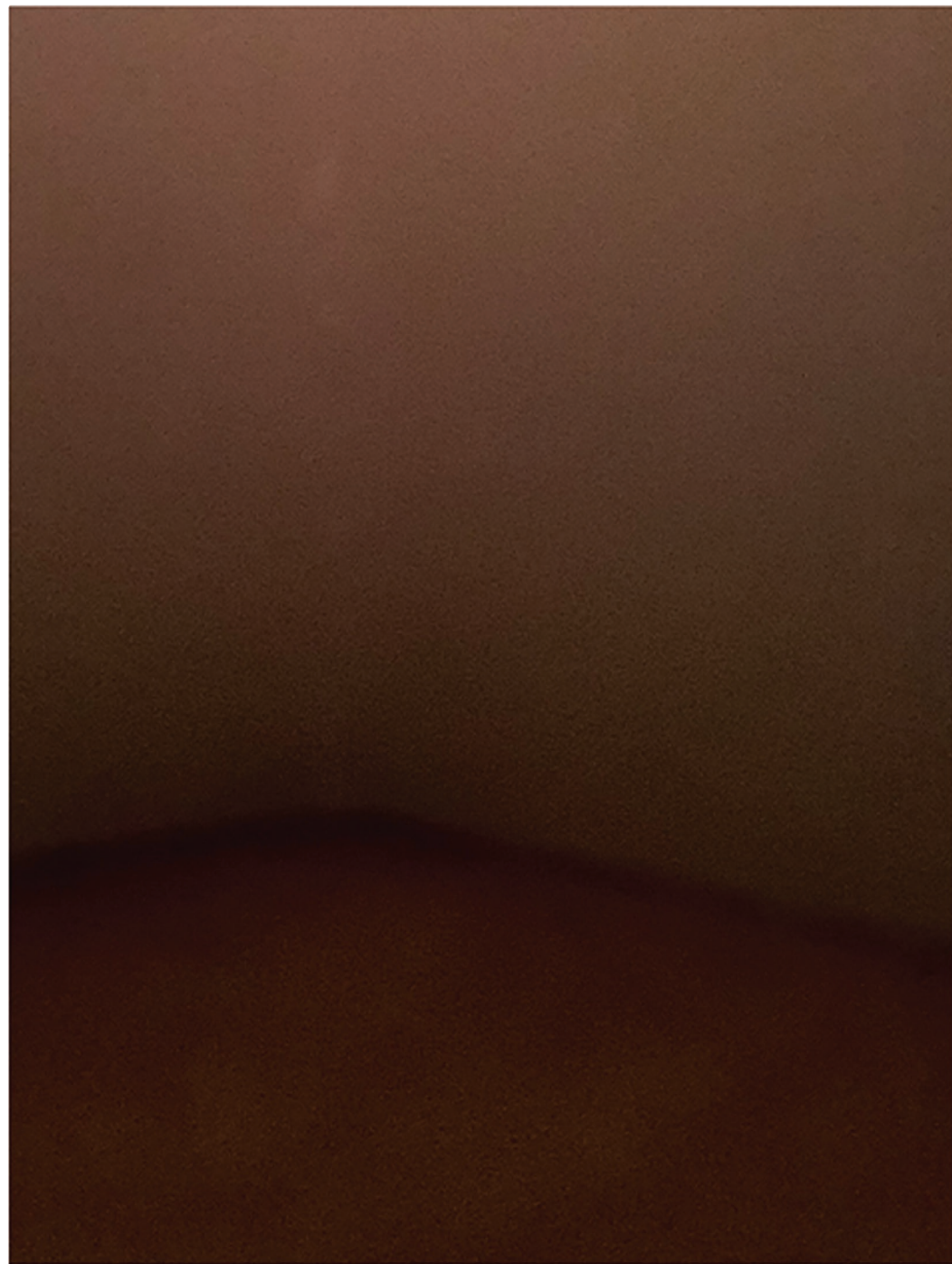
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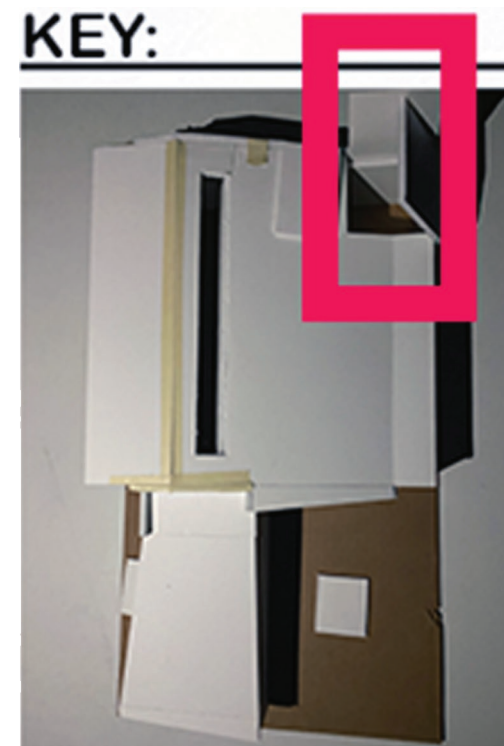


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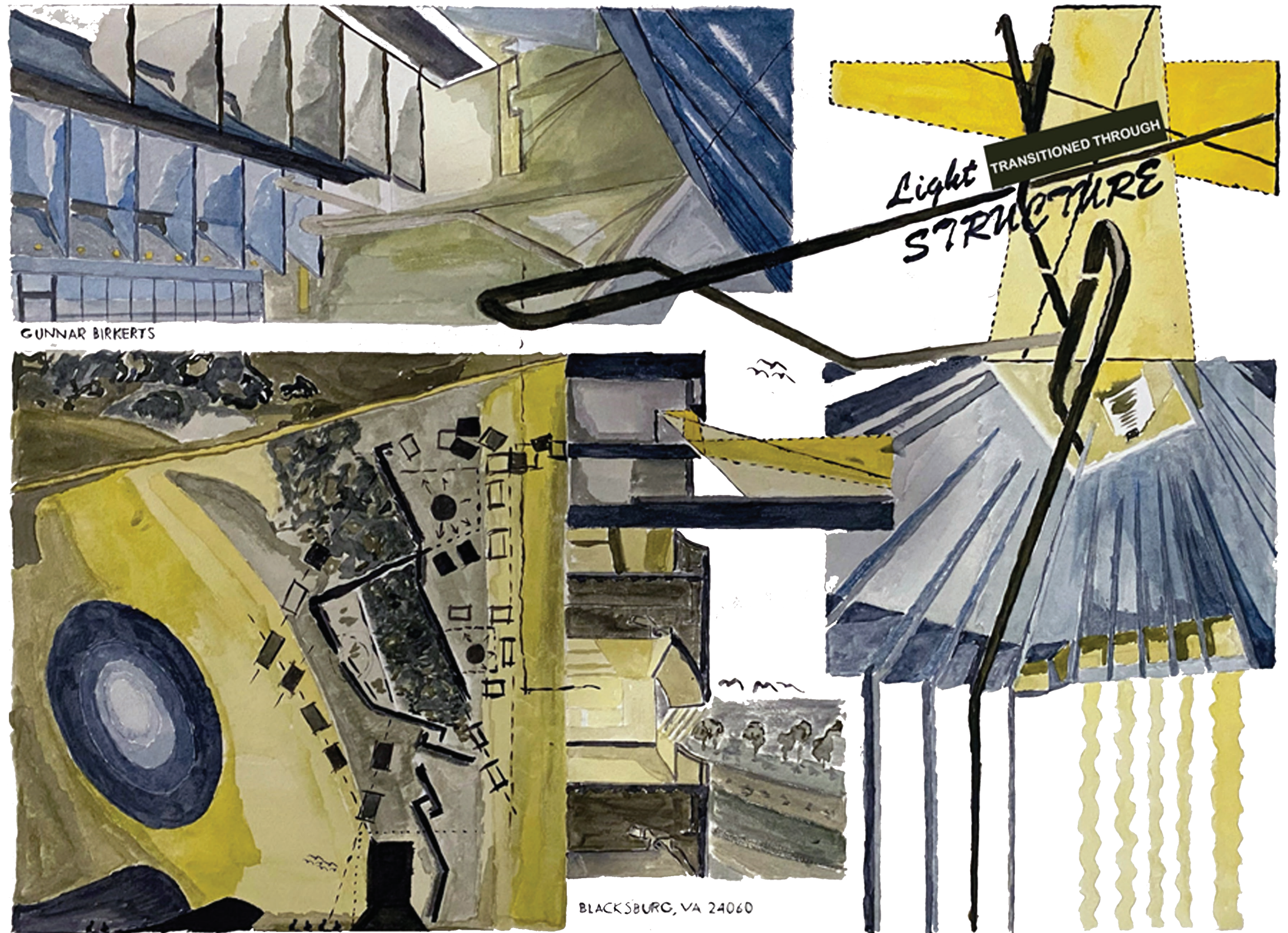


