

DEFINED BY SHADOW

Master's Thesis 2015
Chalmers School of Architecture
LINDA HUTCHINS

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A daylight design study within a residential context.
Formulation of a Lighting Syntax library applied in a
design proposal for a daylight-tuned dwelling on the
island of St Croix.

Linda Hutchins

Master's thesis
Chalmers School of Architecture 2015
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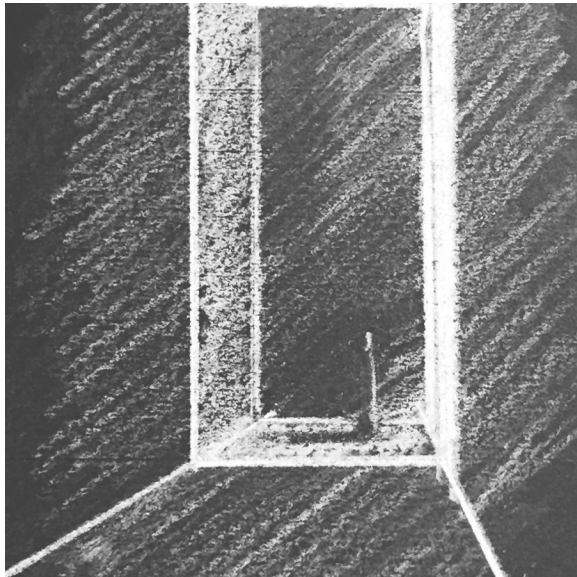
CHALMERS

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INTRO

Part 1
Lighting syntax element library

The first part investigates daylight design on a conceptual level, aiming to identify lighting phenomena and structure them into the form of a library of lighting syntax elements. The goal was to study, articulate and formulate some of the many ways to work with light (delimited to a residential context), and initiate the construction of a library of lighting elements, that can be used by any designer in any given project.

Part 2
Design Proposal

The second part of this project studies the implementation of some of these lighting elements identified in part 1, in a design proposal for a building - a daylight-tuned dwelling, on the island of St Croix, USVI.

ABSTRACT

This Master Thesis aims to investigate an immersive integration of daylight into a residential context, to explore how light and darkness – and the tensions in between them – shape the structure itself and the ways one lives within it.

The project aims to elaborate a daylight program and to explore means of reaching desired lighting targets through the use and development of passive architectural daylight methods. It intends to revisit, and perhaps redefine, conventional lighting standards and to promote an architecture that advocates the integration of daylight into the every day of life lived within it.

The result and the final goal is to implement the findings into the design of a building, a daylight-tuned dwelling, that is in harmony with its surroundings and its users. A building that encourages to live with light and that enables

an active dialogue with its surroundings and the natural rhythms of life.

The design proposal aims to tell a story of the visual perception of space that alters with the pace of daylight. It is a story that is predictable while at the same time truly variable, thus very fascinating. Defined by shadow is the story of a static structure that comes alive through the integration of daylight. It is the design of a divergent space that has a diverse set of spatial qualities, activated and enhanced by the ever changing surrounding lighting situation.

Focus

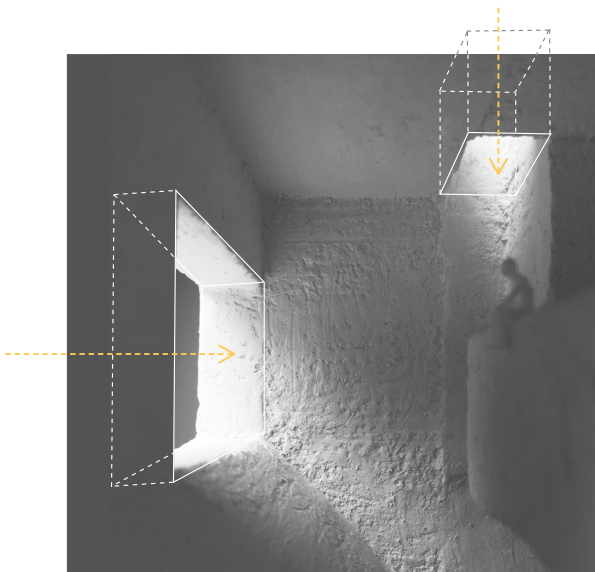
Explore the creation and sculpturing of space without the use of a tangible material. Investigate perceived geometrical alterations of space, solely by the use of light. Distinguish and recognize how light, and its absence, can generate different

atmospheres in the same physical environment. Explore the interplay and the correlation between light, darkness and materiality. Study how architecture can communicate with its surroundings, with nature and with time.

Relevance

Daylight is free to all – and it is abundant. I would like to inspire others to work more with daylight and to explore all the benefits from doing so. My hope is that designing with daylight can inspire to a simpler lifestyle by promoting sustainable daylight solutions with less energy consumption and better thermal control. I feel that developing new methods for daylight design and the integration of artificial light, that can be used in any given residential context, is particularly relevant today.

WHAT IS DAYLIGHT DESIGN?



The visual perception of our physical environment is revealed by light and light itself is only revealed by the material it encounters. The spatial effects perceived by light will then always be dependent on built form. Due to the dependence on variables such as ever-changing sky conditions, time of day and the viewers physical position the effects will never be static and the space will constantly be perceived differently.

The passage

Daylight design is distinctly linked to the building envelope and the density and opacity of the structure dictates how it enters a space. The light is channeled, directed and distributed in to an interior according to the limitations of an opening. Thus, the interior effects of light are determined by the characteristics of the the passage from outside to inside and becomes a sort of memory of the shape and material through which it passed.

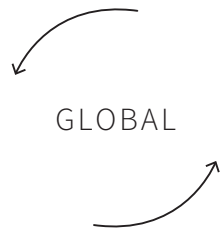
One aperture - two openings

Daylight design is about forming this pathway from exterior to the interior of a building. A careful consideration of placement, dimensions, directions and materiality for each opening is therefore essential. Each opening has two apertures and the distance and shape between them constitutes the pathway and determines each lighting effect.

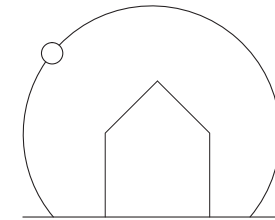
Direct and indirect lighting

The openings and its apertures can accomplish two general groups of internal lighting effects, the indirect and the direct - atmospheres (mood) and moments. Indirect illumination produce a soft light in the room because of the diffuse dispersion of light. Illumination with direct light allows the three-dimensionality of objects, materials and textures to be emphasized by shadows.

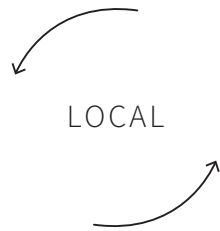
THREE LEVEL DAYLIGHT DESIGN METHOD



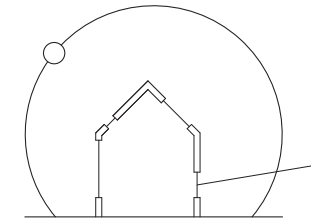
Sun Path
Topography
Obstructions (eg. neighboring structures and vegetation)
Time



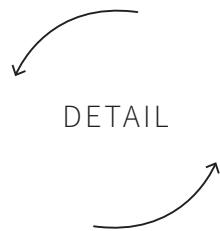
Massing and Orientation



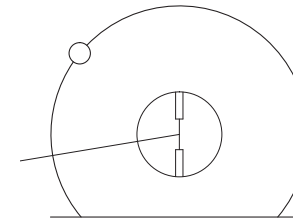
Atmosphere/mood
Function/Usage/Tasks
Social Interaction
Views
Time



Aperture type and location

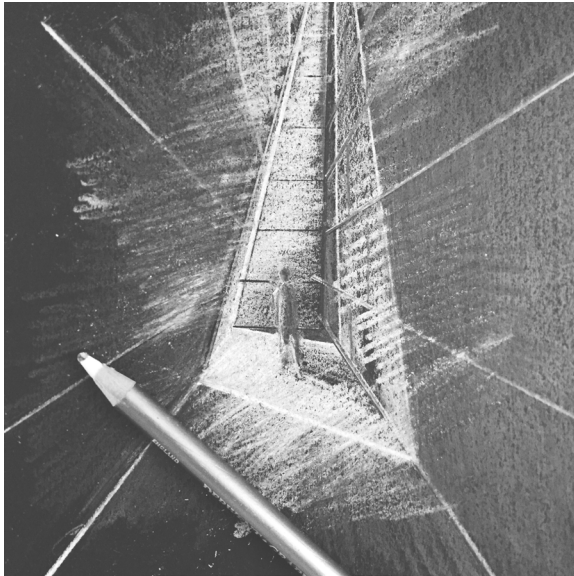


Dimensions
Texture
Perspective
Time



Light passage formation and dimension

NOTES ON LIGHT



In the electrified society of today, interior lighting pollution is just as big of an issue as it is in our exterior, urban environments. What the effects upon the users are of over-illuminated interiors, both in public and in residential settings, are topics for research in themselves. This thesis takes its point of departure in the statement that we do over-illuminate our interiors, and thereby expose the users to excessive and sometimes even improper spectral composition lighting to an extent that it can effect both physical and mental health. Through this thesis I intend to revisit, and perhaps even redefine, some of the conventional lighting standards. The final goal is to design a piece of architecture that promotes an immersive integration of daylight, advocates a

careful artificial lighting scheme, and allows the combination of the two to shape the structure itself and the way one lives within it.

As humans we strive for variation, we seek to change and rearrange our environments more often than perhaps is necessary. When designing with daylight, if done right, one could utilize and benefit from its inherent qualities - such as variation in intensity, contrast and direction - and generate a space which is constantly altered, and thereby keeping an active dialogue with its surroundings. And, important to note, daylight is free to all and this project aims to seek ways to take advantage of this immersive energy provided for everyone.

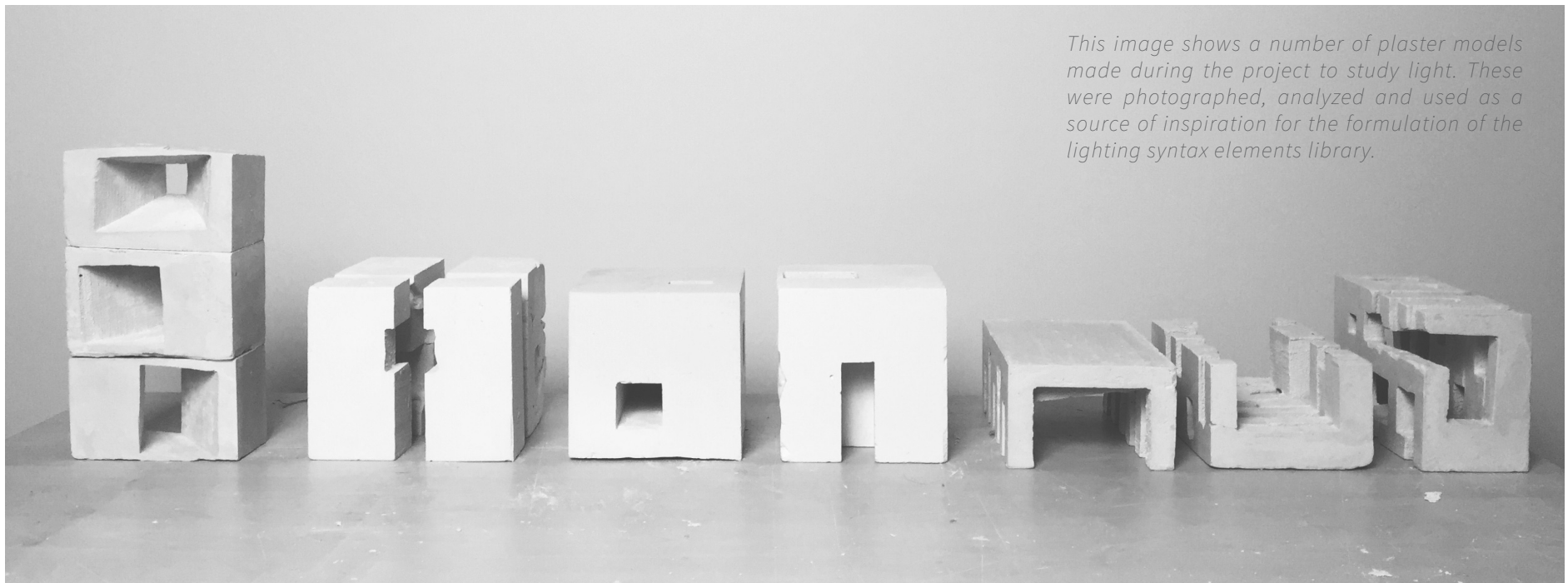
PART 1

LIGHTING SYNTAX ELEMENT LIBRARY

The first part of this thesis studies ways that daylight enters a building envelope. The result is the formulation of the six first, broadest elements of the library - level 1. This should be seen a start and the formulation of the elements allow refinement and improvement.

