

A Synthesis of Geometry and Light

Prakhyaa Mukesh Jain

Thesis submitted to the faculty of Virginia Polytechnic Institute and State University in
partial fulfillment of the requirement for the degree of

Master of Architecture

Steven R. Thompson
Committee Chair

James R. Jones

Howard S. Gartner

December 1, 2020
Blacksburg, VA

Keywords

Contemplation, Geometric Transformation, Light, Cube, Cone, Sun Path

A Synthesis of Geometry and Light

Prakhyaa Mukesh Jain

Abstract

The poetics of an architecture of a moment is explored through design of a contemplative room (wherein the geometric transformation of a cubic base to a cone) demonstrates the rhythm and proportion of the construction of the room and the relative motion of the sun in the space. The relationship of the sun rays on the walls of the room passing through a reflecting pool are shown using demonstrative and constructive means of descriptive geometry as both the design generator and poetic expression. The composition of the buildings reveals the play of light on form.

A Synthesis of Geometry and Light

Prakhyaa Mukesh Jain

General Audience Abstract

An exploration to understand the relationship of architecture and the material sensible world. The work seeks to reveal that through the tangible architectural strategies of form, structure, material and light, the intangible qualities of architecture are defined.

Table of Contents

Introduction	1
Studies	2
List of Figures	41
Bibliography	42

Introduction

“The Ultimate meaning of any building is beyond architecture; it directs our consciousness back to the world and towards our own sense of self and being” Juhani Pallasama.

When I started the thesis year, I wanted to explore the relationship of architecture and the material sensible world. I explored individual senses such as sight, sound and touch. The drawings are limited in doing that. Only the presence of a building can offer this. While at the Steger Center for International Scholarship in Riva San Vitale in Switzerland for the final semester, visits to buildings like Convent Sainte-Marie de la Tourette, Notre-Dame du Haut, in western France; Church of San Giovanni Battista in Mogno Switzerland; Basilica de la Sagrada Familia and Casa Mila in Barcelona helped me realize that I have to experience it first hand.

“A great building must begin with the unmeasurable, must go through the measurable means when it is being designed and in the end must be unmeasurable.” Louis Kahn.

The work seeks to reveal that through the tangible architectural strategies of form, structure, material and light, the intangible qualities of architecture are defined.

The poetics of an architecture of a moment is explored through design of a contemplative room (wherein the geometric transformation of a cubic base to a cone) demonstrates the rhythm and proportion of the construction of the room and the relative motion of the sun in the space. The relationship of the sun rays on the walls of the room passing through a reflecting pool are shown using demonstrative and constructive means of descriptive geometry as both the design generator and poetic expression.

The composition of the buildings reveals the play of light on form. The interplay of geometry and light occurs when walking down the ramp experiencing the transparent glass container wrapping the stone conoid and when light reveals the geometric transformation of the cubic base to a truncated cone in the contemplative room. The contemplative room reveals the more universal geometry of the sun's course throughout the seasons and throughout the day.



Figure 1

In the aerial view of the site, the universal geometry of the sun in its course setting at the end of the day is captured.

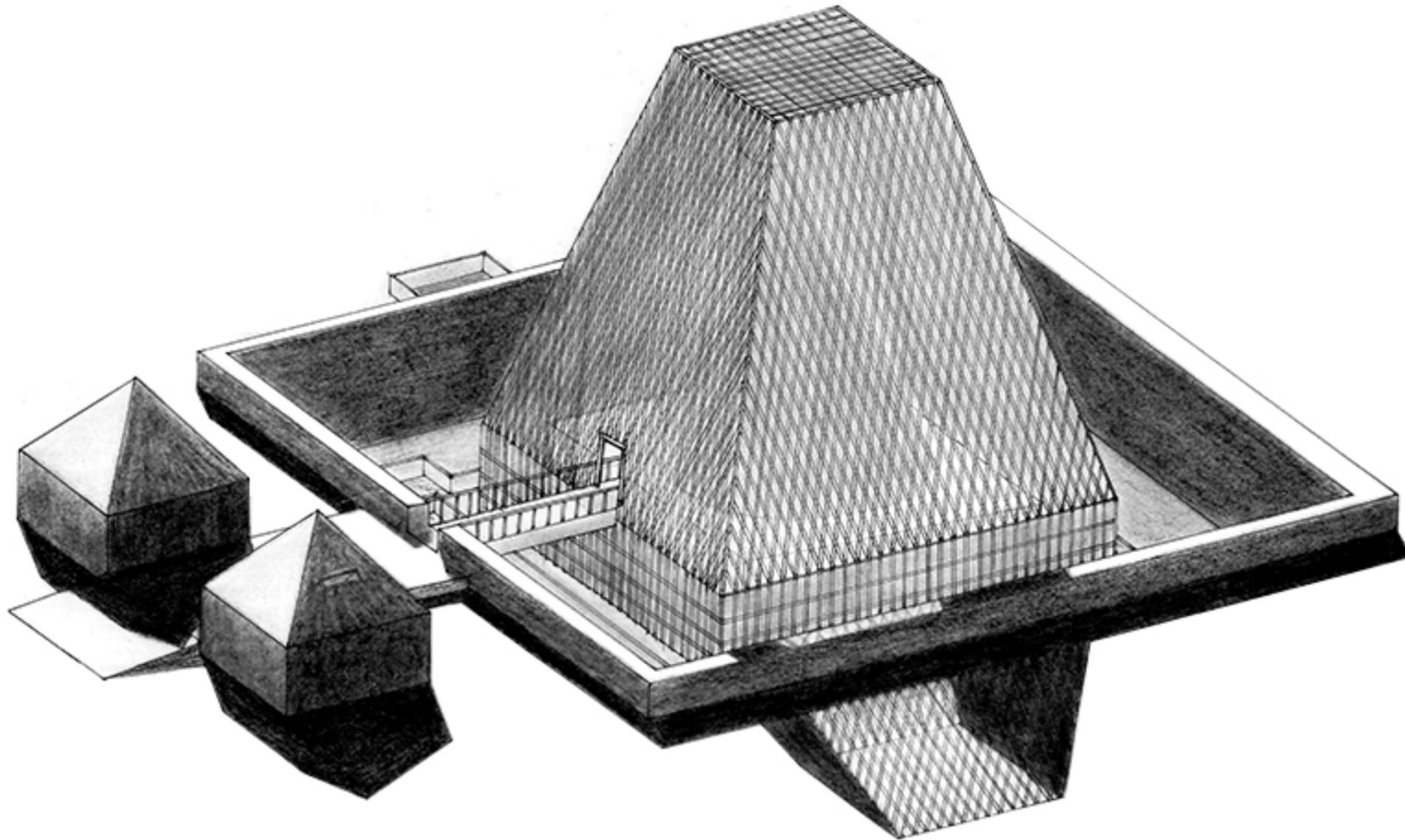


Figure 2

Architecture is the masterly, correct and magnificent play of masses brought together in light - Le Corbusier.

The architecture is perceived as a composition of geometric masses. The play of geometry as light interacts with it through light, shadow and contrast is going to reveal the geometry of the building. Descriptive geometry is instrumental to project the overall form: an earthly cubic base projects upward transforming into a conical form tending toward the spiritual realm.