Color palette

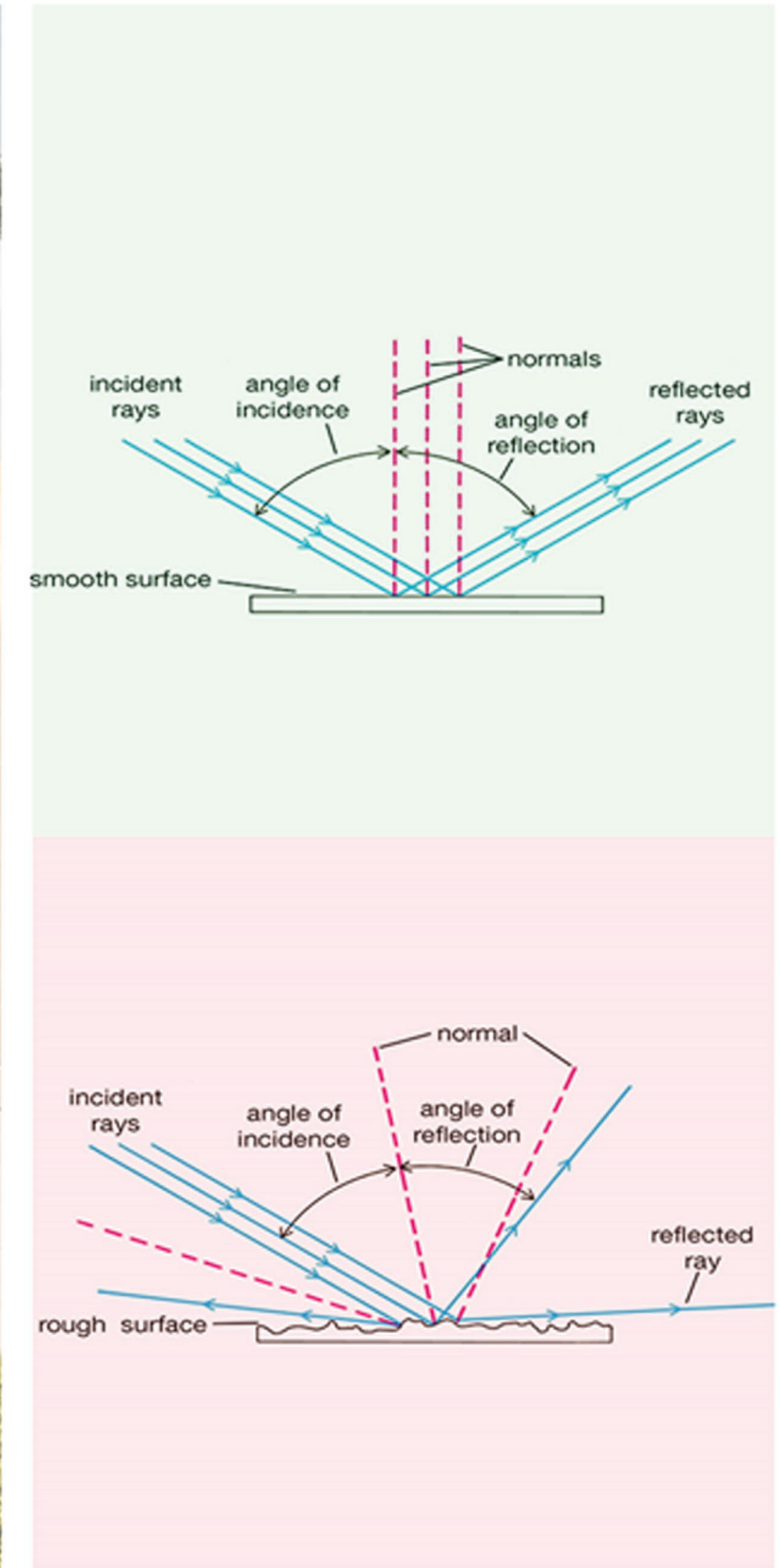
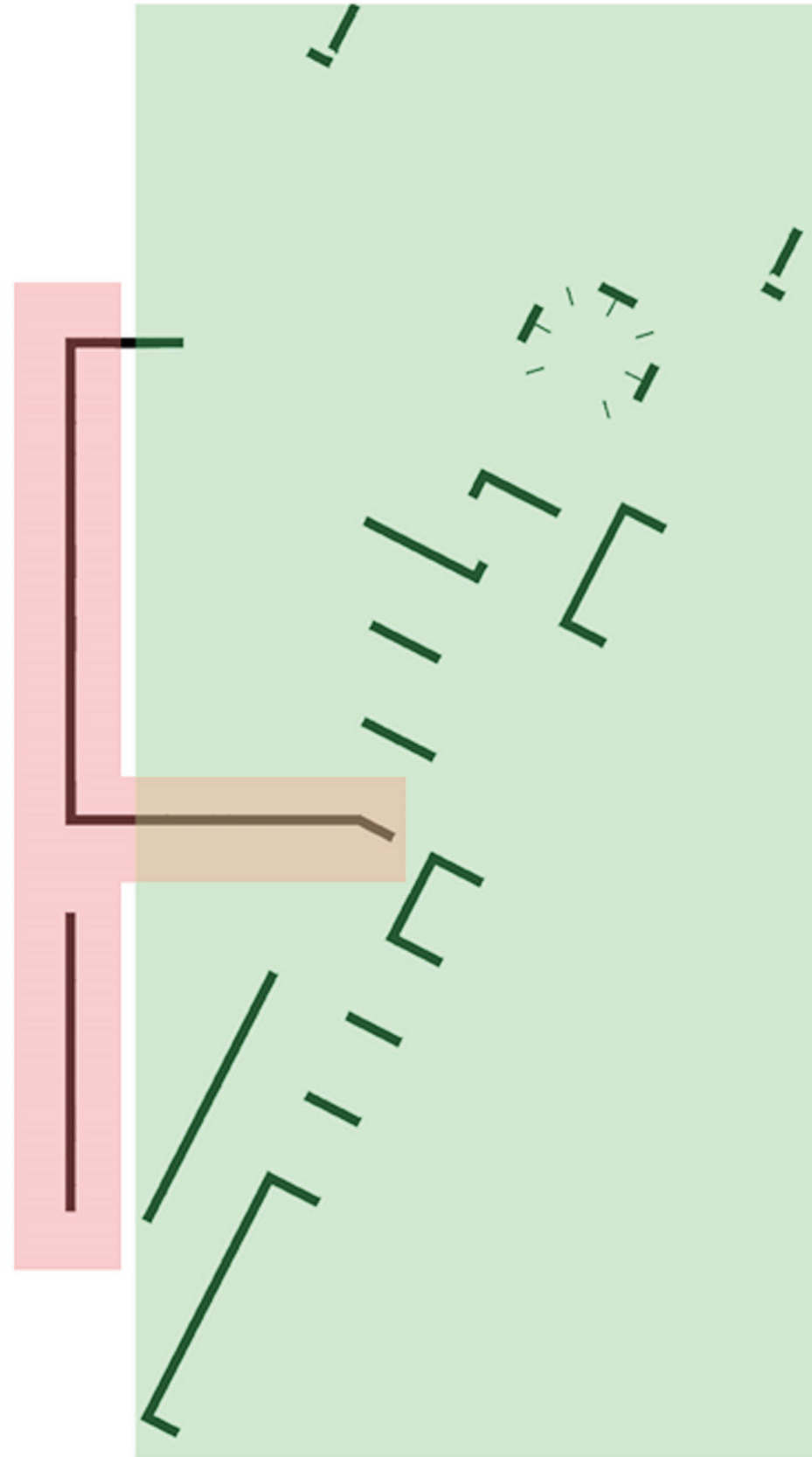