The library has the structure of a network, starting with the broader elements covering a general approach and moving towards the more narrow, allowing for more specific and detailed aspects. The elements can be categorized and subcategorized and thereby become a network of tools.

The library would work as a tree of ideas, branching out in a explicit structure that simplifies the selection of appropriate tools for any design project at hand. In collecting relevant elements for each project the designer builds up a language for that particular setting, which s/he then can fall back and rely on to inform the end result.



This image shows a number of plaster models made during the project to study light. These were photographed, analyzed and used as a source of inspiration for the formulation of the lighting syntax elements library.

LIGHTING SYNTAX ELEMENTS - LEVEL 1



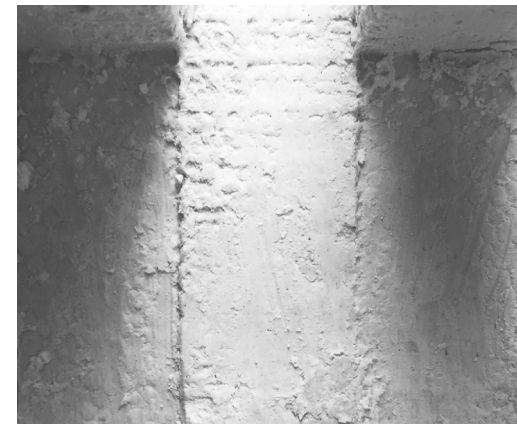
UNOBSTRUCTED

The point of this element is to stay out of the way of incoming light, allowing as much as possible to pass through providing strong illumination.



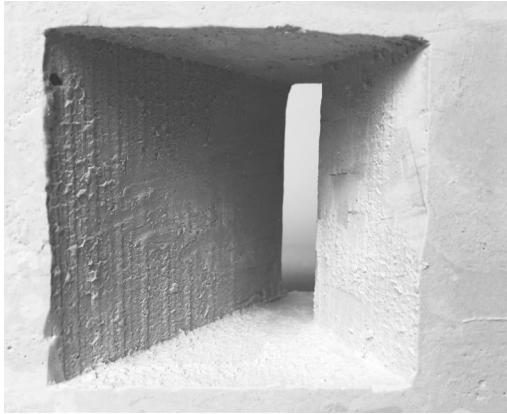
FRAMED

By framing the light entering the structure, optical characteristics of the aperture gain focus.



CHANNELED

Rather than allowing light free access to the space within, it is channeled to hint at the unseen, awaken interest and provide spatial contrast.



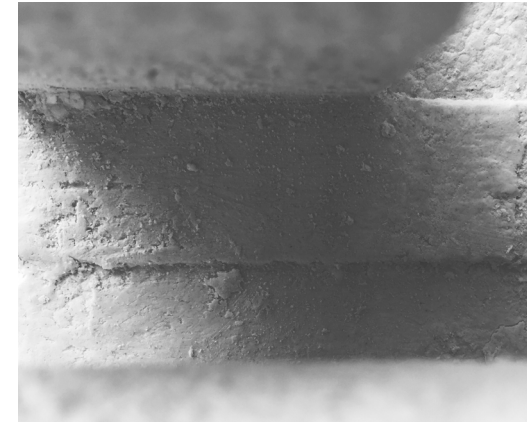
ANGLED

Rather than traversing directly into a space, light is slanted in a controlled manner. This allows painting swathes of light on otherwise unlit surfaces.



FILTERED

Sunlight is filtered physically, giving a rich pattern of light and shadow.

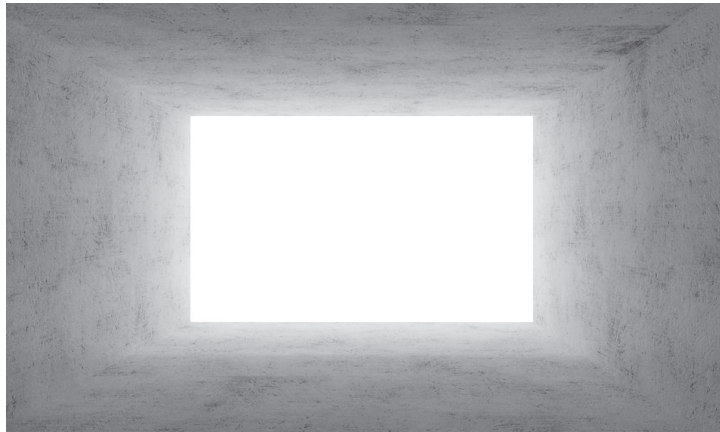


DIRECTED

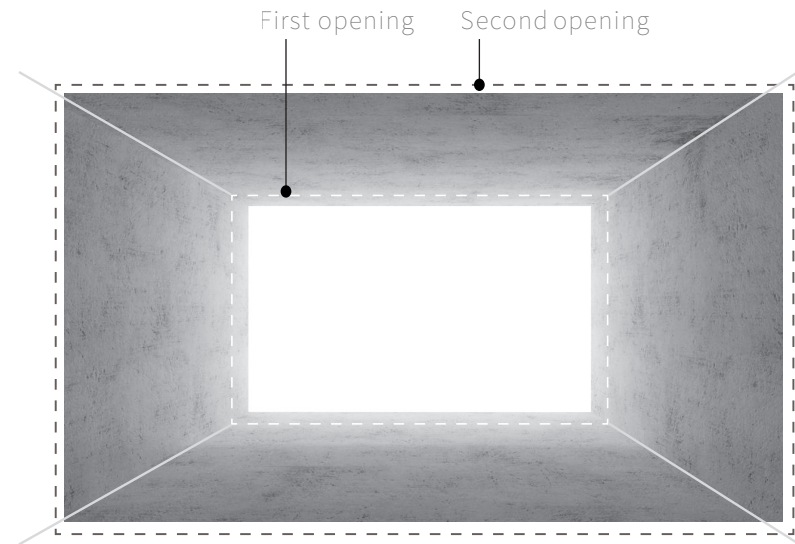
Physical structural attributes enforce direction on the incoming light. Strongly directing where and when light effects distinct parts of the space.

LIGHTING SYNTAX ELEMENT #1
THE UNOBSTRUCTED

Definition
Obstructed - prevent or hinder
Unobstructed - not obstructed



The point of this element is to stay out of the way of incoming light, allowing as much as possible to pass through providing strong illumination. The Unobstructed syntax element allows a full panorama of light and imagery. Observation is a key use of this space.



The first opening covers an entire partition, and the *light passage* is then determined by the characteristics of the surfaces of the entire room. The second opening in this syntax element becomes the other end of the room, or simply just negligible.

Lighting Syntax Element #2

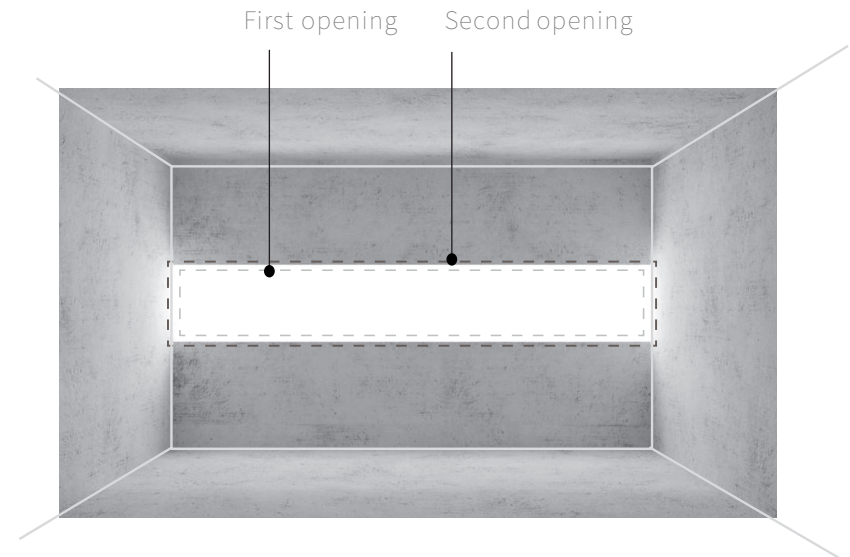
THE FRAMED

Definition

Frame - a rigid structure that surrounds or encloses something or in a specified direction.



By framing the light entering the structure, optical characteristics of the aperture gain focus.

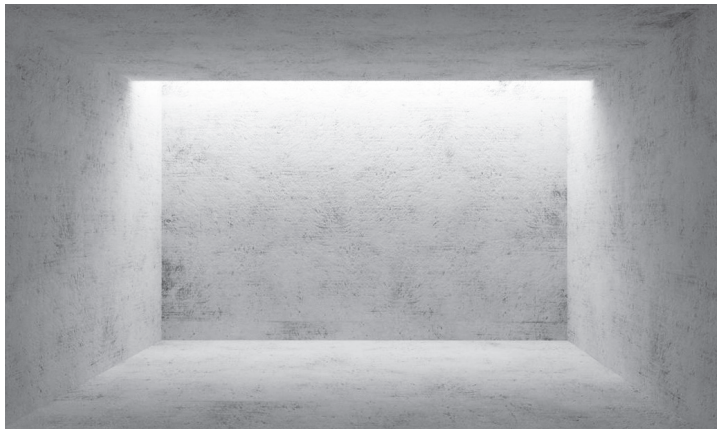


The first and second openings are in this syntax element close to each other and the *light passage* thereby becomes negligible. The aperture will be perceived as very bright and the surfaces adjacent to it will be perceived as dark due to the high level of contrast between the two.

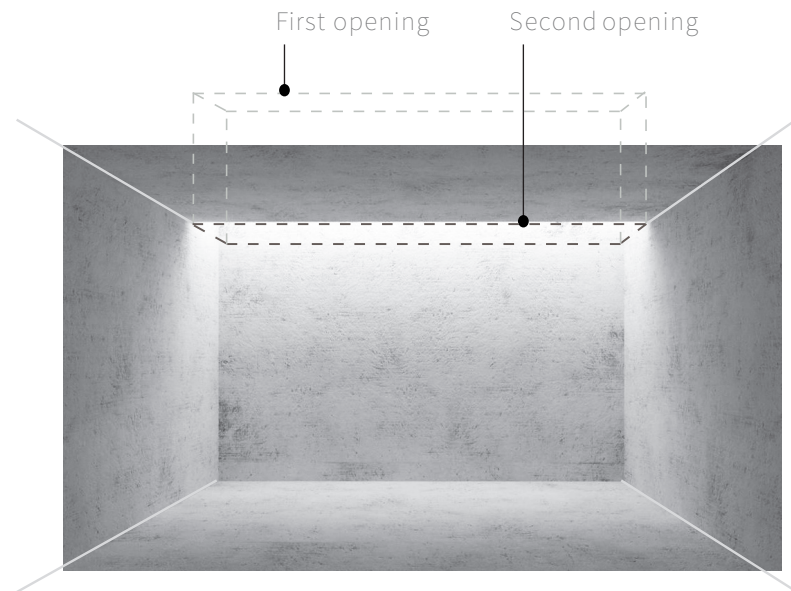
LIGHTING SYNTAX ELEMENT #3

THE CHANNELED

Definition
Channel- direct toward a particular end or object.



Rather than allowing light free access to the space within, it is channeled to hint at the unseen, awaken interest and provide spatial contrast.



The first opening in this syntax element is not visible to the observer. The journey that the light has to make, from the first opening into the *light passage* and finally reaching the room, defines the type of lighting effect on the interior surfaces adjacent to the second opening.