Figure 3

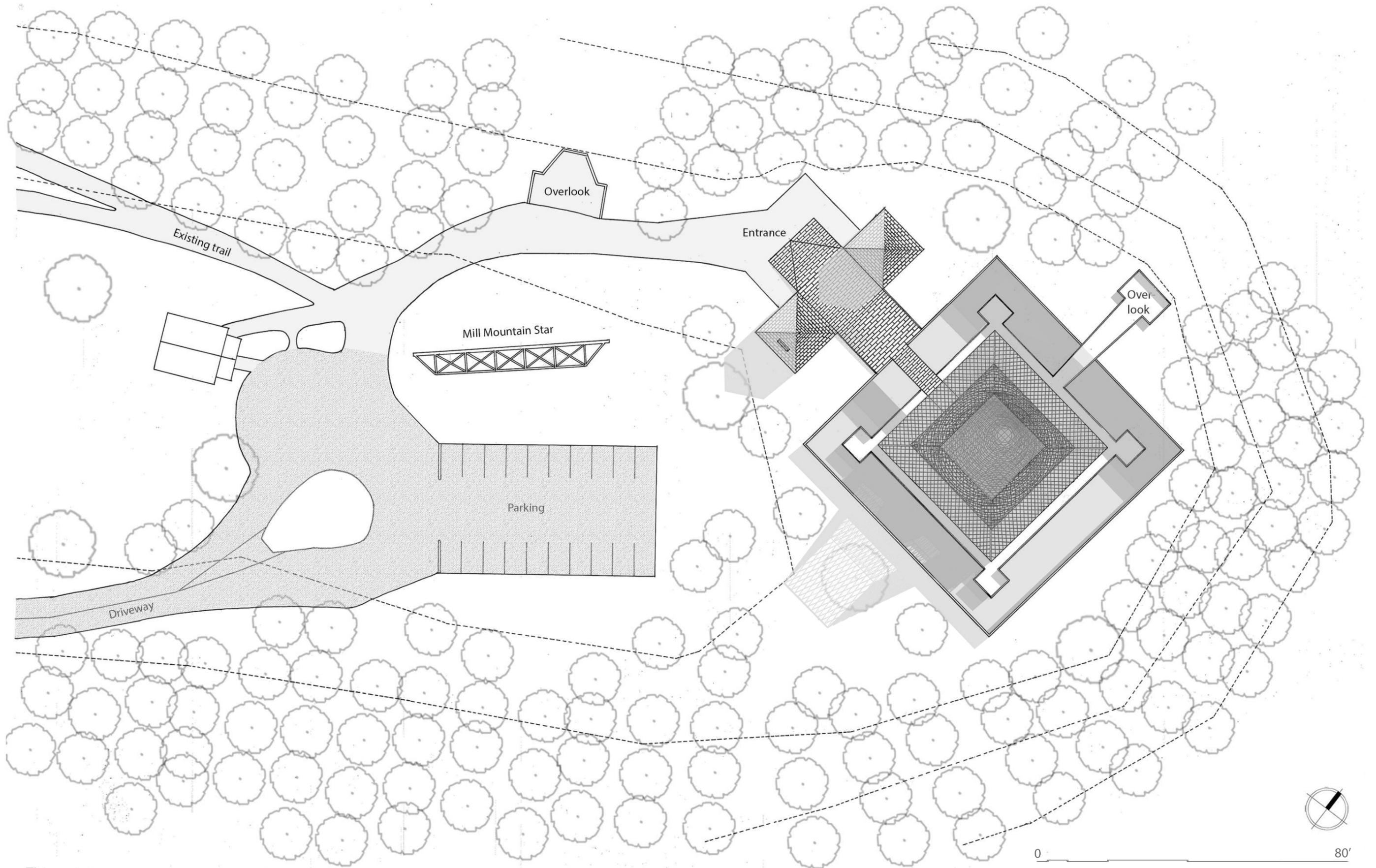


Figure 4

SITE PLAN

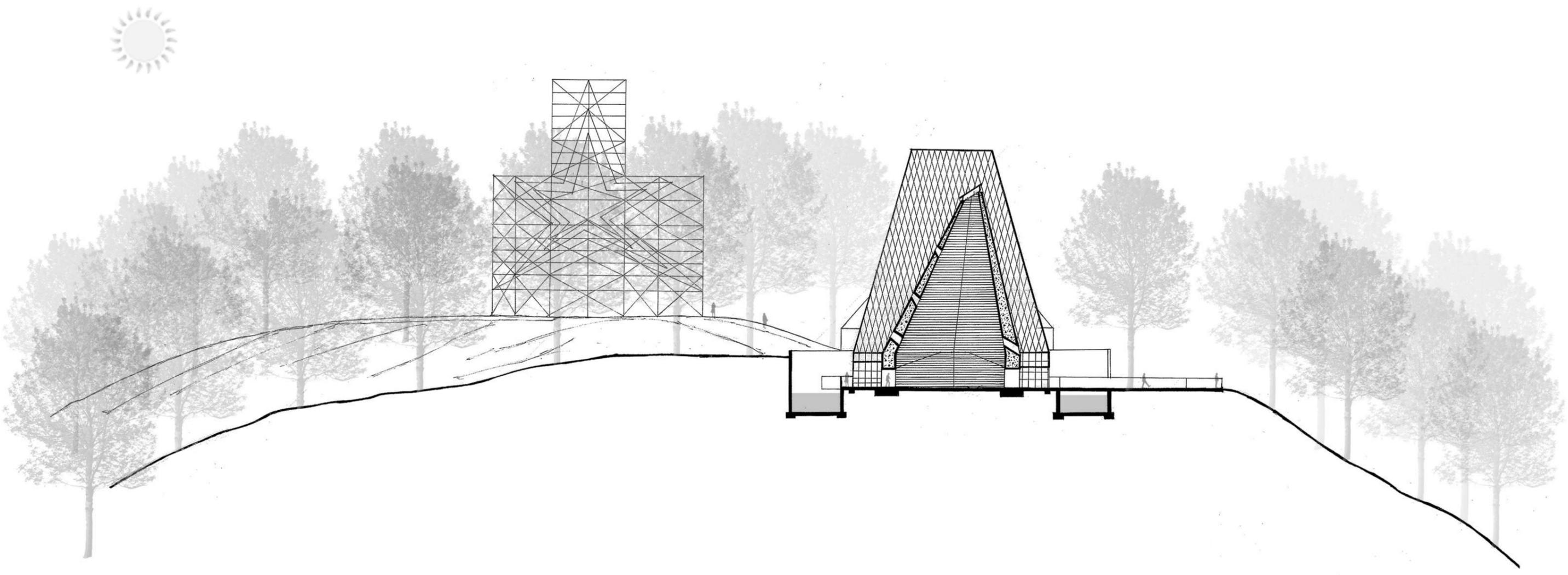
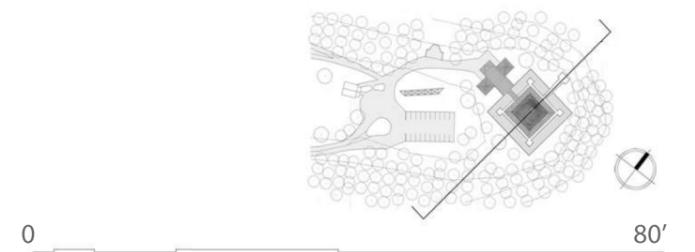