Concept development (The story)

The topography, wall, canopy, aperture, and path of this placemaking wants to tell a story about the healthcare worker and the patient within this healthcare setting.



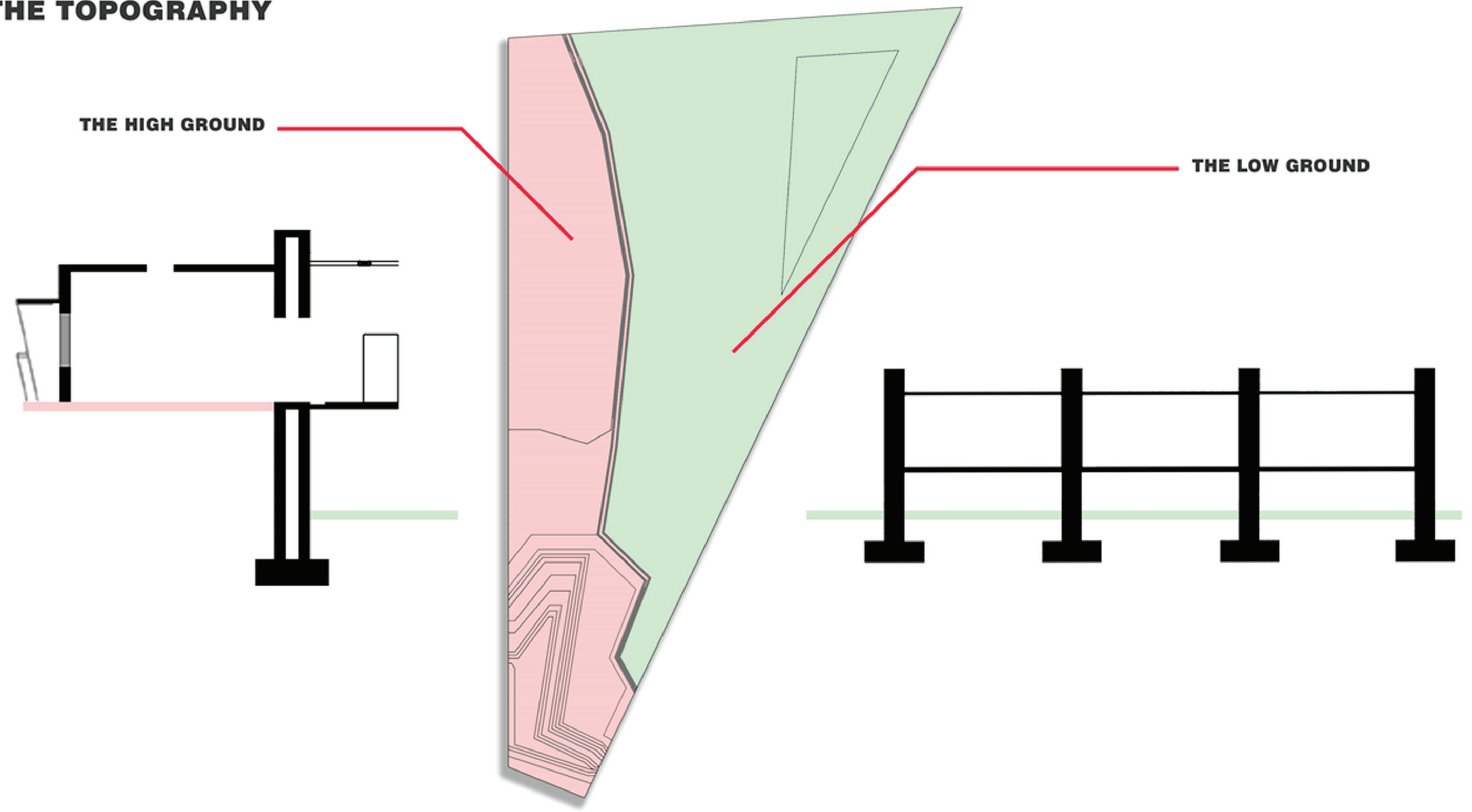
THE WALL



Contrast relationship

On the one hand, a soft and smooth concrete wall wants to represent the healthcare worker to reflect their humility and kindness. On the other hand, a rigid and rough concrete wall wants to represent the patient and encourage them to be strong and to survive.

THE TOPOGRAPHY



Complementary relationship

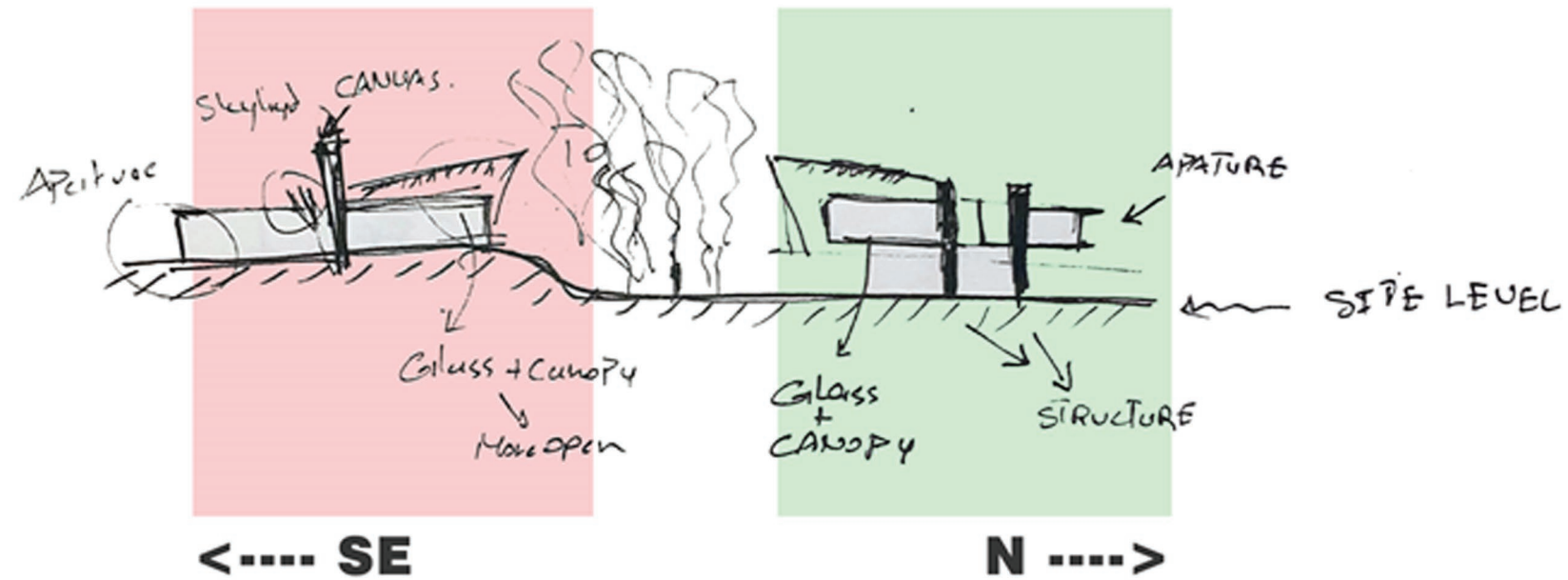
To observe and give care the healthcare worker's department sits on the high ground. While to receive and help lift the patient up thier department is elevated from the low ground.