LIGHTING SYNTAX ELEMENT #4

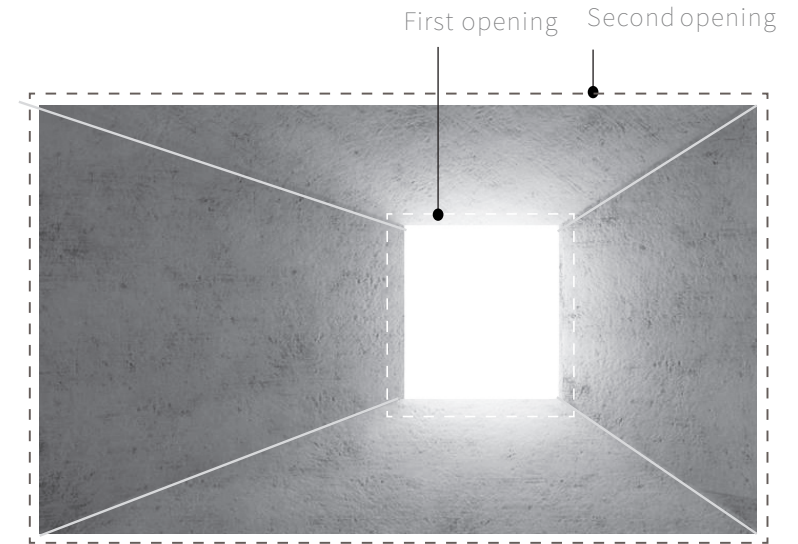
THE ANGLED

Definition

slant - slope or lean in a particular direction; diverge or cause to diverge from the vertical or horizontal.



Rather than traversing directly into a space, light is slanted in a controlled manner. This allows painting swathes of light on otherwise unlit surfaces.



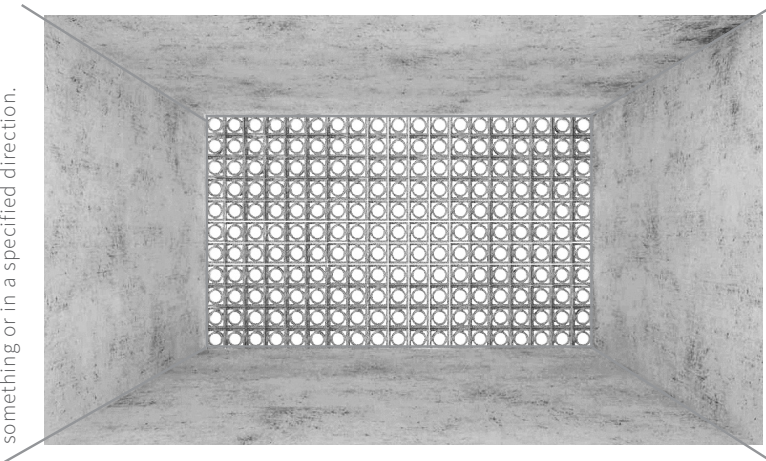
The first opening and the second opening in these elements are shifted away from each other creating an angled *light passage*. These slanted surface making up the passage are gradually lit by light traveling from the first to the second opening.

LIGHTING SYNTAX ELEMENT #5

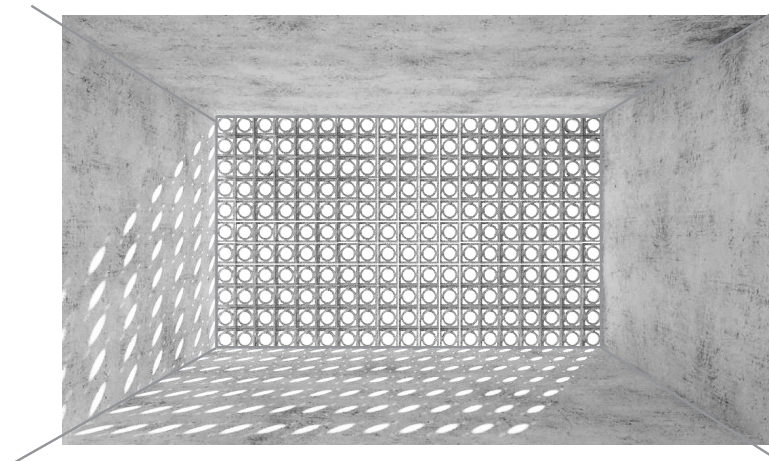
THE FILTERED

Definition

Filter - Move slowly or in small quantities or numbers through something or in a specified direction.



Sunlight is filtered physically, giving a rich pattern of light and shadow. Light is entering a room in a filtered manner, either trickled through a perforated partition or screen, or muffled by the passage through a coating or a film.

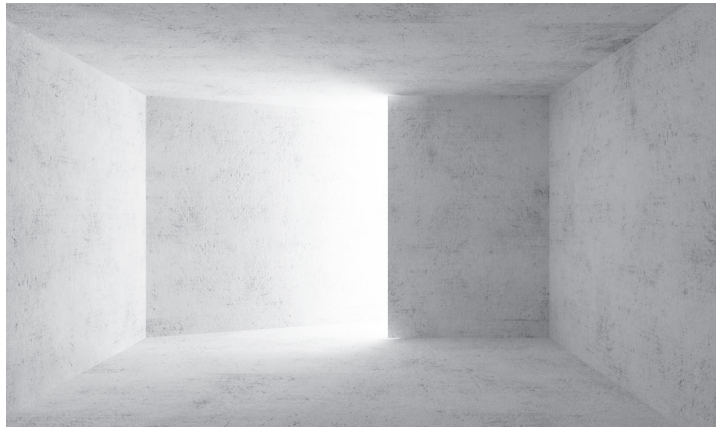


Light passing through a perforated partition is projected onto the surfaces of a room, generating a rich play of light and shadow, all defined by the geometry of the openings for each aperture, large or tiny. View is partly or largely blocked depending on the structure of the filter. Light passing through a coated surface is softened and generates a smoother lighting situation for the interior but blocking all view.

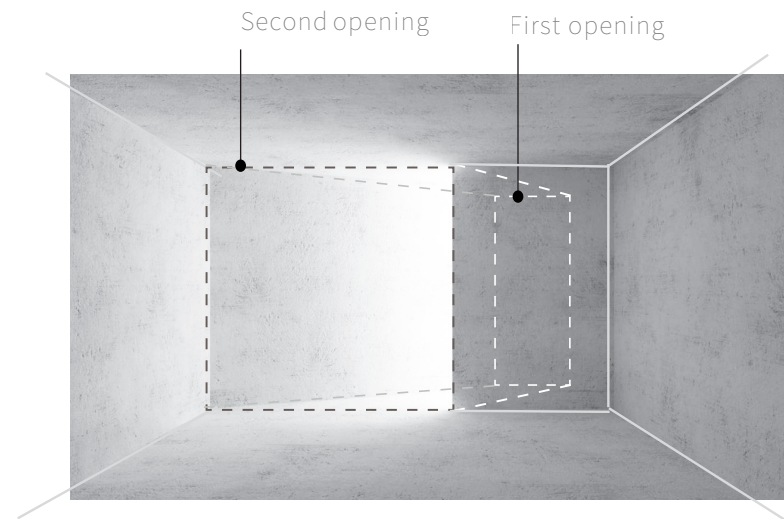
LIGHTING SYNTAX ELEMENT #6

THE DIRECTED

Definition
Direct - control the operations of;
manage or govern



Rather than allowing light free access to the space within, it is channeled to hint at the unseen, awaken interest and provide spatial contrast.



The first opening is shifted from the second and thereby directing light into a space in a controlled manner. Light can with this syntax element be either averted or conducted into a space to comply with desired spatial usage.



PART 2

A DAYLIGHT-TUNED DWELLING ON THE
ISLAND OF ST CROIX

Caribbean Sea





SITE

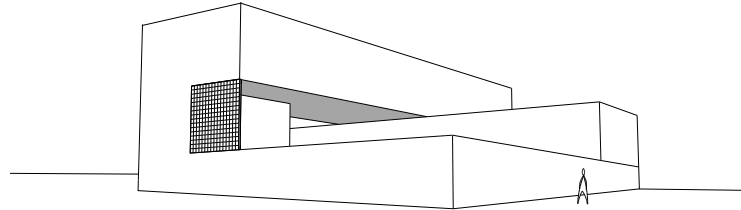
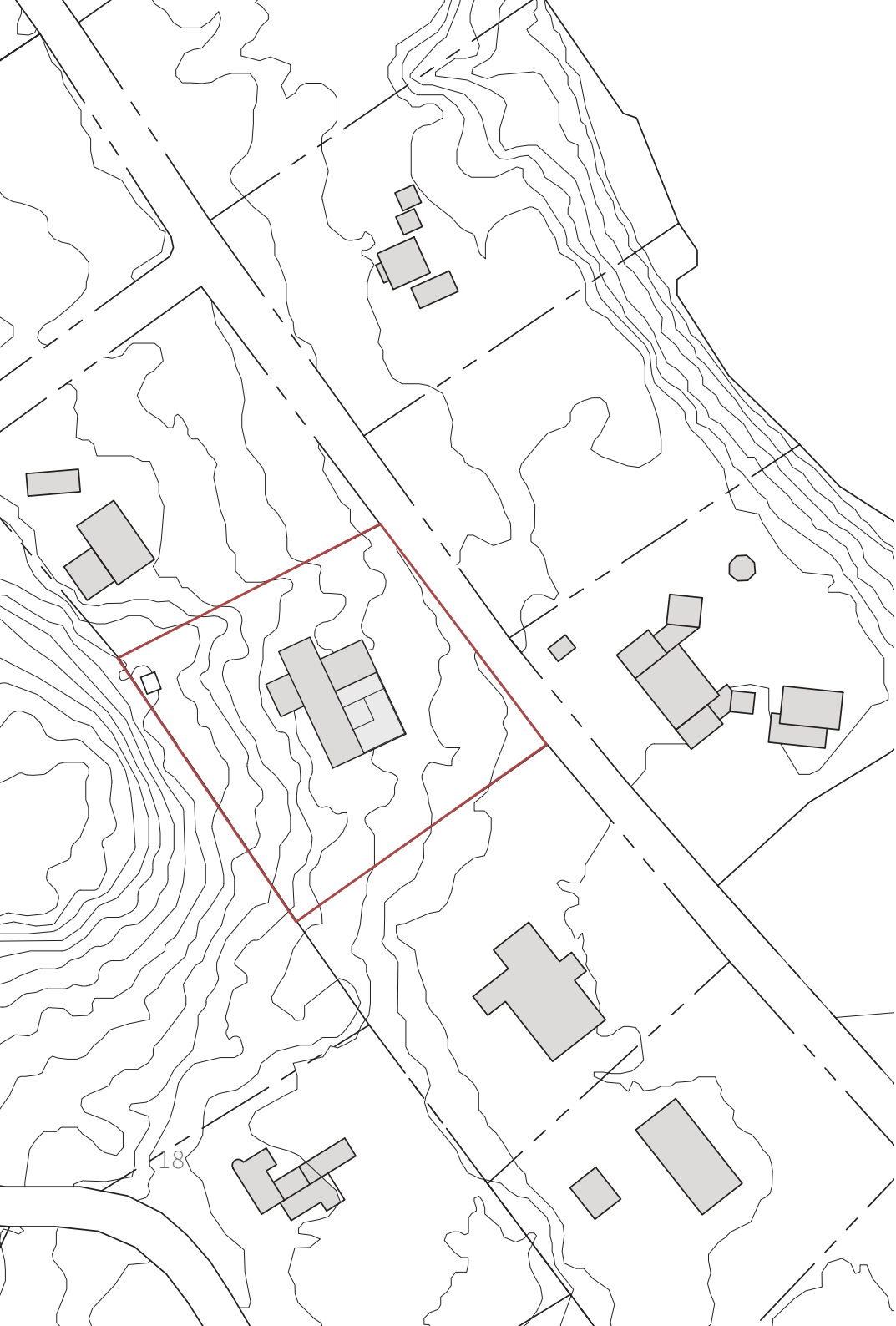
17.7397° N, 64.7389° W

*#80 Jeffersons Way
Judiths's Fancy, St Croix
US Virgin Islands*

The site is on a tropical island, where sun, wind and natural forces can be both friends and foes. The sun gives light and heat, desirable to some extent, but they also pose a threat in the way of too much heat and too much brightness to the eye. This building is oriented to offer welcoming light situations at all seasons, but with an optimal protection against heat. In this thesis the focus will be the use of daylight.