Figure 5

SITE SECTION



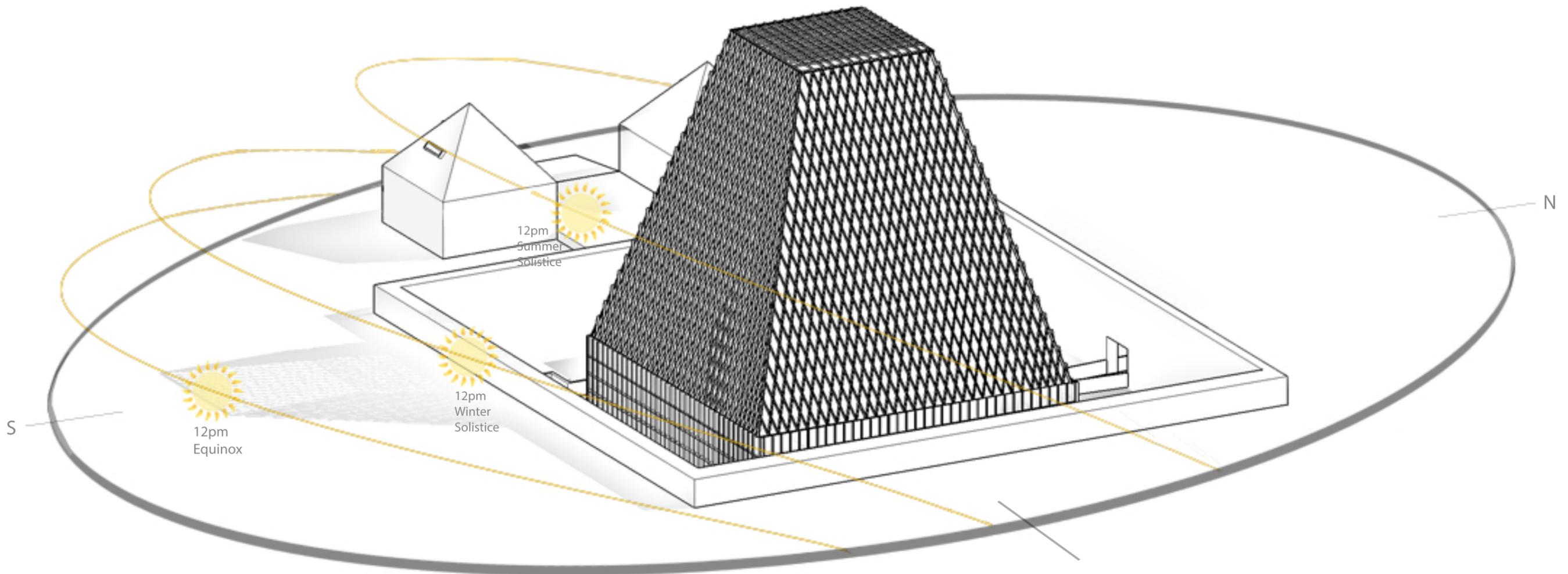


Figure 6

SUN PATH DIAGRAM

The sun in its course throughout the seasons and throughout the day form a universal sensible and intelligible pattern described through geometry giving a sense of a greater world beyond the immediate material world.

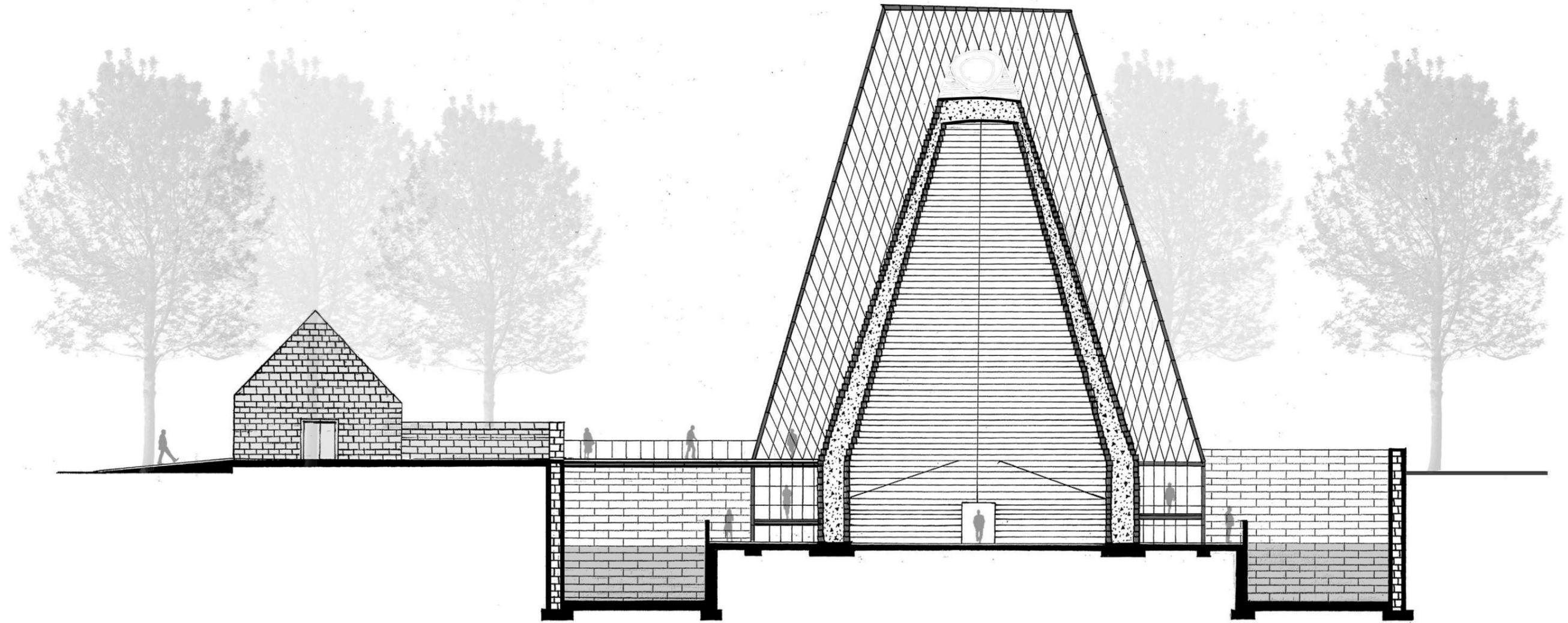
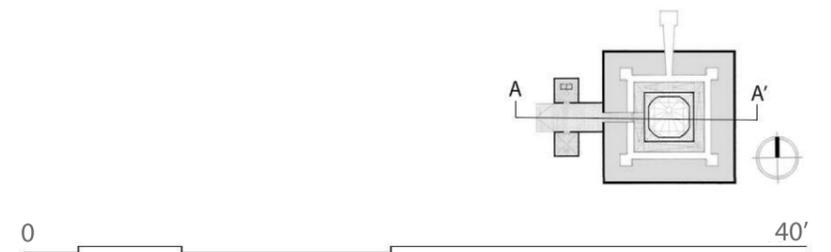


Figure 7

SECTION - AA'