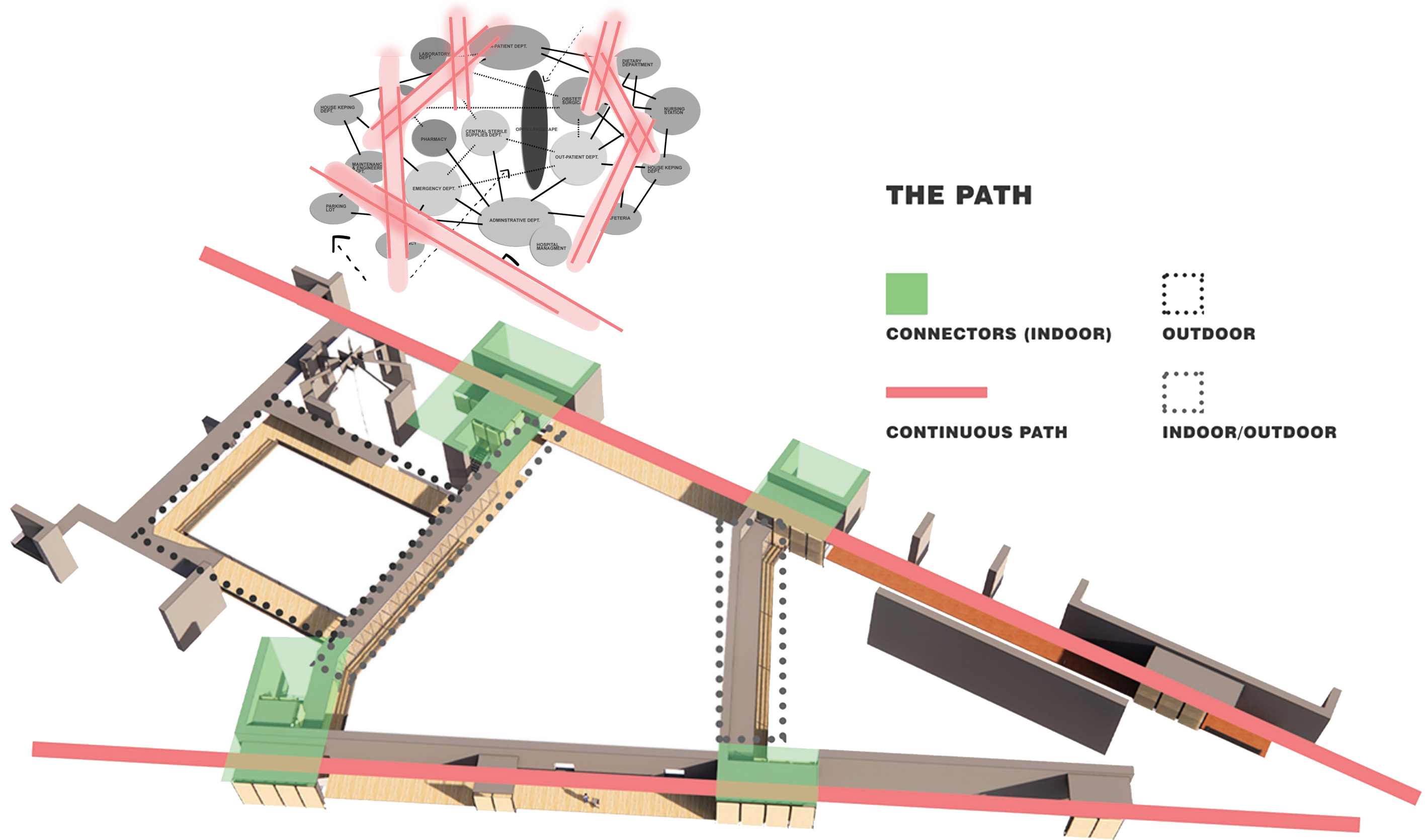
THE APERTURE



Responsive relationship

The apertures change in size and function as a response to the sun path and topography. South facing views are framed with exterior shades to demonstrate how the patient wants to be sheltered. While the north facing views could be seen through an open wall without exterior shading elements to expound the unconditional support healthcare workers provide.

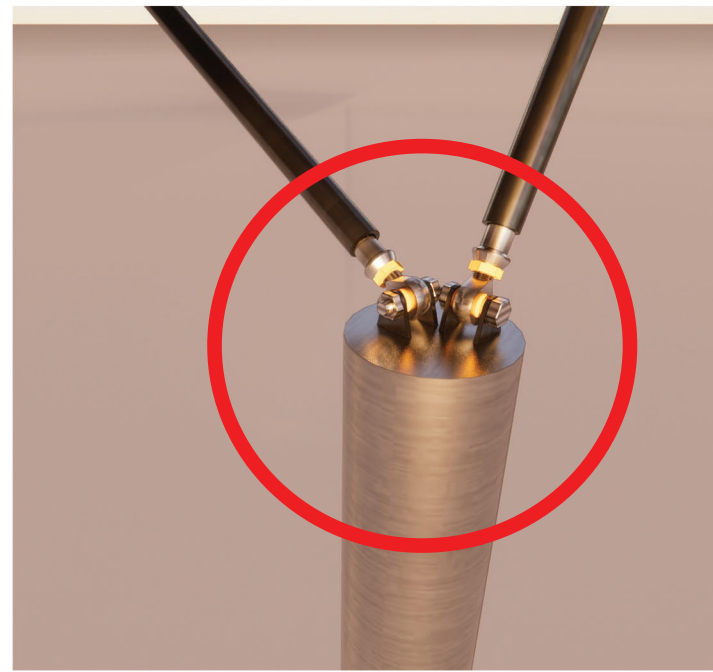
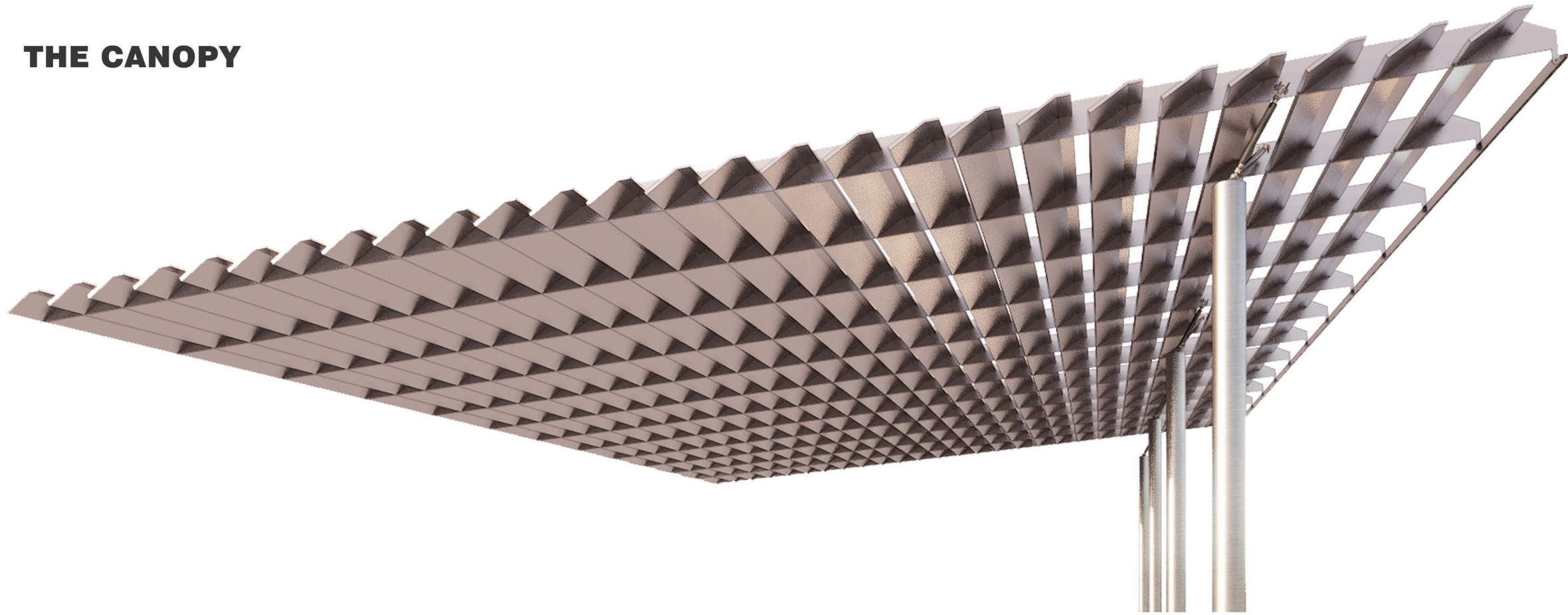