The most dominant natural element is the ever present ocean with all its special attributes, such as a continuous sound, winds from mainly one direction (north east) and a sunlight reflection that varies

greatly with the weather conditions. On the whole the oceans contribution to the lighting situation is considerable. The site is about one hundred meters from the ocean, with no natural obstructions. The elevation variation of the building site is 2,5 - 3 meters, which gives a good ocean view from the back of the site where the house will be placed. The site is open to sun and wind carrying sea salt, and this combination takes a great toll on all materials, something that has been taken into consideration in every detail. The building is designed to cooperate with the natural elements in the most effective way.



BUILDING HEIGHT

From JF Covenants 2014;

(1.) No building shall be constructed with a maximum roof height in excess of twenty-two (22') feet above the highest natural elevation of the plot as defined below.

(2.) The highest natural elevation of a plot shall be defined as the average elevation of the highest twenty percent of the undisturbed area of the lot. It is not intended that a spur or artificial anomaly shall determine the elevation.

27' is the average elevation of the highest twenty percent of the undisturbed area of the lot.

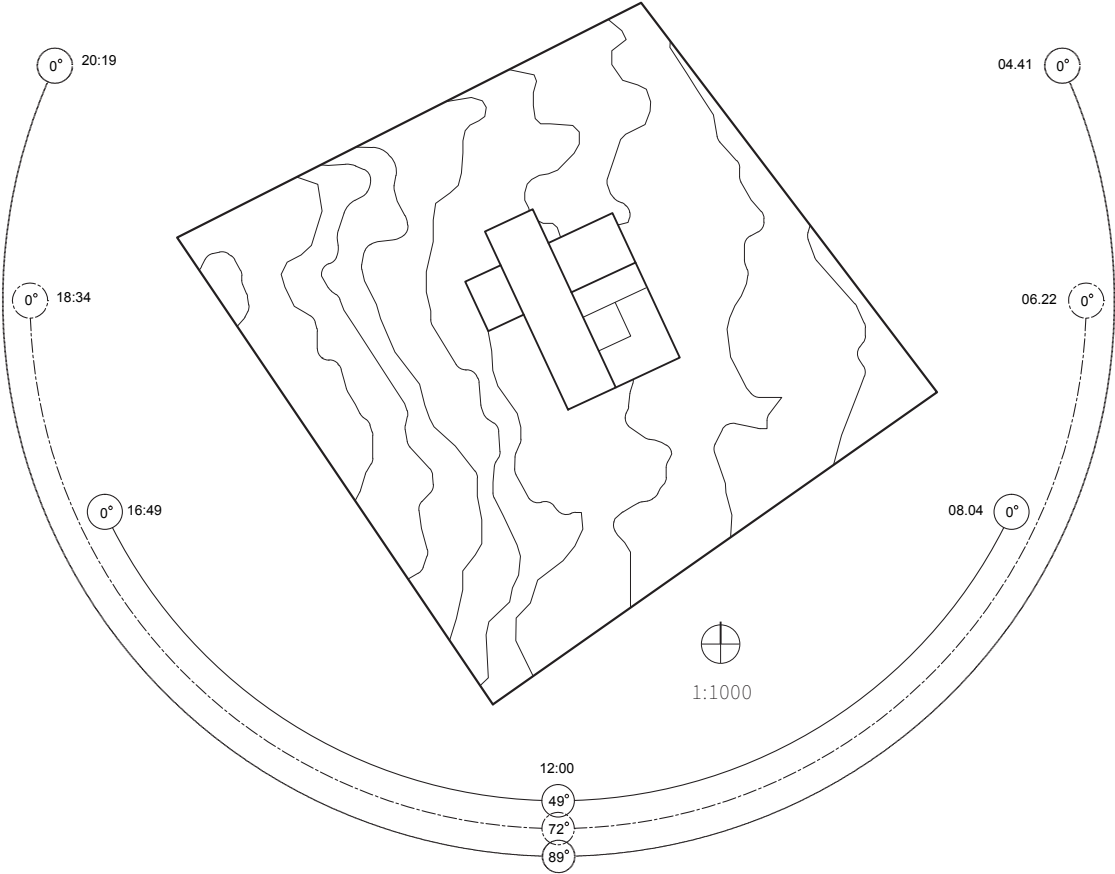
27'+22' = 49' ALLOWED HIGHT ABOVE SEA LEVEL



SUN PATH DIAGRAM

The three circle parts in this diagram shows the azimuth angle and the sun path from sunrise to sunset in summer-, spring and autumn and winter solstice. The smaller full circles illustrates the sun and tells the elevation angle at a sunrise, midday and sunset for each of the three paths.

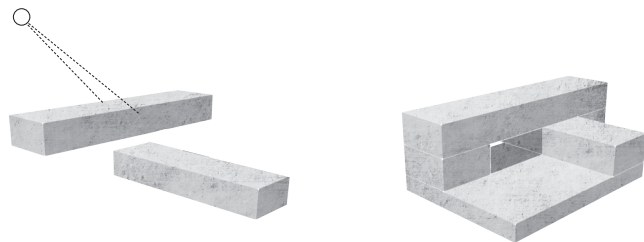
- 21 June ———— ○
- 21 March/Septeber - - - - ○
- 21 December ———— ○



THE FRAMEWORK

The structure developed in this project is intended as a framework or carrier for a number of fundamental natural lighting principles. These principles or ideas are basic syntax elements in a lighting language. This language is a method of expressing and implementing good lighting design with poetic artistry together with sound physical principles. The syntax elements are discussed in an earlier section of this thesis.

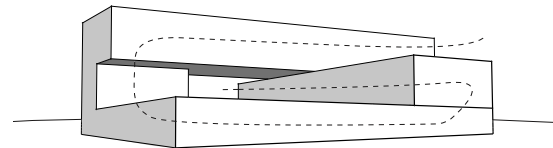
Incorporating the syntax elements in this framework creates a whole which is more than the sum of its parts. The intent is to create a structure that actual speaks intelligibly to dwellers, visitors and by-passers on both a sub-conscious and conscious



Narrow building volume to increase amount of daylight reaching the central parts. Careful orientation of the building on the site to optimize daylight penetration and shading of exterior living spaces.

level. The structure has been designed primarily for variable, medium term occupation with the flexibility to comfortably adapt for between 2 and 22 people. Through extensive use of the lighting syntax elements, functional and enjoyable levels of light and visually pleasing views are provided for all occupants and appropriately in all spaces. Providing a safe environment for people of all ages has been a priority.

The idea of safety includes many distinct and different aspects, among them, avoiding physical dangerous places and details, and providing protection from intrusion. In almost all cases good lighting is an important part of providing safety.

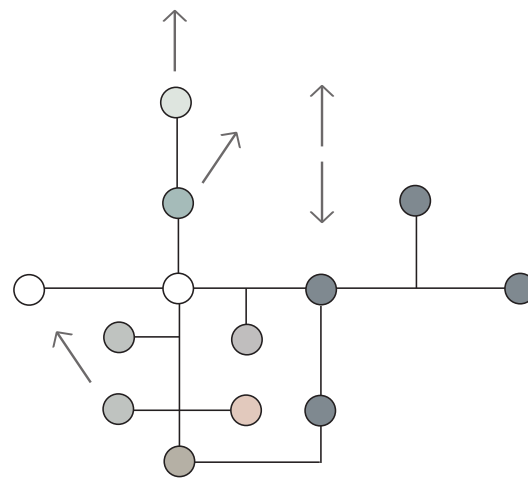
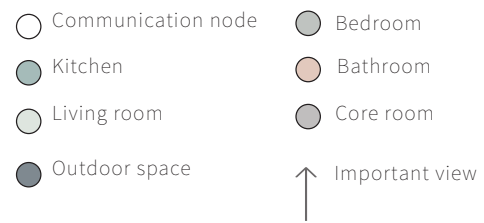




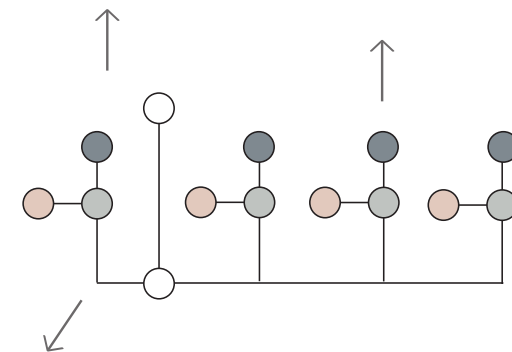
VIEW FROM JEFFERSONS WAY, JUDITHS FANCY, ST CROIX

SPACE SYNTAX MODEL

Space syntax model showing the spatial connections in a programmatic matter.