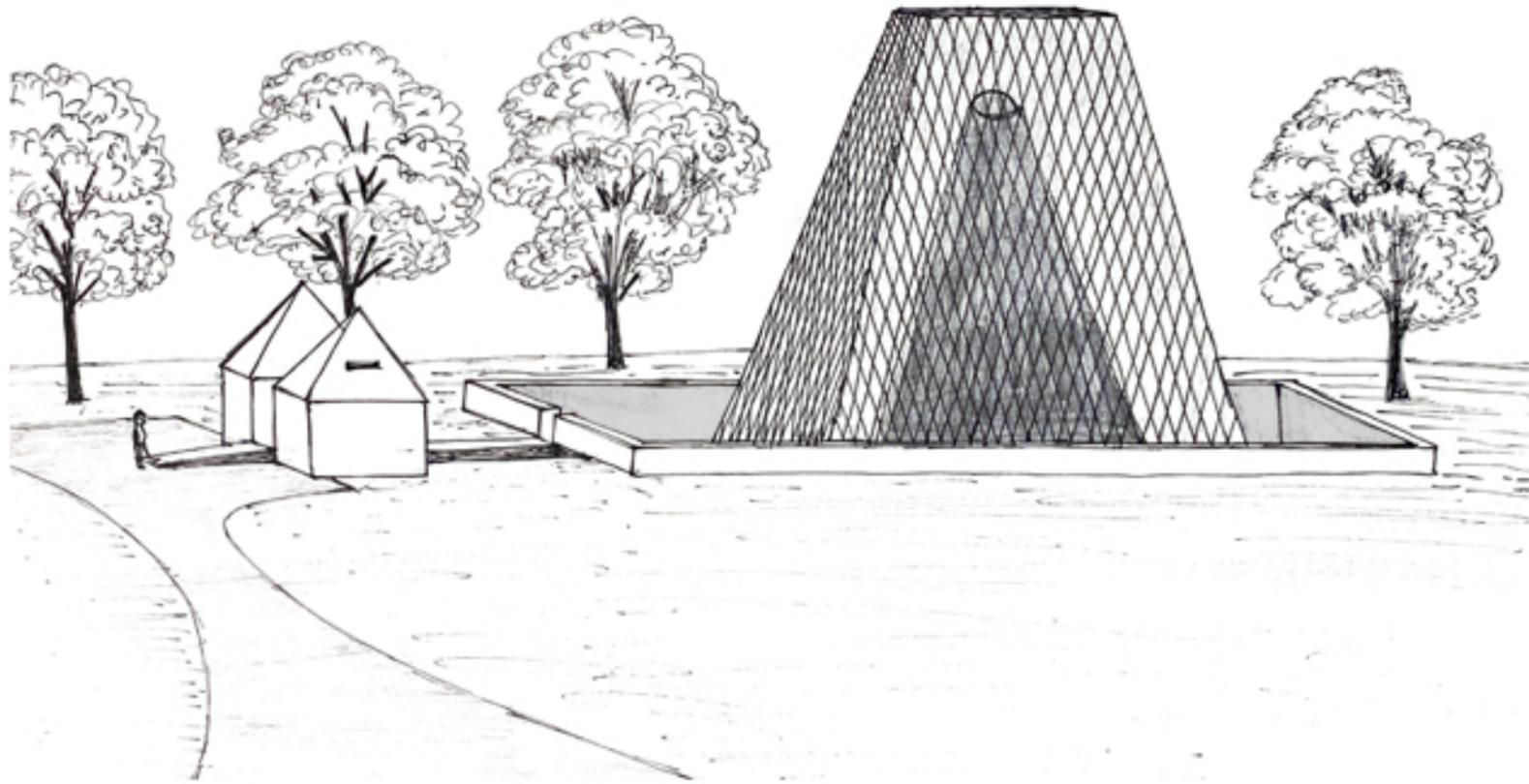


Figure 8

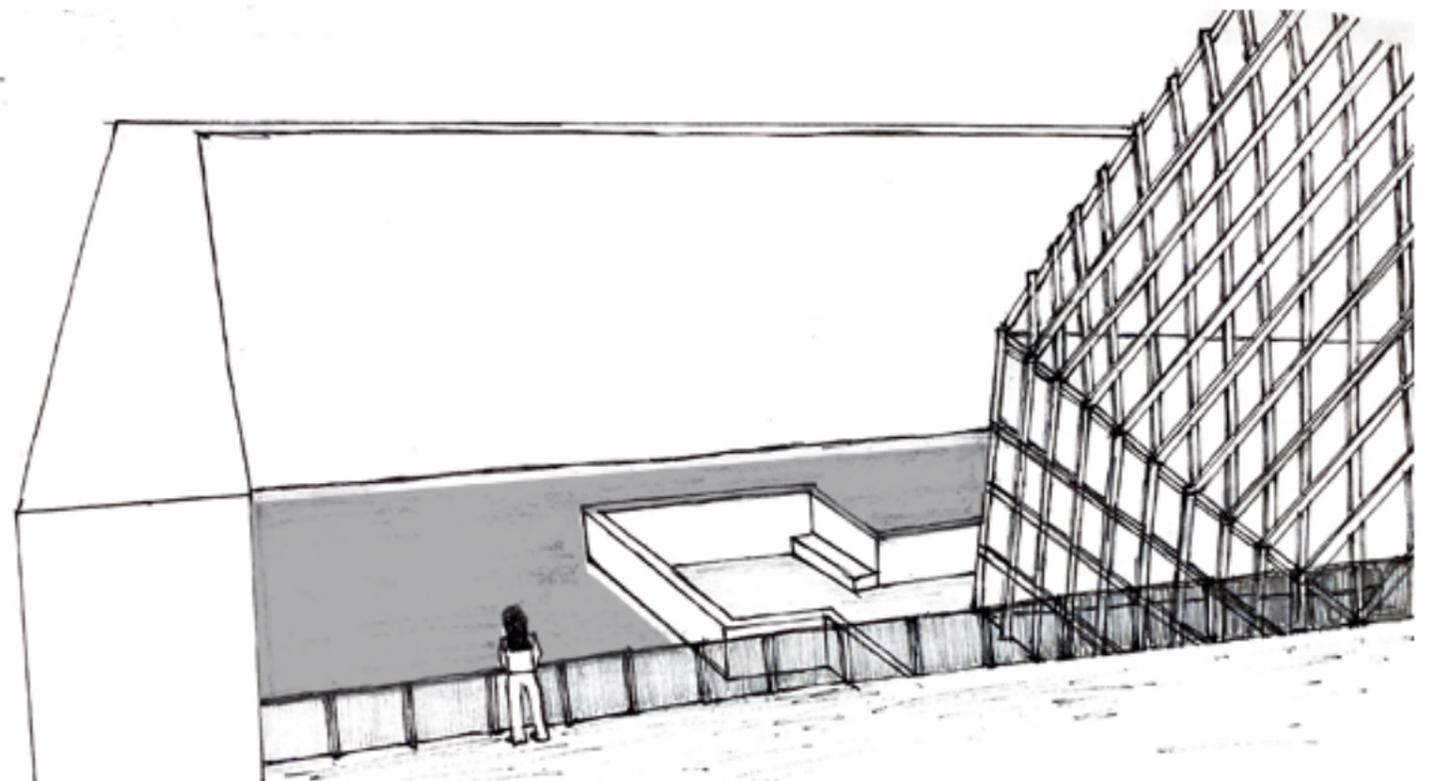


Figure 9



Figure 10

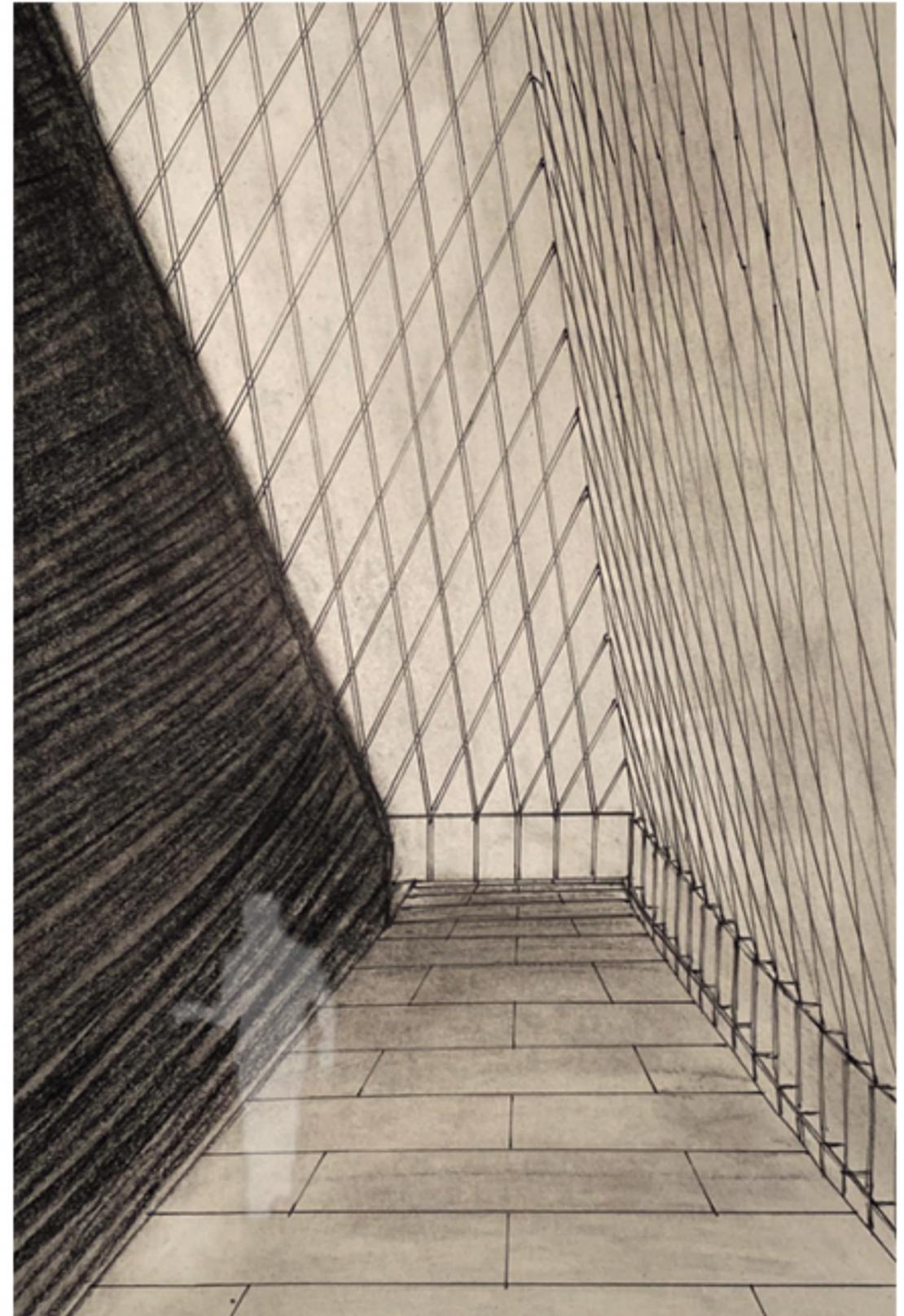
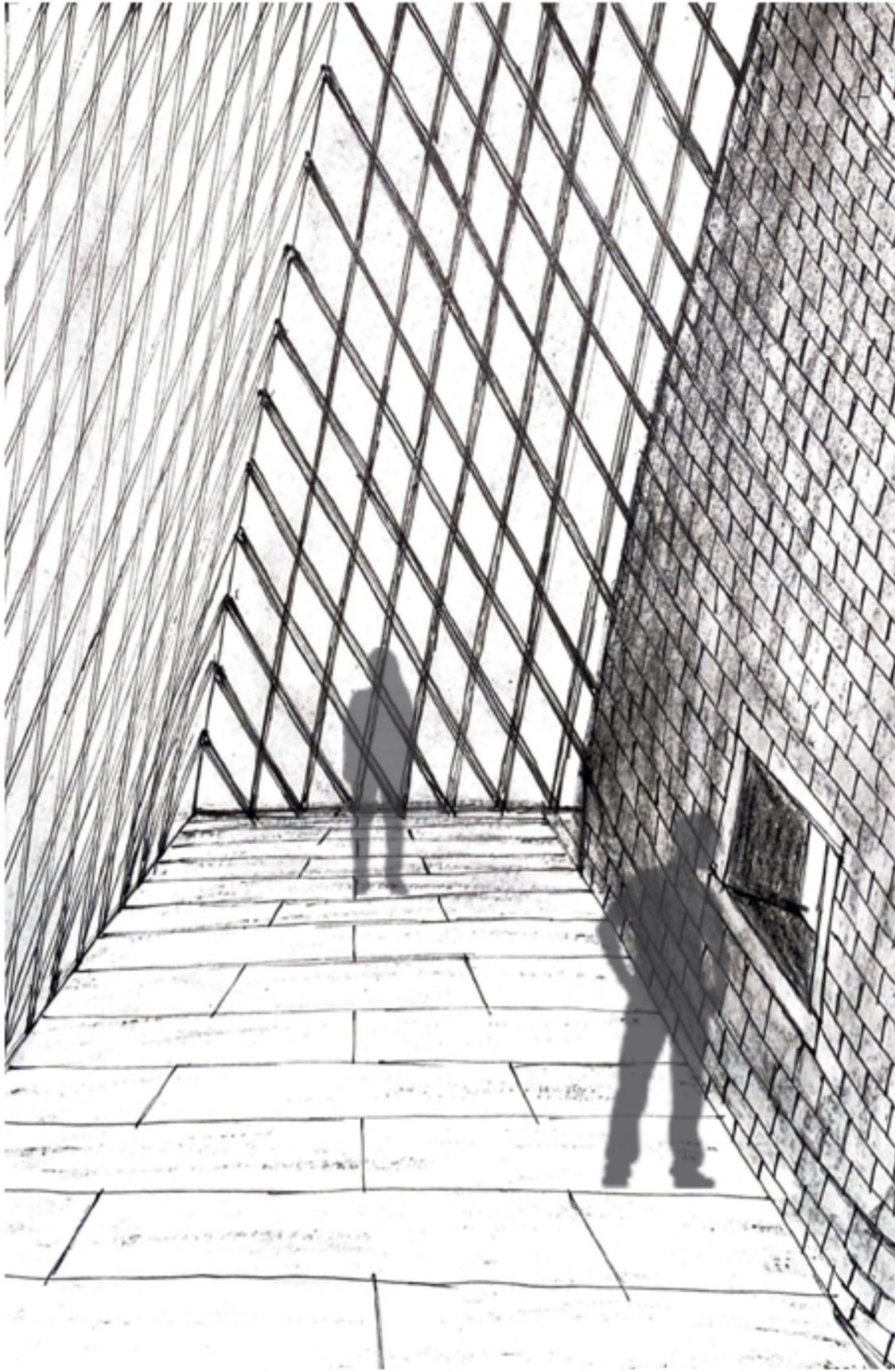


Figure 11

The texture of the surface of the stone is experienced walking along the ramp. The roughness of the granite contrasts with the transparent and smooth