Continual relationship

The path wants to be continuous throughout the entire project, indoor and outdoor, bringing the patient and healthcare worker together.

THE CANOPY



Integrated relationship

The integration of placemaking and nature can be considered as an authentic strategy to help improve the healthcare process. An example of this incorporation can be seen in a canopy, a tree acts as a natural canopy that shelters us from the direct sun light, and a steel structure canopy also acts a refuge from both sun and rain.

The project:

PROGRAM

25-BED HOSPITAL

Schedule of Accommodation (areas in square meter)

Items #	Components/Elements	Quant/No	Sub-Total Area	Total Area m ²	Total Area m ² Sub Components	Total Area m ² Components	Remarks (Special Design Requirements)
1. MAIN ENTRANCE/SERVICES:							
1.1	Reception & information desk & office	1	18.00	18.00			office for night shift
	Supply receiving/distribution	2	6.00	12.00			Dry storage + wet storage
	Security office	1	9.00	9.00			connected to main sec. area (closed circuit TV cameras)
	Exhibition area	1	60.00	60.00			Could be used as multi-purpose hall
	Waiting area	1	32.00	32.00			50 person
	Public toilets (M/F)	2	14.00	28.00			8 person each
	Cafeteria	1	56.00	56.00			30 person
	Laundry and Linen Area	1	10.00	10.00			2 person
	Maintenance and housekeeping Area	1	12.00	12.00			2 person
	Gift/Flower shop	1	12.00	12.00			
	Waste holding room	1	8.00	8.00			
	TOTAL				257.00		
1.2	Administration						
	Waiting area	1	9.00	9.00			
	Business Office	1	9.00	9.00			
	Chief of Hospital	1	12.00	12.00			
	Supply Room	1	8.00	8.00			
	Staff offices	2	9.00	18.00			
	Meeting room	1	18.00	18.00			
	Medical records	1	8.00	8.00			
	Toilets (M/F)	2	8.00	16.00			
	TOTAL				98.00	355.00	355.00
2. IN-PATIENT DEPARTMENT:							
2.1	Entry Lobby:						
	Waiting area	1	20.00	20.00			30 person
	Reception/Registration	1	6.00	6.00			
	On-the-go nurse work area	1	12.00	12.00			
	Patient transfer area	1	9.00	9.00			
	Payee window	1	6.00	6.00			
	TOTAL				53.00		
2.2	Nursing Station: 2 stations						
	Reception/Check-In/Check-Out	2	6.00	12.00			
	Working space	2	14.00	28.00			
	Supervisors' office	2	9.00	18.00			
	Toilets/Dressing (M/F)	2	8.00	16.00			
	TOTAL				74.00		
2.3	Patients' Room: 25 beds						
	Bed room	25	8.00	200.00			1 bed each
	Toilet	25	6.00	150.00			
	Equipment storage/Locker room	25	1.00	25.00			
	TOTAL				375.00		
2.4	Family Lounge:						
	Family support zone	1	32.00	32.00			30 person
	Family's Nourishment/Cafeteria	1	20.00	20.00			
	Toilets (M/F)	2	9.00	18.00			
	TOTAL				70.00		
Supporting Facilities:							
	Staff break room	1	12.00	12.00			
	Conference room	1	12.00	12.00			
	Clean utility room	1	9.00	9.00			
	Dirty utility room	1	9.00	9.00			
	Samples storage room	1	6.00	6.00			
	Instrument/equipment storage	1	6.00	6.00			
	Disposal room	1	6.00	6.00			
	TOTAL				60.00	632.00	632.00

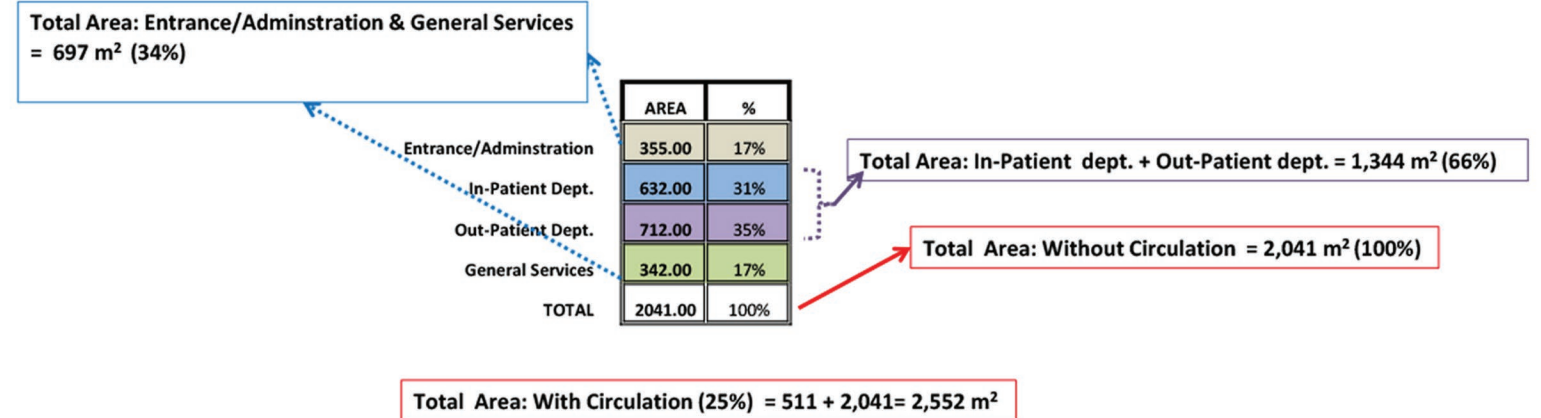
3. OUT-PATIENT DEPARTMENT:							
3.1 Entry Lobby:							
	Waiting area	1	20.00	20.00			
	Reception/Registration	1	16.00	16.00			
	On-the-go nurse work zone	1	12.00	12.00			
	Payee window	1	6.00	6.00			
	Public toilets (M/F)	2	14.00	28.00			
	TOTAL				82.00		
3.2 Emergency room:							
	Waiting area	1	12.00	12.00			10 person
	Reception/Registration	1	12.00	12.00			20 person
	Police room	1	9.00	9.00			
	Duty doctor's room	2	9.00	18.00			
	Duty nurses room	1	9.00	9.00			3 nurses
	Examination and treatment rooms	4	9.00	36.00			1 person each
	Observation area	1	16.00	16.00			4 person each
	Record room	1	8.00	8.00			
	Stretcher storage	1	8.00	8.00			
	Equipment storage	1	6.00	6.00			
	Toilet (M/F)	2	6.00	12.00			
	TOTAL				146.00		
3.3 Consulting and exam (Internal medicine dept.):							
	Medicine clinic	1	12.00	12.00			
	Eye clinic	1	12.00	12.00			
	ENT clinic	1	12.00	12.00			
	Dermatology and allergy	1	12.00	12.00			
	Orthopedic	1	12.00	12.00			
	Neurology	1	12.00	12.00			
	Nephrology	1	12.00	12.00			
	Thoracic clinic	1	12.00	12.00			
	Cardiology clinic	1	12.00	12.00			
	General surgery clinic	1	12.00	12.00			
	Lungs function clinic	1	12.00	12.00			
	Urology clinic	1	12.00	12.00			
	Gastro-intestinal clinic	1	12.00	12.00			
	Diabetes	1	12.00	12.00			
	Mental health	1	12.00	12.00			
	TOTAL				180.00		
3.4 Surgical and Obstetrical dept.:							
	Major Operating room	1	34.00	34.00			
	Delivery room	1	34.00	34.00			
	Sub-sterilizing area	1	6.00	6.00			
	Sterile instrument, supply and storage area	1	6.00	6.00			
	Scrub-up area	1	6.00	6.00			
	Clean-up area	1	6.00	6.00			
	Pre-operative room	1	9.00	9.00			
	Post-operative room	1	9.00	9.00			
	Room for plaster application	1	9.00	9.00			
	Room for plaster removal	1	9.00	9.00			
	Dressing room	2	6.00	12.00			
	Stretcher storage	1	8.00	8.00			
	Toilets (M/F)	2	9.00	18.00			
	TOTAL				166.00		
3.5 Nursing Station:							
	Reception/check-in/check-out area	2	6.00	12.00			1 for emergency room 1 for out-patient clinics