BOTTOM LEVEL

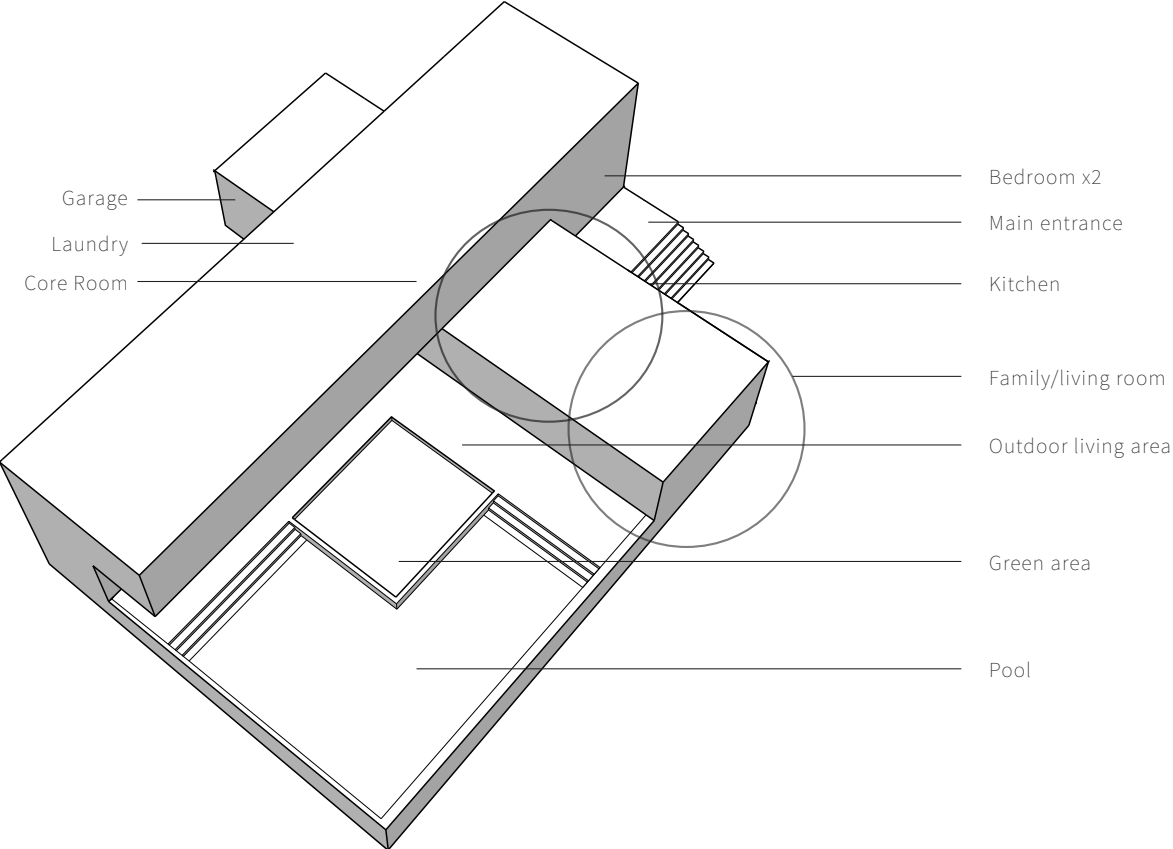


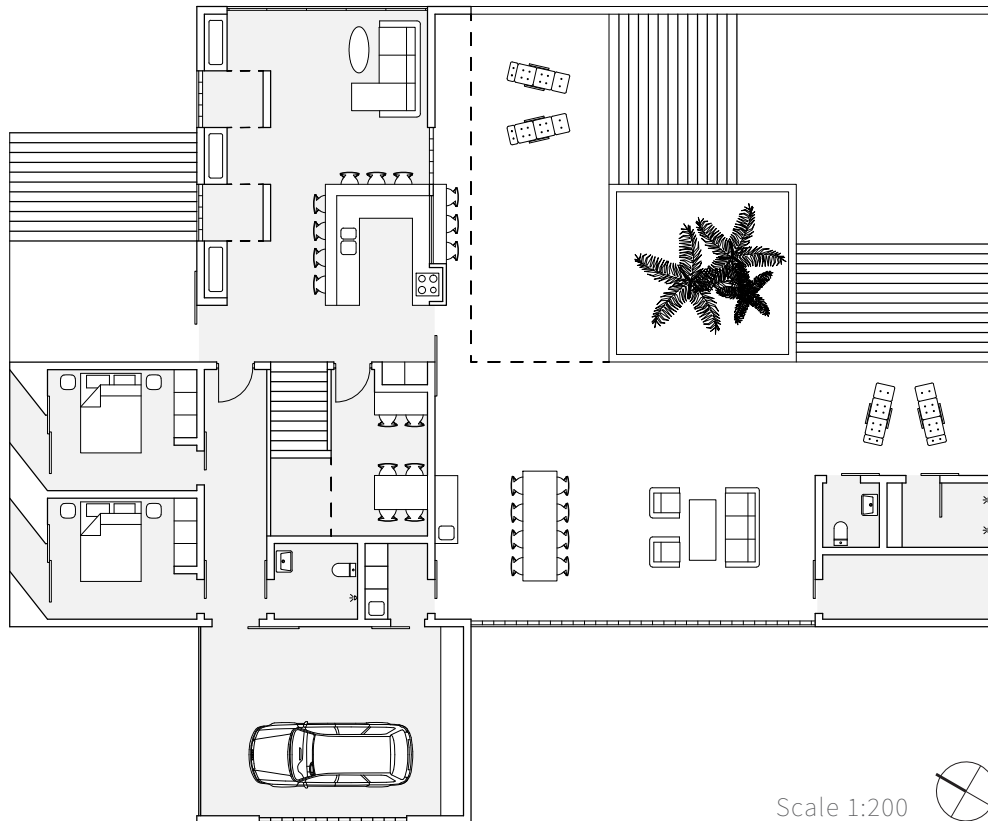
TOP LEVEL



SOUTH FACADE

BOTTOM LEVEL
Program



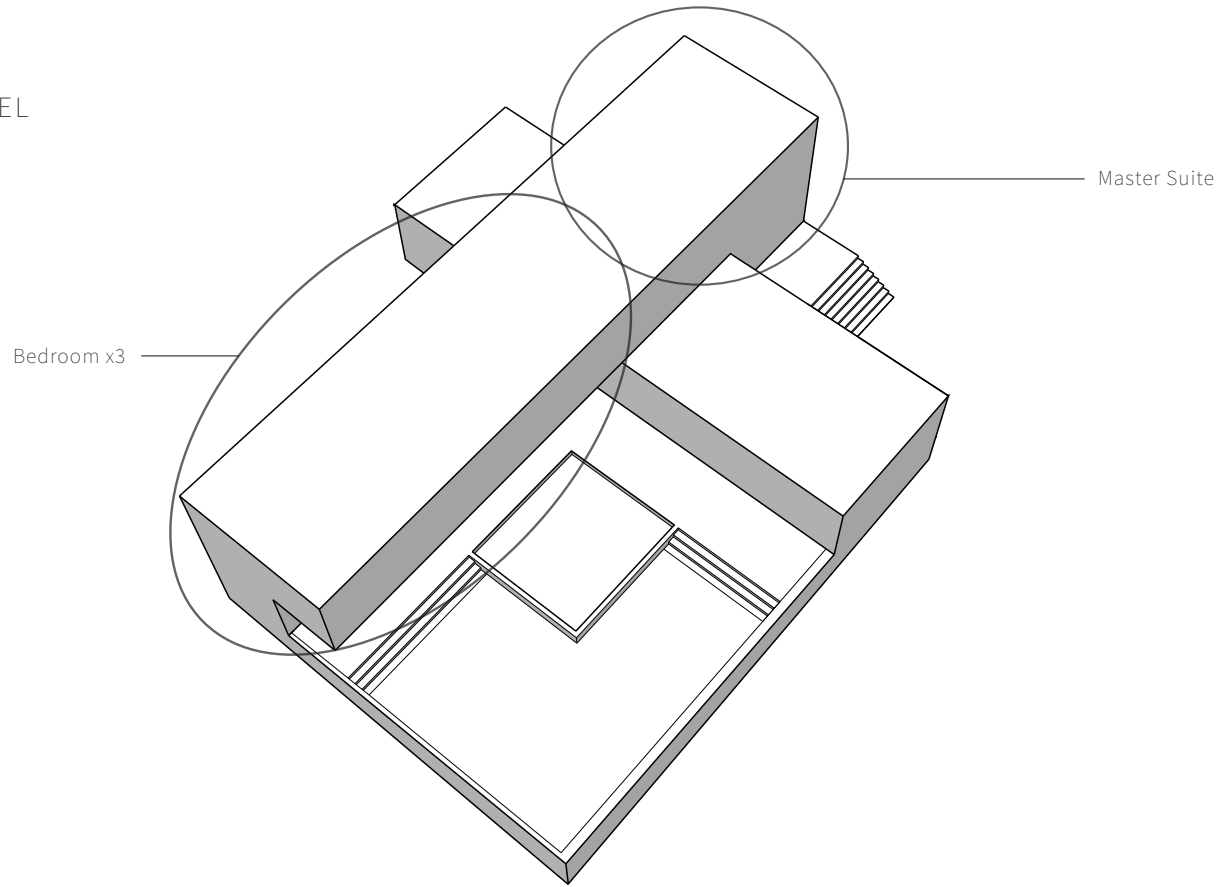


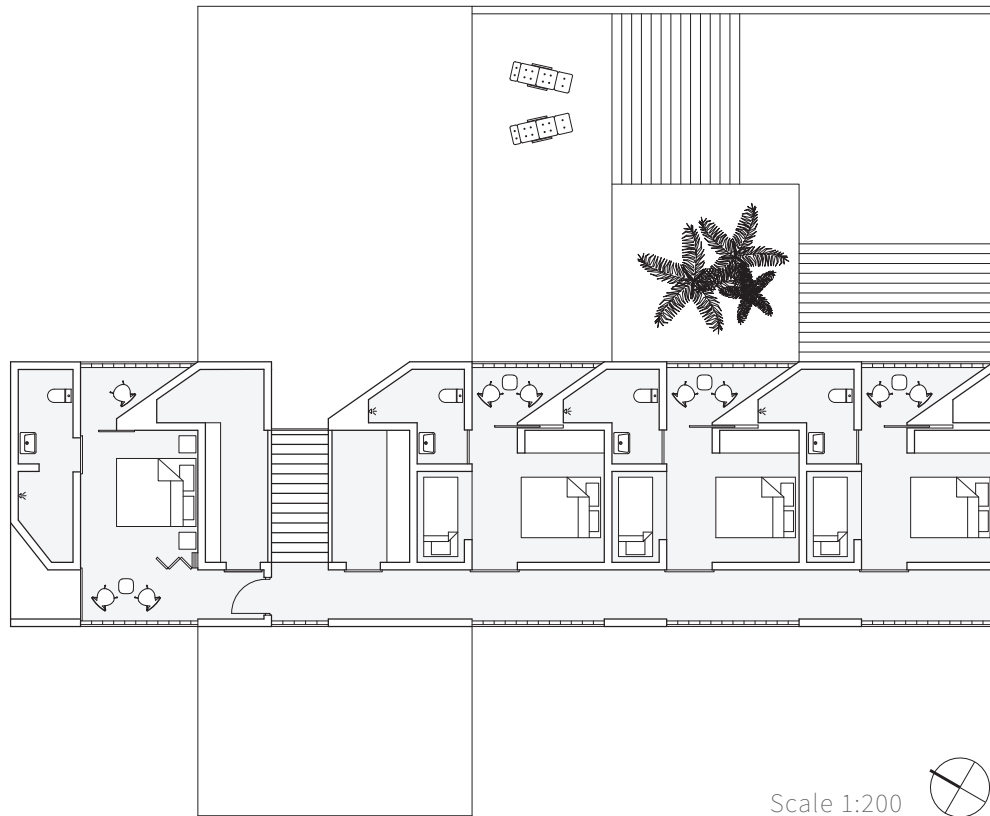
FLOOR PLAN (BOTTOM LEVEL)

The lower floor holds the main activity areas, such as kitchen, living room and dining area. Utility spaces with laundry, a garage and storage also include what we call a core room. This room is the only air conditioned room in the house. It is completely enclosed and provides protection from salt and humidity for electronically equipment. It can also be used as shelter in case of hurricanes. The building meets Swedish accessibility requirements. There is only one entrance door with a wide open stairway which provides good security.

This floor has two smaller bedrooms in the northern corner. These rooms have openings directed northeast to give ocean view but never direct sunlight.

TOP LEVEL
Program





FLOOR PLAN (TOP LEVEL)

The second floor has only bedrooms and some storage. Here the bedrooms have openings facing the ocean at such an angle that the rooms in daytime will always have enough light, but only controlled direct sun. This, in combination with ventilation through openings in the ceiling, will keep the bedrooms cool without air condition. The passway to the bedrooms along the back of the house has a wall of perforated blocks that lets in light and a cool breeze. The master suite is located in the northwest corner and has an ocean view as well as a view towards the west with a glimpse of the sunset. Bedrooms with second floor location also provides a more secure feeling.



VIEW FROM OUTDOOR AREA

Outdoor Area

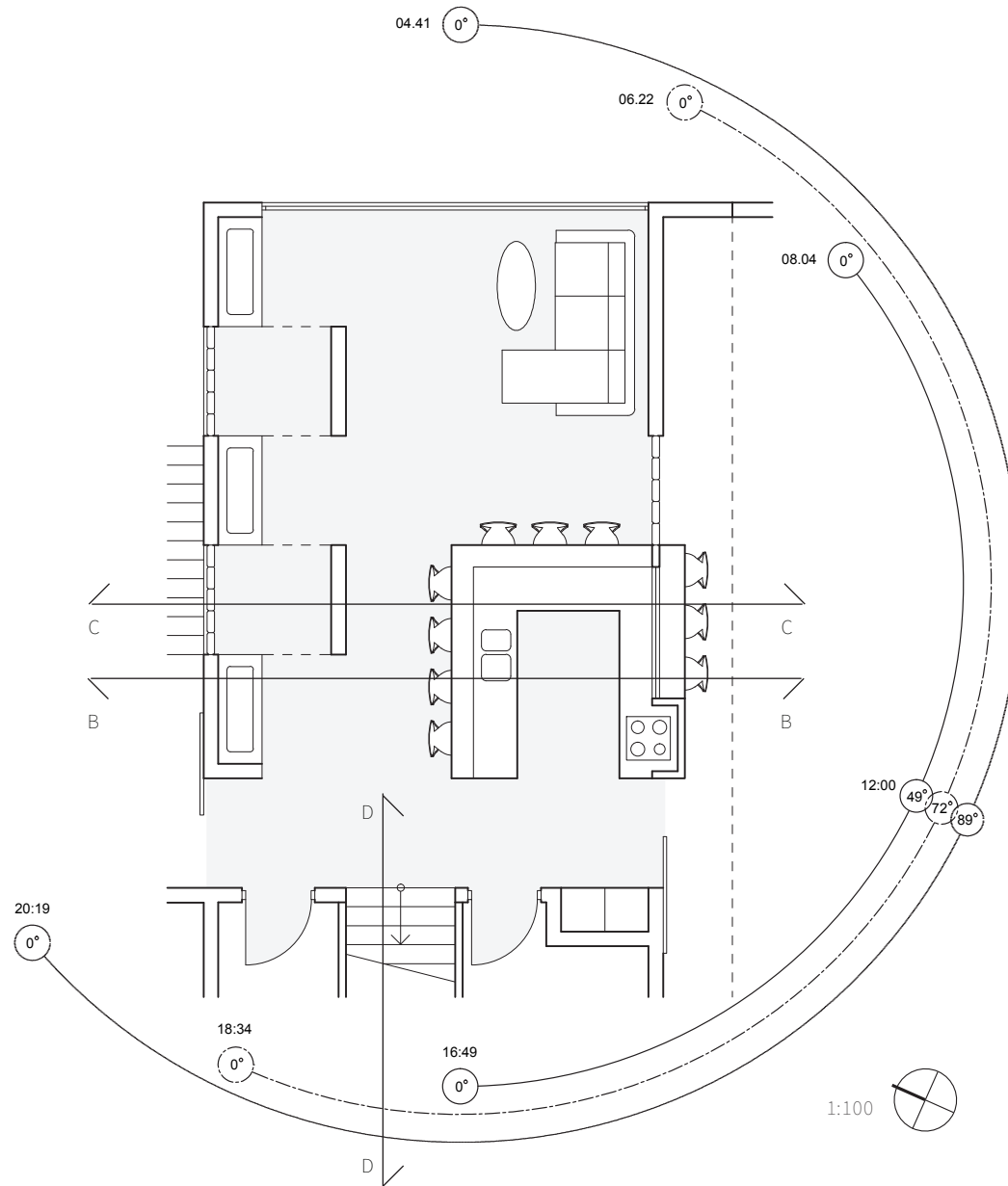
The open pool area is designed to always provide shade in some part. The back wall is open to let the ocean breeze flow through. A large part of the patio area is covered by a roof and is well suited for outdoor meals at any time of the day. The southern corner of the building holds a cabana bath with shower and toilet. The pool is accessed from two orthogonally placed wide staircases, which provides a choice for how the swimmer faces the sunlight and is affected by the reflections



NORTH FACADE

KITCHEN AND LIVING ROOM

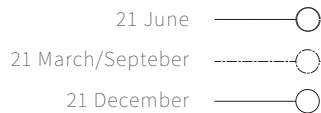
The large main room on the bottom level is a multifunctional space designed to house many people and many different activities at the same time. The kitchen has large and well lit working surfaces and provides interaction between indoor and outdoor environments.