surface of the steel & glass pyramidal enclosure.



While walking along the ramp, a person can look into the conoid and experience the contrasting condition of the light steel and glass enclosure he stands in and the thick dark contemplative room that he is about to enter.

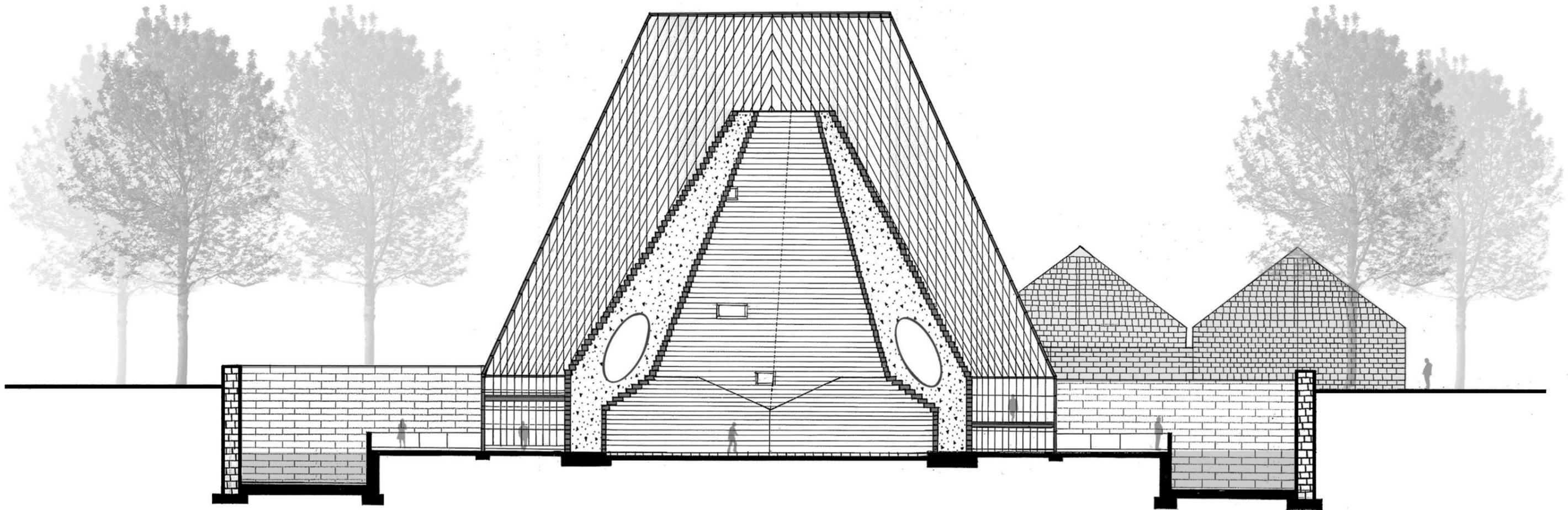
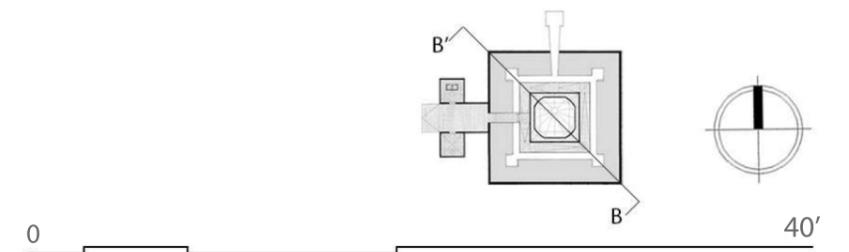