PROGRAM

. Examination room	2	6.00	12.00		1 for emergency room 1 for out-patient clinics
. Working space	2	12.00	24.00		1 for emergency room 1 for out-patient clinics
. Supervisors' office	1	9.00	9.00		1 office for both
. Toilets/dressing (M/F)	2	6.00	12.00		
		TOTAL	69.00		
Supporting Facilities:					
. Duty doctor's rest room	1	9.00	9.00		
. Meeting room	1	12.00	12.00		
. Staff break room	1	12.00	12.00		
. Clean utility room	1	6.00	6.00		
. Dirty utility room	1	6.00	6.00		
. Samples storage room	1	6.00	6.00		
. Instrument/equipment storage	1	6.00	6.00		
. Janitor's closet	1	6.00	6.00		
. Disposal room	1	6.00	6.00		
		TOTAL	69.00	712.00	712.00
4. GENERAL SERVICES					
4.1 Diagnostic, Radiology & Imaging, treatment services:					
. Registration area	1	6.00	6.00		
. Waiting area	1	8.00	8.00		
. Radiologist's room	1	9.00	9.00		1 person
. X-ray	1	14.00	14.00		
. X-ray change room	1	4.00	4.00		
. X-ray control room	1	6.00	6.00		
. CT scan	1	14.00	14.00		
. CT scan control room	1	6.00	6.00		
. CT scan change room	1	4.00	4.00		
. ECG	1	14.00	14.00		
. Ultra sonogram	1	9.00	9.00		
. Technical staff room	1	12.00	12.00		2 person
. Storage room	1	6.00	6.00		
		TOTAL	106.00		
4.2 Central Sterilizing and Supply Dept.:					
. Receiving and releasing area	1	6.00	6.00		
. Work area	1	9.00	9.00		
. Sterilizing room	1	6.00	6.00		
. Sterile supply storage area	1	6.00	6.00		
		TOTAL	27.00		
4.3 Pharmacy:					
. Dispensing desk	1	4.00	4.00		
. Pharmacist's room	1	9.00	9.00		
. Medicine store	1	9.00	9.00		
		TOTAL	22.00		
4.4 Primary Clinical Laboratory:					
. Clinical work area with lavatory/sink	1	9.00	9.00		
. Pathologist area	1	9.00	9.00		
. Storage	1	6.00	6.00		
		TOTAL	24.00		
4.5 Dietary dept.:					
. Dietitian room	1	9.00	9.00		
. Supply receiving area	1	6.00	6.00		
. Cold storage	1	6.00	6.00		
. Dry storage	1	6.00	6.00		
. Food preparation area	1	6.00	6.00		
. Cooking and baking area	1	6.00	6.00		
. Serving and food assembly area	1	6.00	6.00		
. Washing area	1	6.00	6.00		
. Garbage disposal area	1	4.00	4.00		
. Toilet (M/F)	2	6.00	12.00		
		TOTAL	67.00		

4.6 Cadaver Holding Room:					
. Cadaver holding room	1	12.00	12.00		
		TOTAL	12.00		
4.1 Substation:					
. Generator	1	24.00	24.00		
. Transformer	1	24.00	24.00		
. AHU	1	24.00	24.00		
. Fire Fitting System	1	12.00	12.00		
		TOTAL	84.00	342.00	342.00