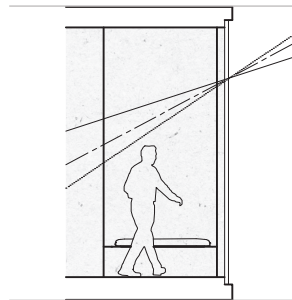
L-S-E IMPLEMENTATIONS FOR KITCHEN AND LIVING ROOM

INCIDENT ANGLE

The three lines in these diagrams show the path of a light beam hitting an opening with the angle of summer, spring/autumn and winter sun. The dotted line illustrates the incident angle of the summer sun, the dashed shows the incident angle of the spring/autumn sun and the solid line shows the incident angle of the winter sun.



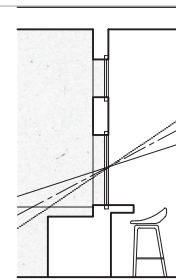
LIGHTING SYNTAX ELEMENT #1
UNOBSTRUCTED



VIEW

The Unobstructed syntax element allows a full panorama of light and imagery. Observation is a key of this space.

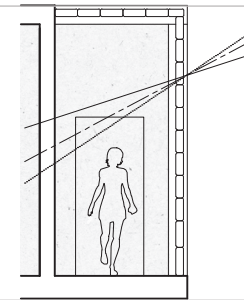
LIGHTING SYNTAX ELEMENT #2
FRAMED



COOK, LOOK AND CHAT

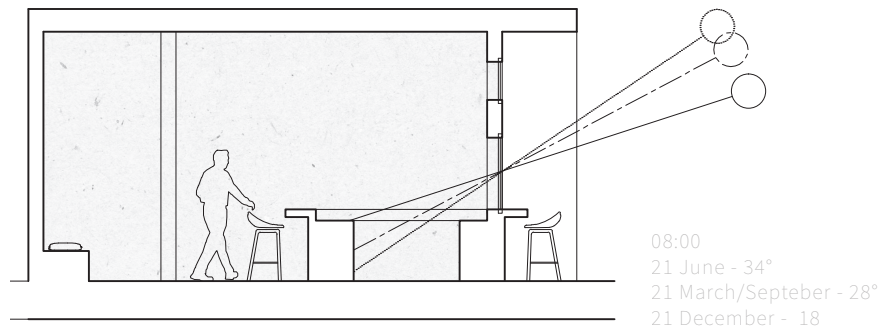
The Framed syntax element highlights edges and views in parallel, providing a space for work and lighter conversation.

LIGHTING SYNTAX ELEMENT #5
FILTERED



BREEZE WAY

The Filtered syntax element fills the breeze way space with light and shadow. This creates a space for so distinctly different uses as transition and reflection, movement and stillness.

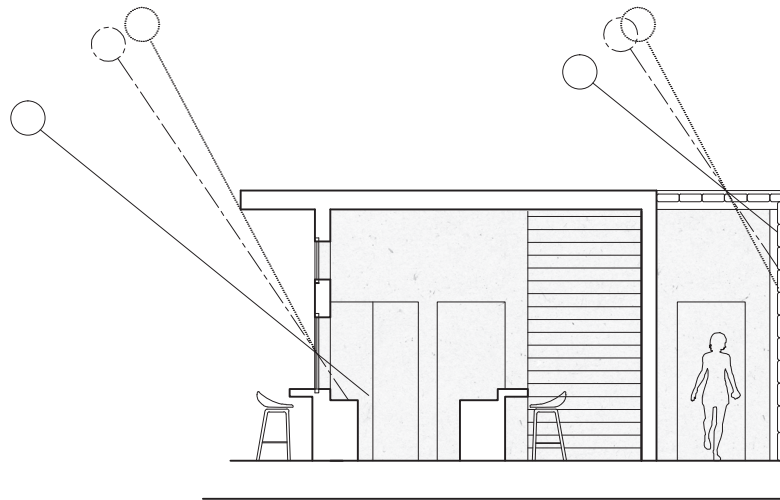


SECTION B-B SCALE 1:100

The eastern wall is fully glazed providing a beautiful view and allowing light to unobstructedly enter the room. In the morning, direct light is fills the part of the room nearest the opening and generates a spatial differentiation between the different areas of the multifunctional space. The kitchen area will be perceived as bright but will not be hit by direct sun light, allowing for preparing and having breakfast in the shade.



KITCHEN AND LIVINGROOM - 21 SEPTEMBER/MARCH 06:45



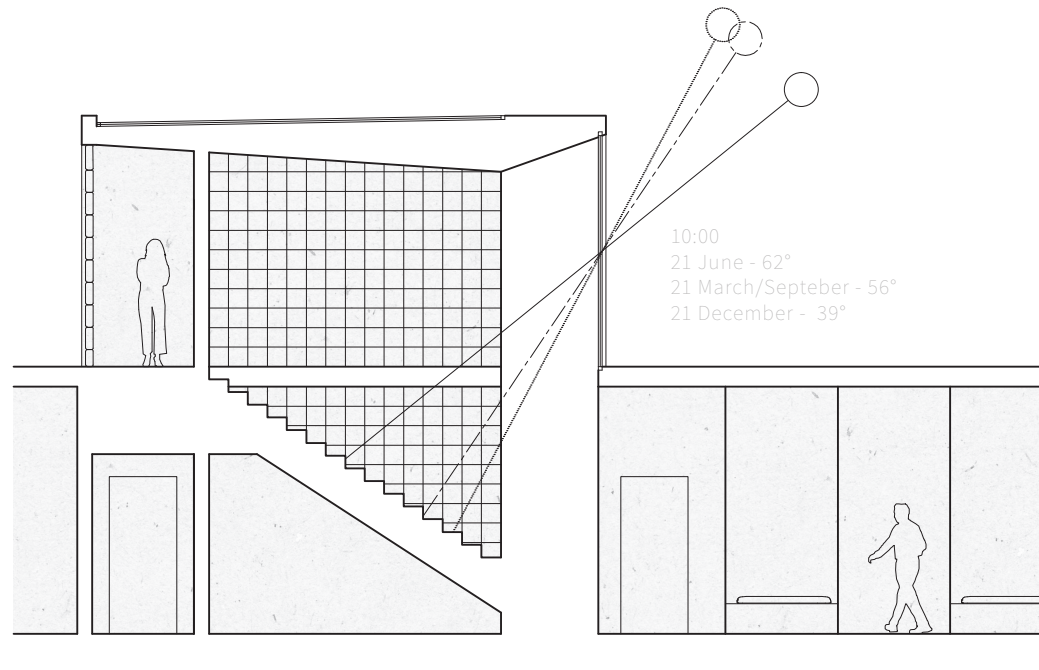
10:00
21 June - 62°
21 March/September - 56°
21 December - 39°

SECTION C-C SCALE 1:100

The kitchen is partly indoor and partly outdoor. Its westward wall and the outermost 1,5 meters of the roof consists of harmonically shaped penetrated concrete blocks. This creates a breeze way and also a pleasant light and shadow pattern varying with seasons.



KITCHEN AND LIVINGROOM - 21 SEPTEMBER/MARCH 08:00

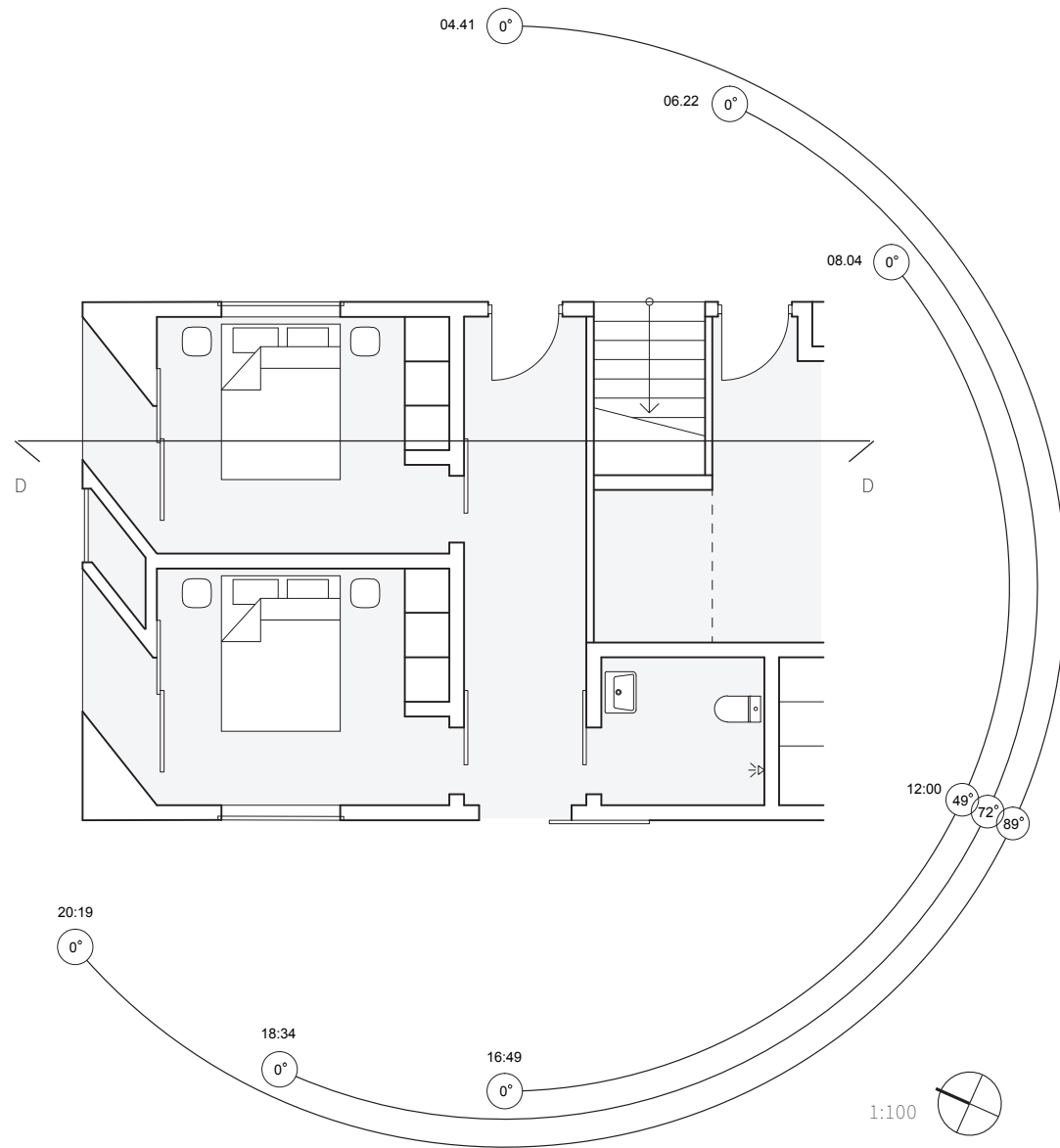


SECTION D-D SCALE 1:100



VIEW FROM KITCHEN TOWARDS THE MAIN ENTRANCE - 21 SEPTEMBER/MARCH 10:00

ATRIUM AND BEDROOM (BL)