Figure 13

SECTION - BB'



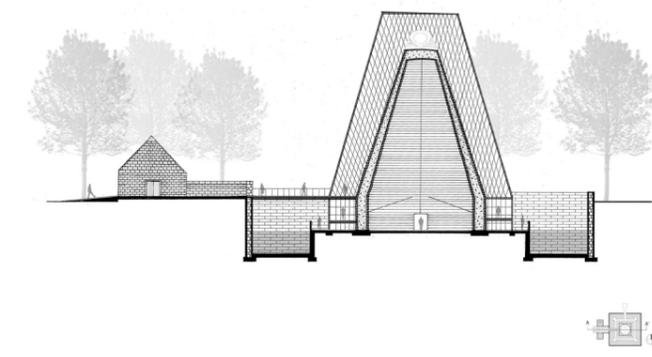
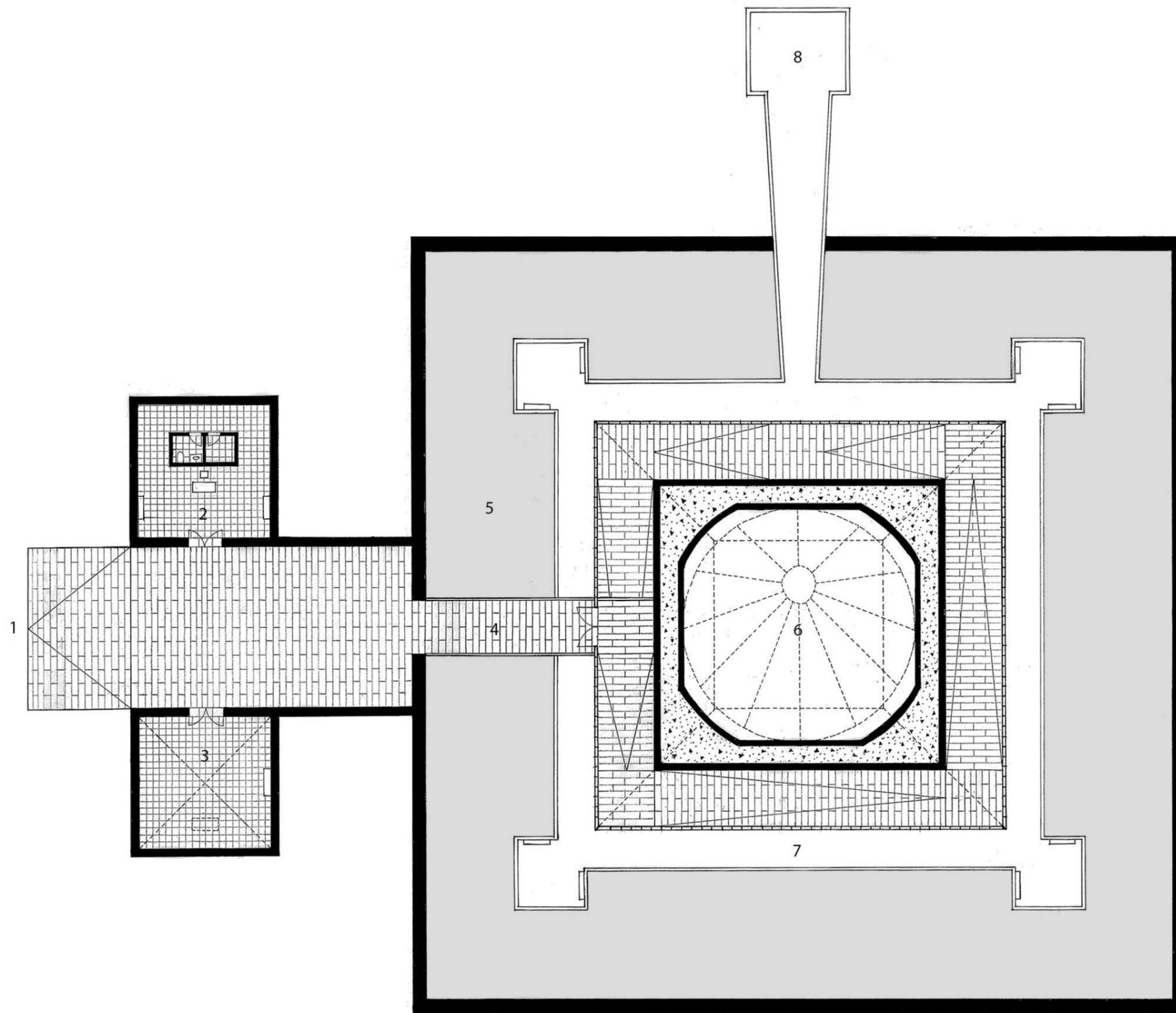
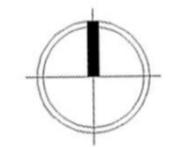


Figure 14

- 1 Entrance
- 2 Reception
- 3 Reflection room
- 4 Bridge
- 5 Reflective pool
- 6 Main Reflection room
- 7 Walkway
- 8 Overlook

GROUND FLOOR PLAN



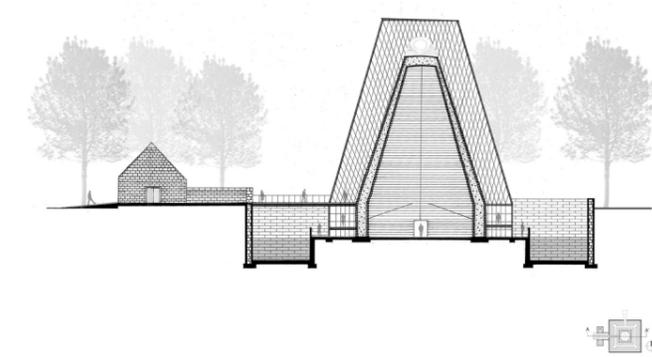
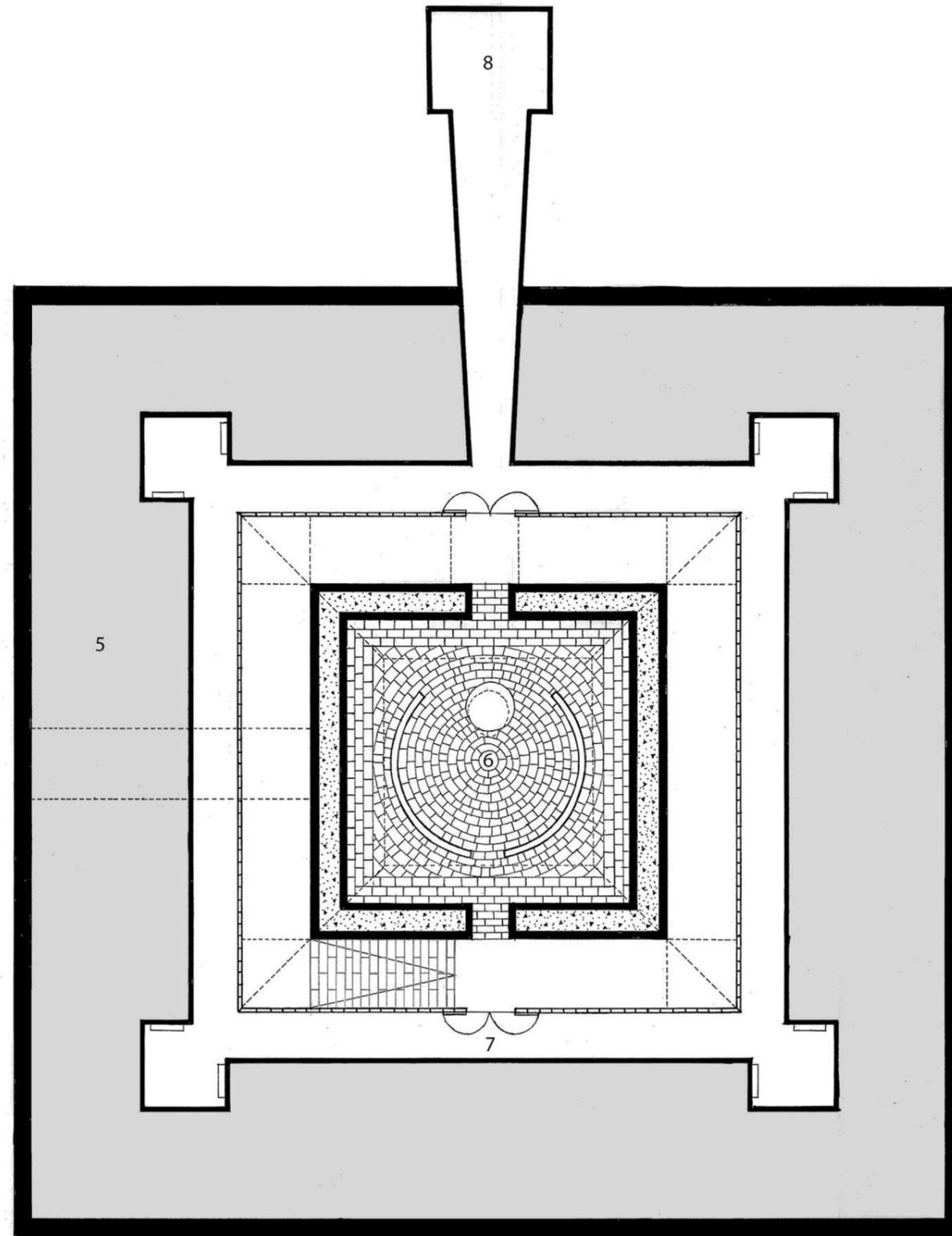
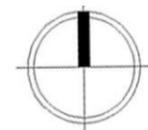