TOTAL AREA



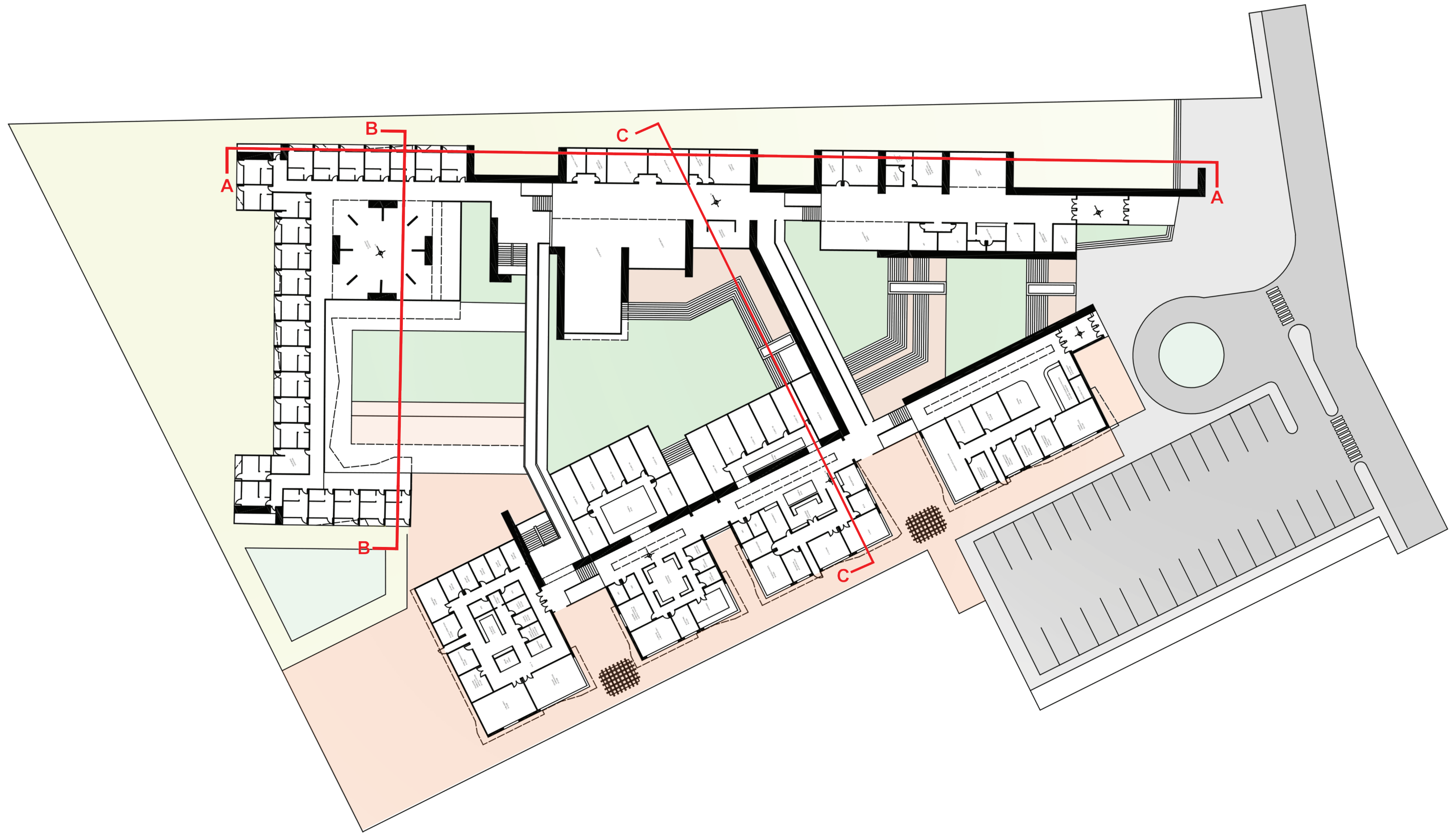
Site plan



Aerial view

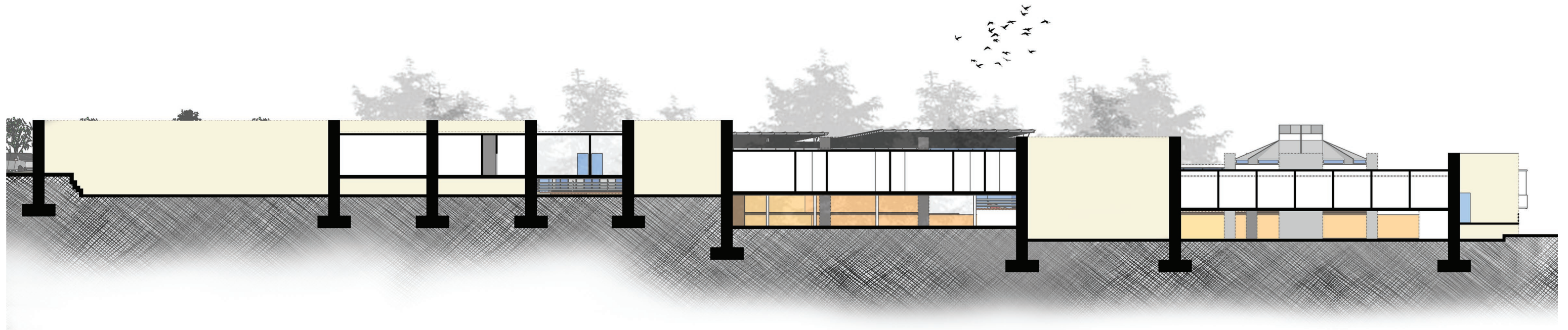


Plan:

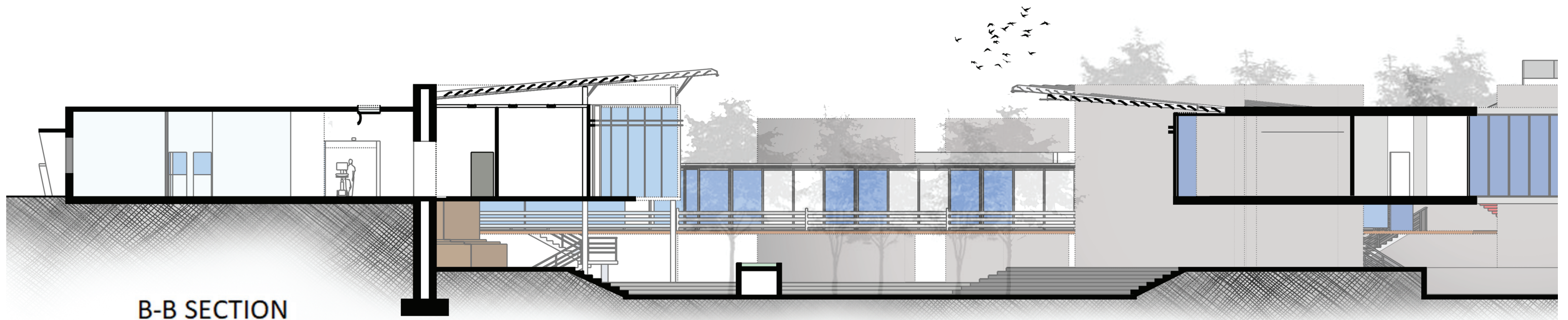


N.T.S

Sections:

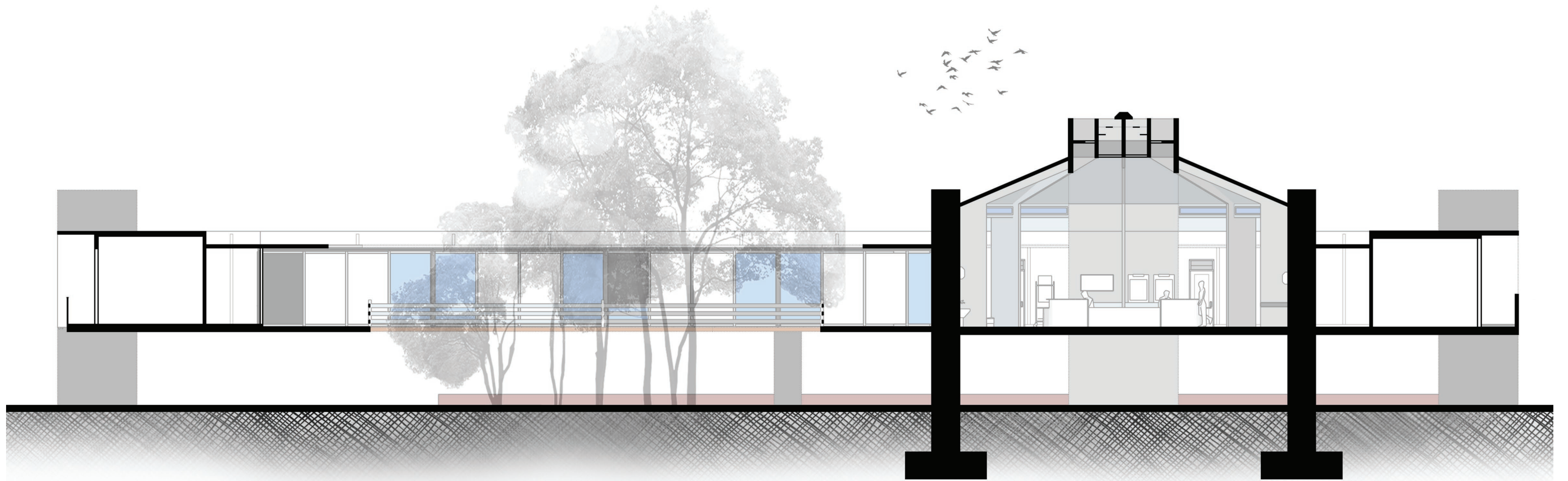


A-A SECTION



B-B SECTION

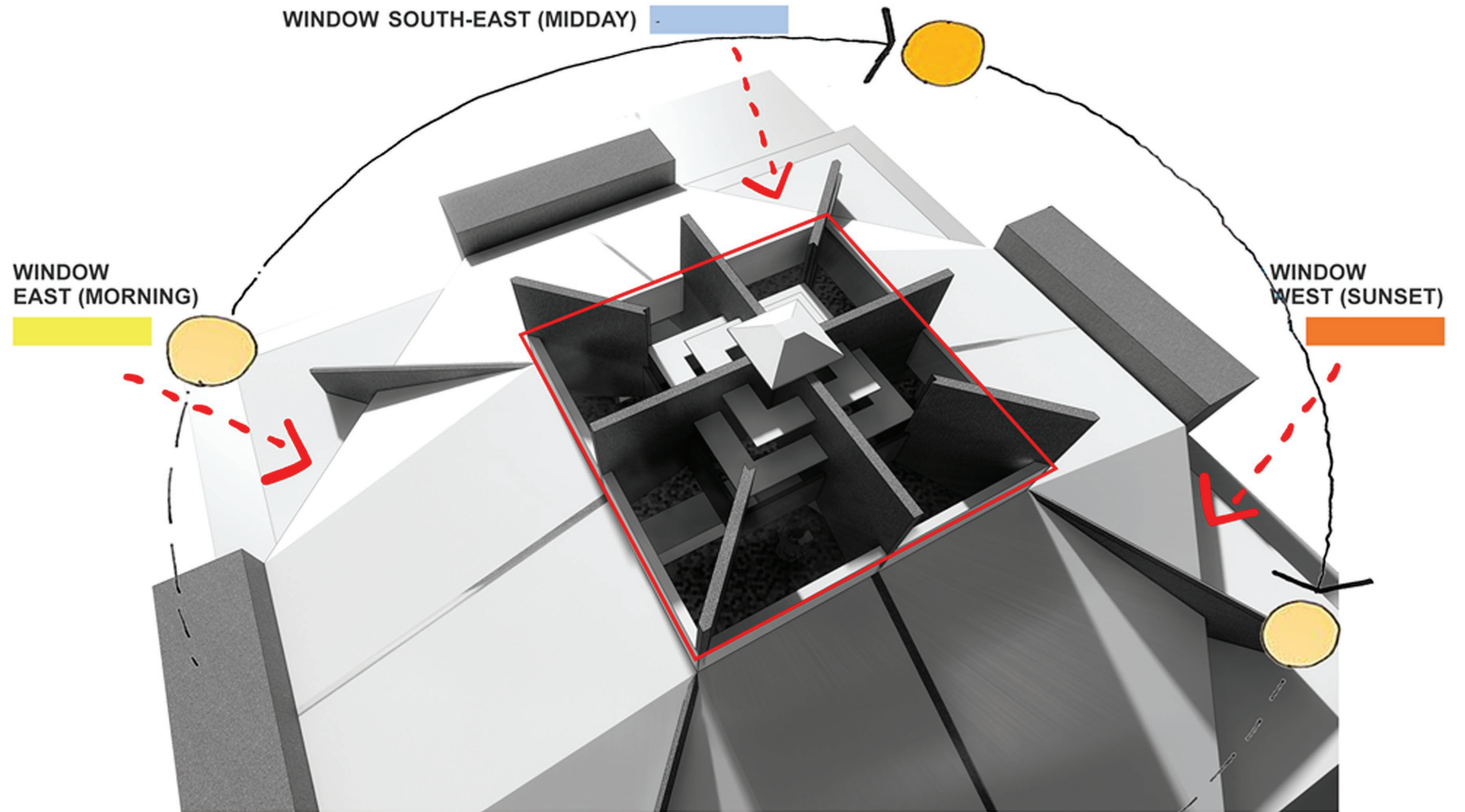
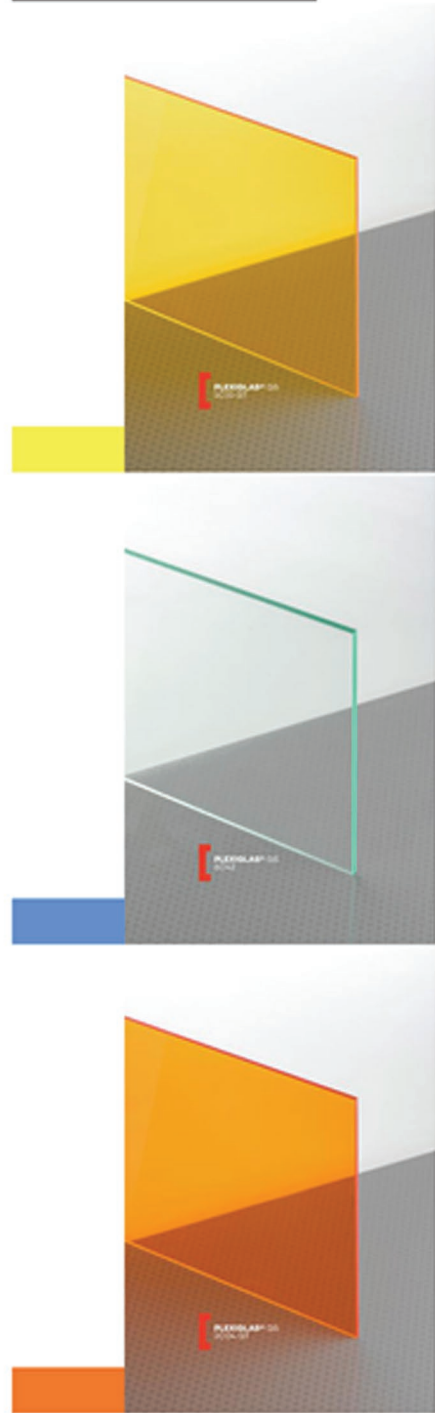
Sections:



C-C SECTION

Circadian rhythm

WINDOW COLOR:



8:00AM



12:00PM



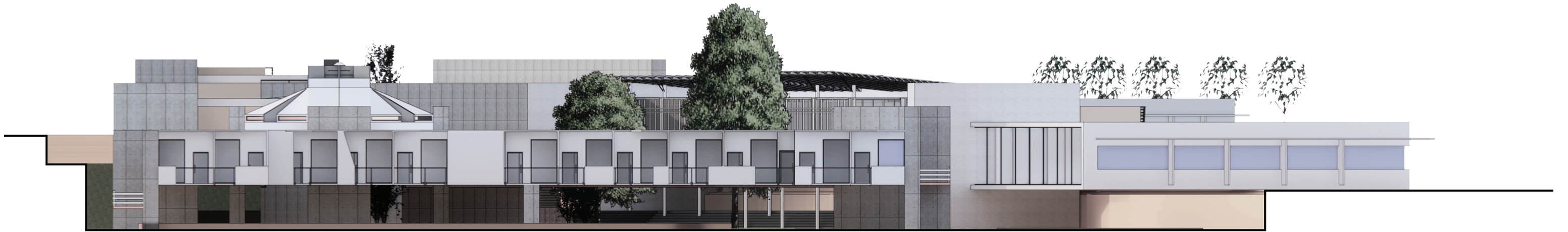
6:00PM



Elevations:



SOUTH-EAST ELEVATION



WEST ELEVATION



NORTH ELEVATION



Exterior shaders

The shading orientation and layout depends on the orientation of the facade, and layout of the windows. Therefore, the use of vertical and horizontal shades was implemented to reduce solar heat gain and lower energy consumption.













8:00AM



12:00PM











Afterword

The architectonic dramatization is proposed in the form of a story about the healthcare worker and the patient, and how they interact with each other within a healthcare setting. The story is architecturally narrated in the midst of the transition of daylight through the topography, aperture, canopy, wall, and path.

The topography suggests a complementary relationship between an observer on the high ground and a participant on the low ground. The apertures propose a responsive relationship to nature, south-facing apertures are framed, while north-facing apertures are open walls to expound the unconditional support healthcare workers provide. The canopy encourages an integrated relationship between the placemaking and nature, a steel structure canopy can be a refuge from sun and rain, while a tree can act as a natural canopy that shelters users from the direct sunlight. The wall recommends a contrast relationship between a soft and smooth concrete (canvas) wall that wants to represent the healthcare worker, and a rigid, rough concrete wall that wants to remind the patient of strength and survival. The path advocates a continual relationship through out the entire setting, indoor and outdoor, bringing the patient and the healthcare worker together.

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