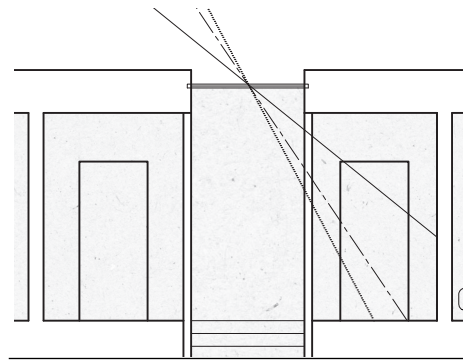
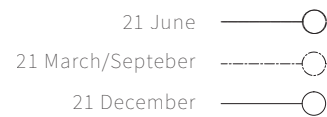
L-S-E IMPLEMENTATIONS FOR ATRIUM AND BEDROOM (BL)

LIGHTING SYNTAX ELEMENT #4 CHANNELED

LIGHTING SYNTAX ELEMENT #5 DIRECTED

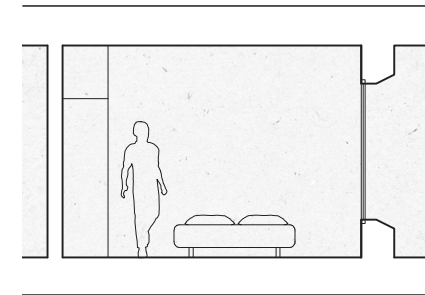
INCIDENT ANGLE

The three lines in these diagrams show the path of a light beam hitting an opening with the angle of summer, spring/autumn and winter sun. The dotted line illustrates the incident angle of the summer sun, the dashed shows the incident angle for spring/autumn sun and the solid line shows the incident angle of the winter sun.



SECTION D-D (SECOND FLOOR) SCALE 1:100

Rather than allowing light free access to the space within, it is channeled to hint at the unseen, awaken interest and provide spatial contrast. (Atrium)



SECTION D-D (FIRST FLOOR) SCALE 1:100

Rather than traversing directly into a space, light is forced in a different, controlled direction, averted to where it is needed. (Bedroom (BL))



ATRIUM AND STAIR - 21 SEPTEMBER/MARCH 10:30

ATRIUM AND STAIR

The point from where the stairs to the second floor start is the central node from which most of the rooms can be accessed. The passage to the second floor is a staircase given light from above as well as from both sides. The walls around the staircase consist of glass blocks, and the roof is a fixed glass window. The glass blocks also enables light to come through to the storage space and to the enclosed core room. The atrium area serves as a light collecting node in the deepest and darkest part of the building. Seen from the kitchen it gives reflected light, varying throughout the day and season depending on the infall of sunlight.

BEDROOM (BL)

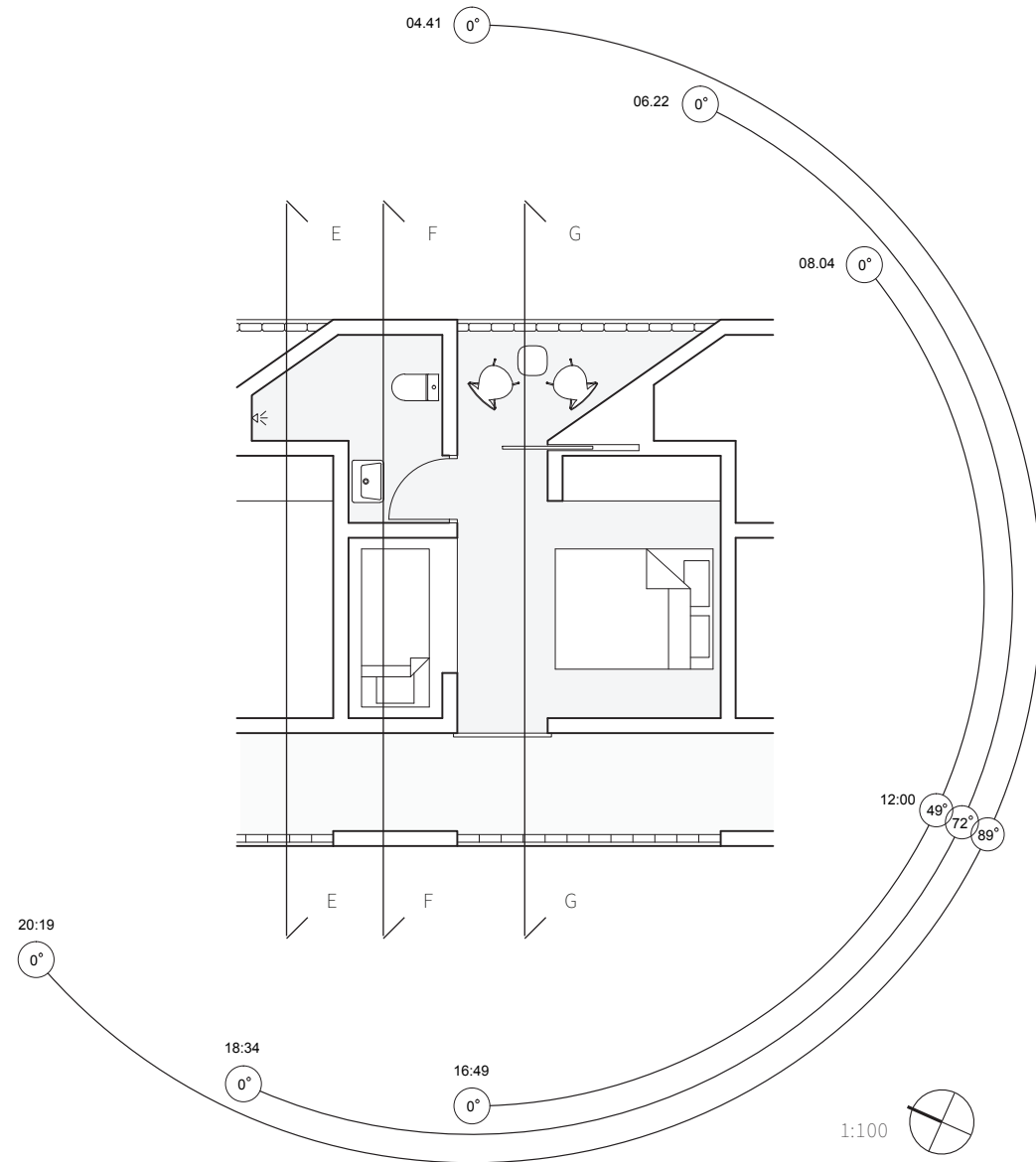
The bedrooms on the bottom level are situated on the north side of the building. Both have one large north facing window each and one high, horizontal opening on the east and west sides respectively. Due to the placement of the large window to the north the incoming light is limited, providing a protected space within the structure. The view is directed towards the ocean and at the same time insight from the neighboring driveway and house is avoided. The limited size of the high horizontal opening gives a sense of protection and solitude to the room but still provides sufficient light throughout the day.



BEDROOM BL - 21 SEPTEMBER/MARCH 06:45

BEDROOM X3 (TL)

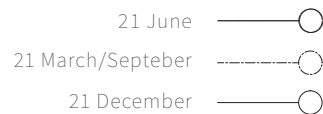
Each of the three bedroom on the top level are designed to provide space for rest. They are laid out to provide a place to withdraw and to find stillness. The glass balcony door supplies an extravagant view but the formation of the aperture still gives a sense of detachment. It gives the user a freedom to look out but not be exposed.



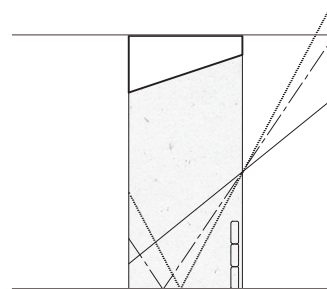
L-S-E IMPLEMENTATIONS FOR BEDROOM X3 (TL)

INCIDENT ANGLE

The three lines in these diagrams show the path of a light beam hitting an opening with the angle of summer, spring/autumn and winter sun. The dotted line illustrates the incident angle of the summer sun, the dashed shows the incident angle for spring/autumn sun and the solid line shows the incident angle of the winter sun.



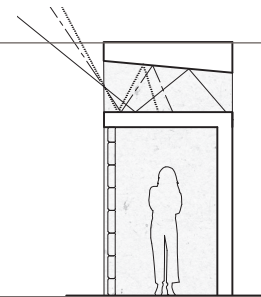
LIGHTING SYNTAX ELEMENT #3
SLANTED



BALCONY OPENING

The Directed syntax element controls the timing and positioning of the access of light to the bedroom within. This provides fascinating variation and a smooth introduction to morning light.

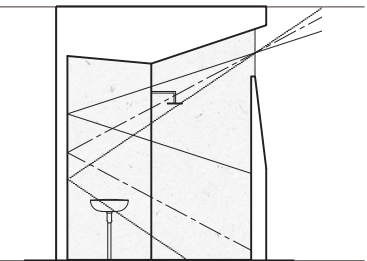
LIGHTING SYNTAX ELEMENT #4
CHANNELED



UPPER SHAFT

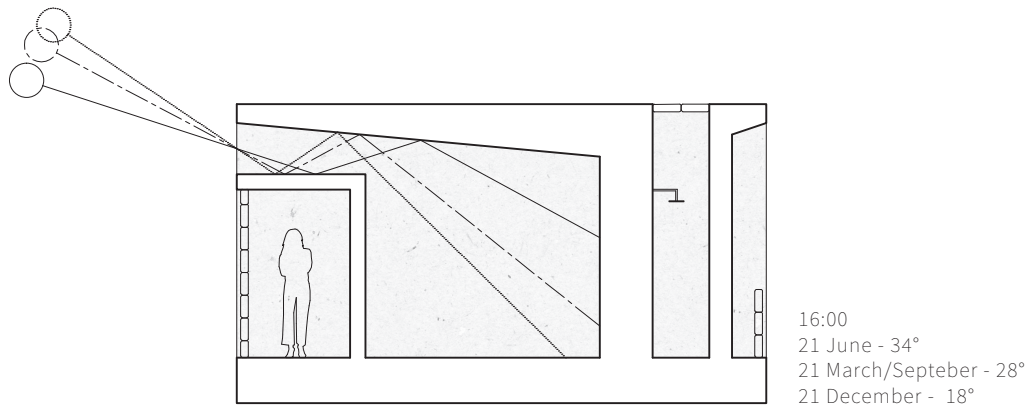
The Travelled syntax element dampens light from a fiery midday sun and yet allows a fading sun access to the inner core of the bedroom.

LIGHTING SYNTAX ELEMENT #6
DIRECTED



BATHROOM BEND

The Averted syntax element forces incoming light in an indirect manner into a small space. This avoids strong direct light and yet fully illuminates the room.

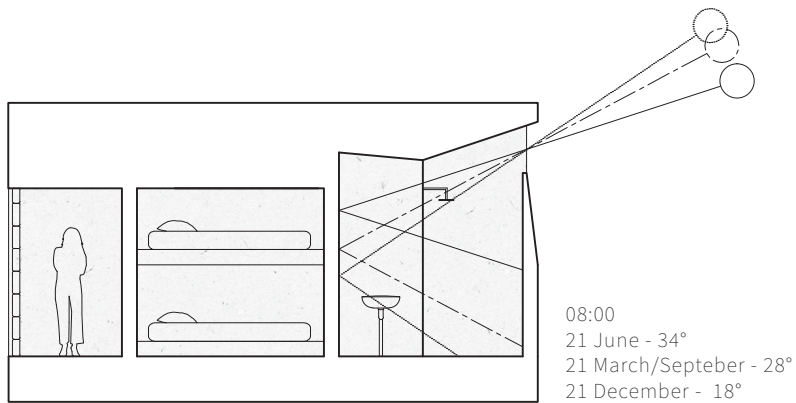


SECTION E-E SCALE 1:100

The upper shaft is channeling light into the room, blocking the harsh, hot and direct south western light hitting the upper level through out the afternoon hours. The light is reflected and redirected several times before it finally reaches the interior, providing light but much less heat. The low angle of the sun in late afternoons and evenings, especially during winter time, lets some direct light pass through that generates a decorative projection on the wall of the opposite side of the room.