Figure 15

- 5 Reflective pool
- 6 Main Reflection room
- 7 Walkway
- 8 Overlook

BASEMENT FLOOR PLAN



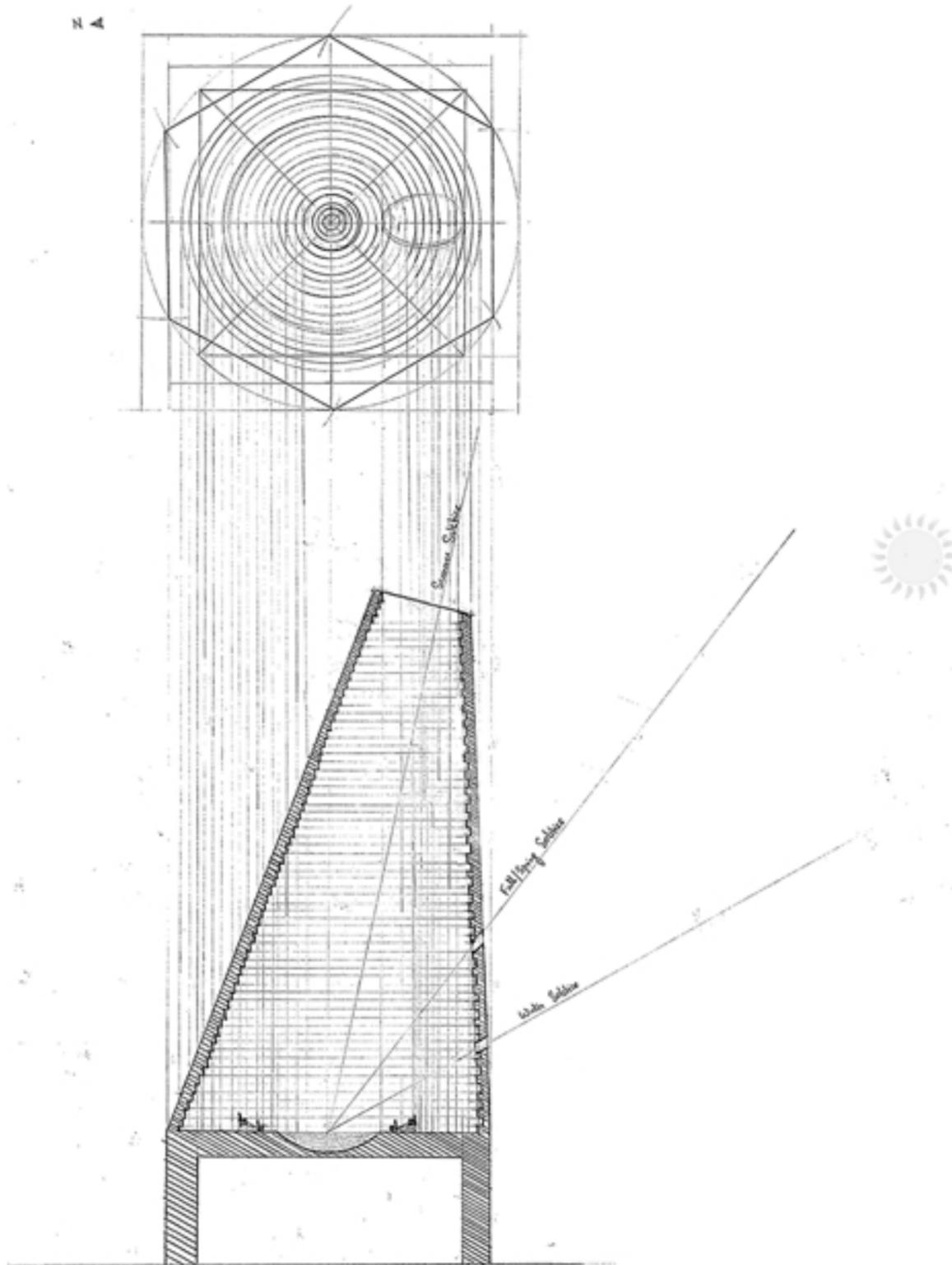


Figure 16

Working with the cubical base and truncated conoid, the conoid is inclined to bring in sun at solar noon on the summer solstice, spring/fall equinoxes and winter solstice respectively which passes through the apertures on the south wall of the cone and reflects off the pool of water in the room.