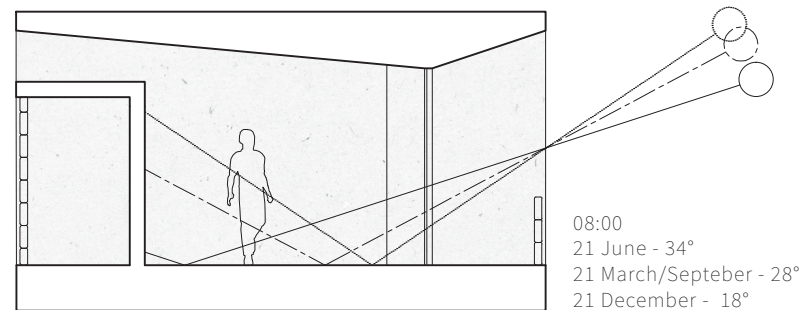


BEDROOM - MARCH/SEPTEMBER 21 13:30



SECTION F-F SCALE 1:100

The orientation of the bathrooms enables the high openings in the outer walls to fill the room with light but avert from heating beams. The room will during the rest of the day be provided with sufficient indirect light.



SECTION G-G SCALE 1:100

The balcony is oriented towards east. This means that the bedrooms will be flooded by morning light, but directed so that it will not hit the beds. The room will be perceived as bright and the higher levels of brightness could then work as a built in wakeup call, enabling the users to rise at sunrise and thereby live in harmony with the natural rhythms of life.

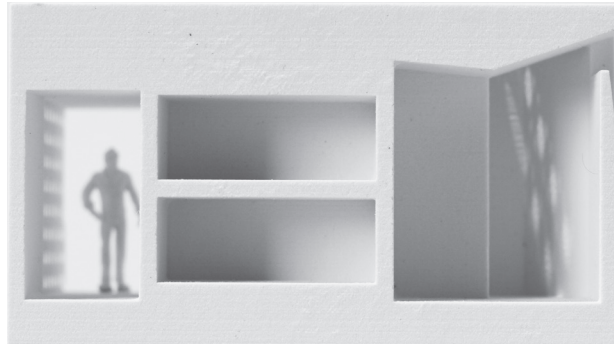


BEDROOM - JUNE 21 07:30



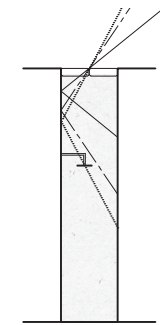
LIGHTING EFFECT OF BATHROOM CEILING WINDOW
12:50 SEPTEMBER

Each bedroom has a bathroom with a shower area with penetrated blocks in the ceiling. This provides free fall for light as well as rainwater. The sunlight moves along throughout the day creating a living pattern. When the cool rain



SECTION MODEL SCALE 1:100

falls the sunlight hitting the drops may even give a small rainbow, adding to the feeling of closeness with nature.



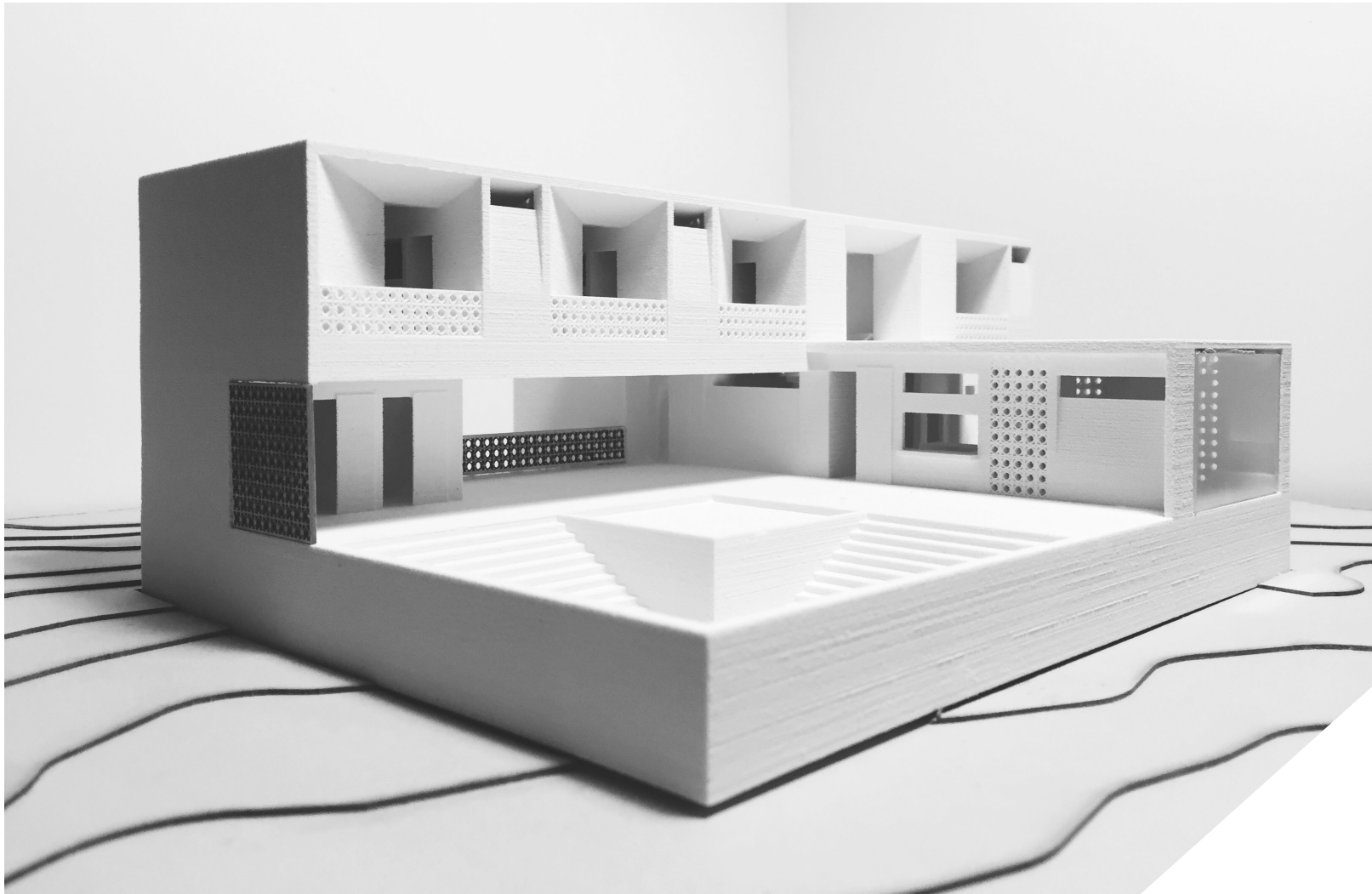
FREE FALL DETAIL



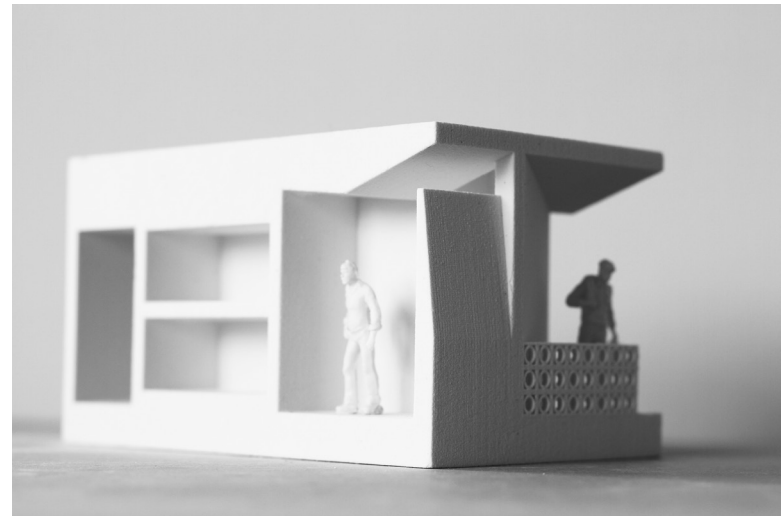
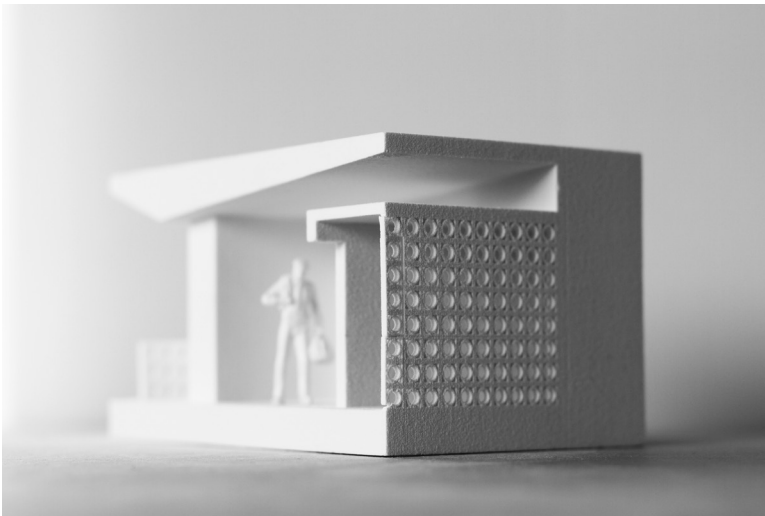
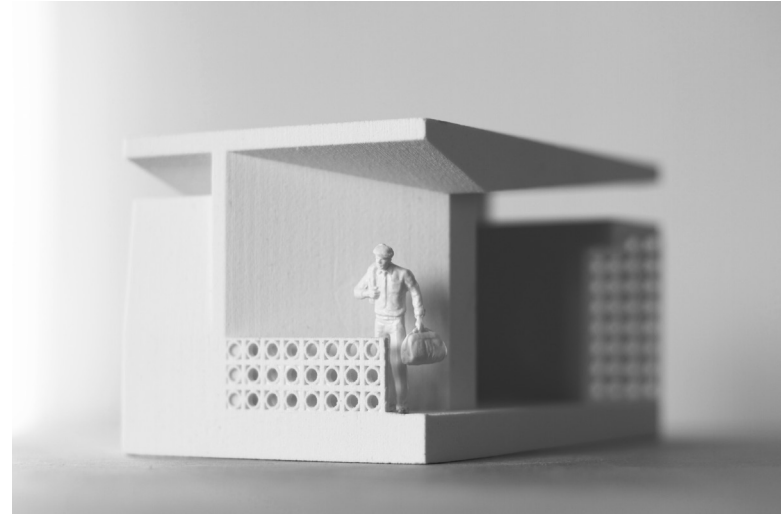
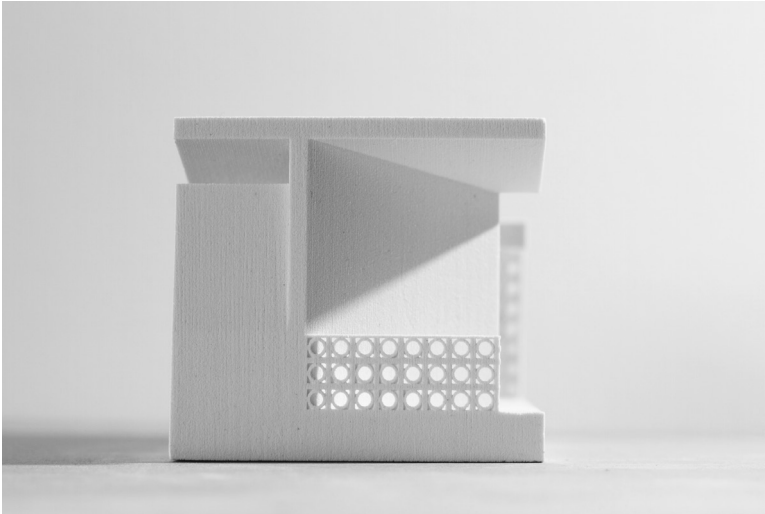
BEDROOM - DECEMBER 21 17:30



MODEL IMAGES



THE HOUSE. 3D-PRINT, PLASTER MODEL. SCALE 1:100
52



BEDROOM SECTION. 3D-PRINT, PLASTER MODEL. SCALE 1:50