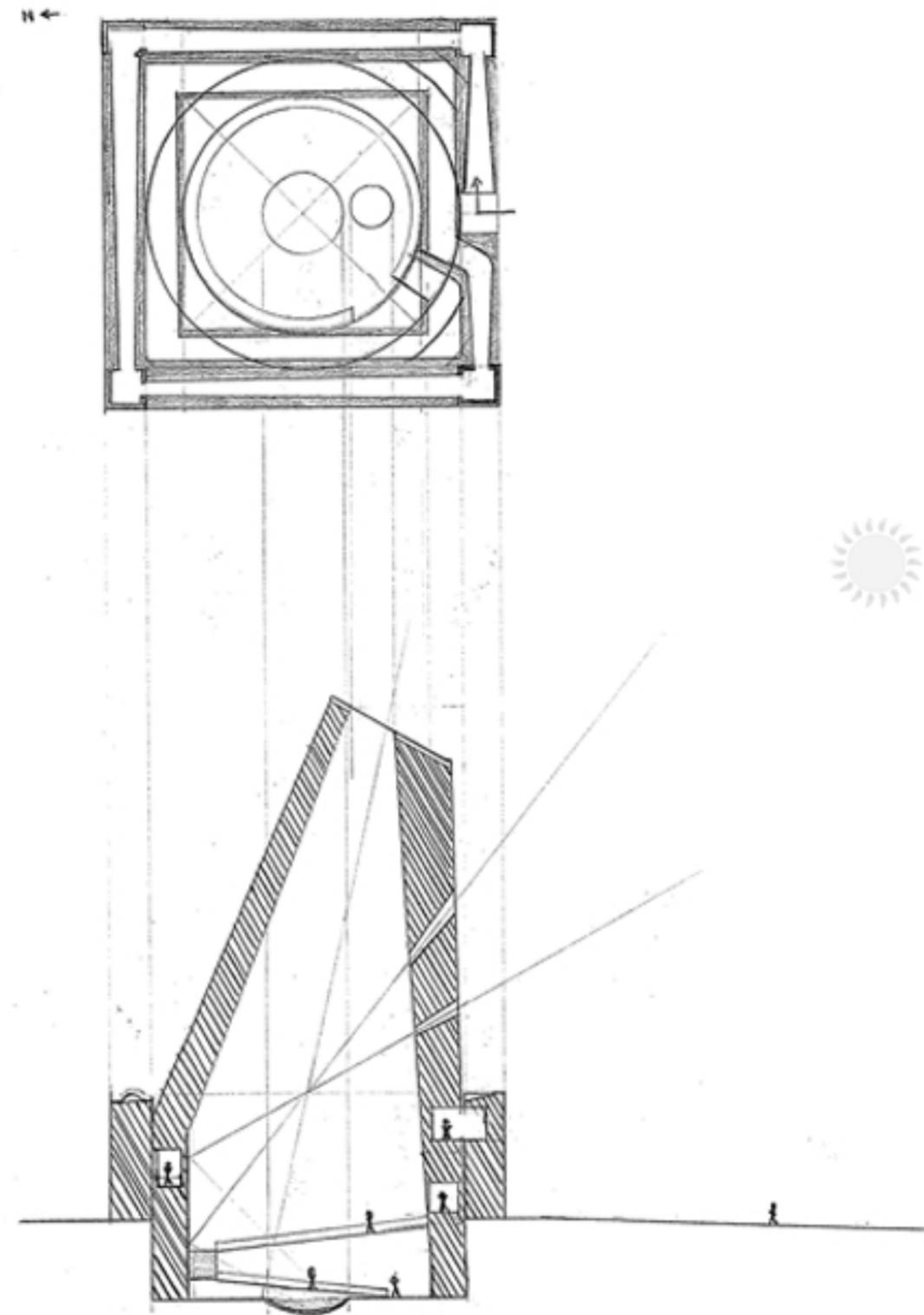


Figure 17

Here, the thickness of the enclosure is used to accommodate a ramp that would lead to the base of the contemplative room.



Figure 18



Figure 20

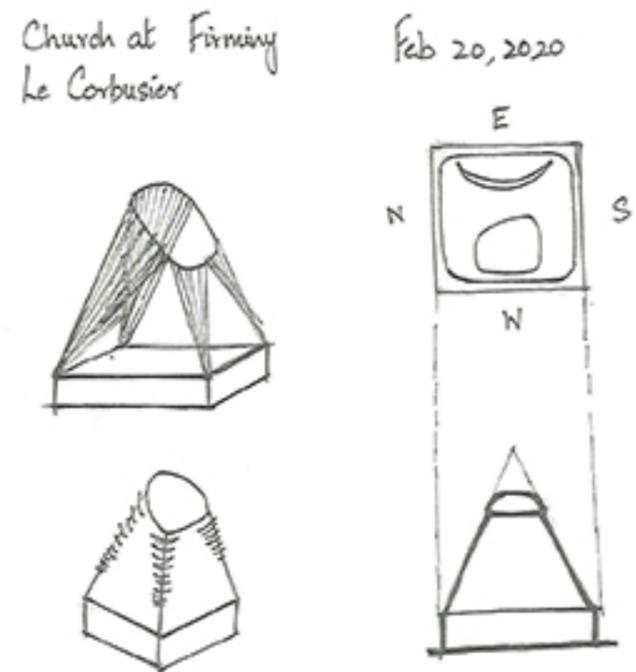


Figure 19

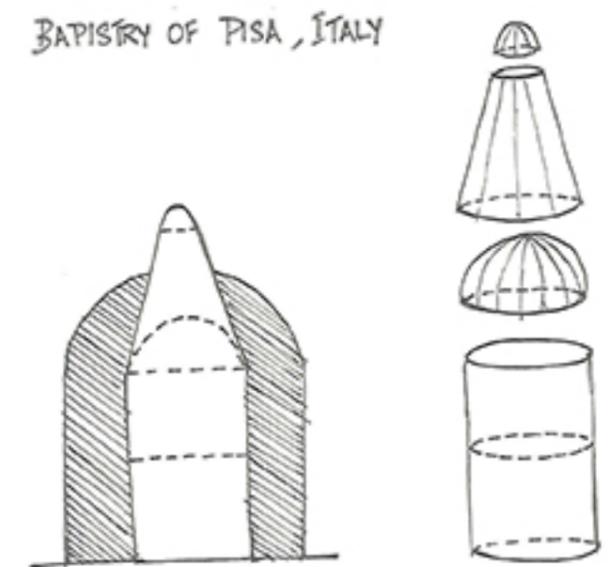


Figure 21

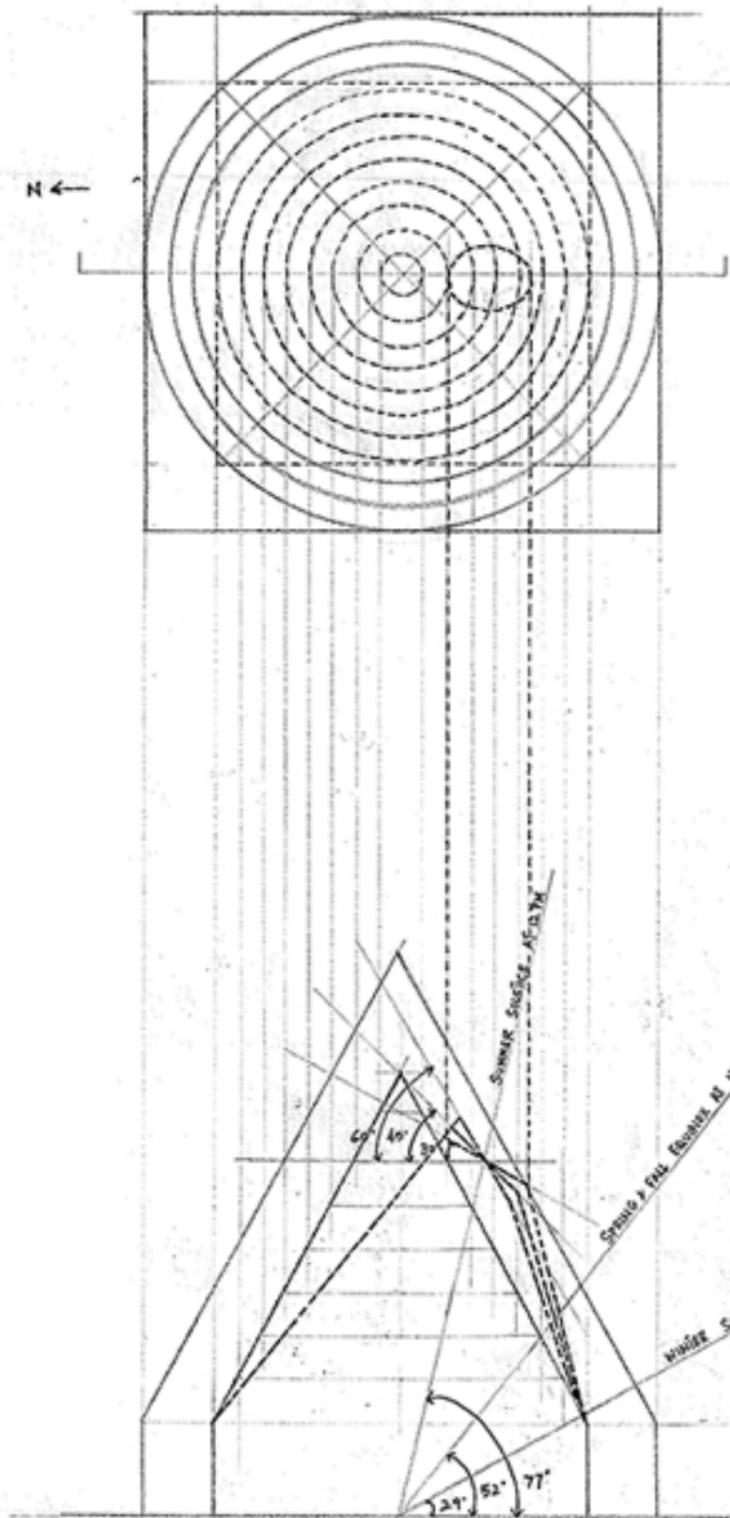


Figure 22

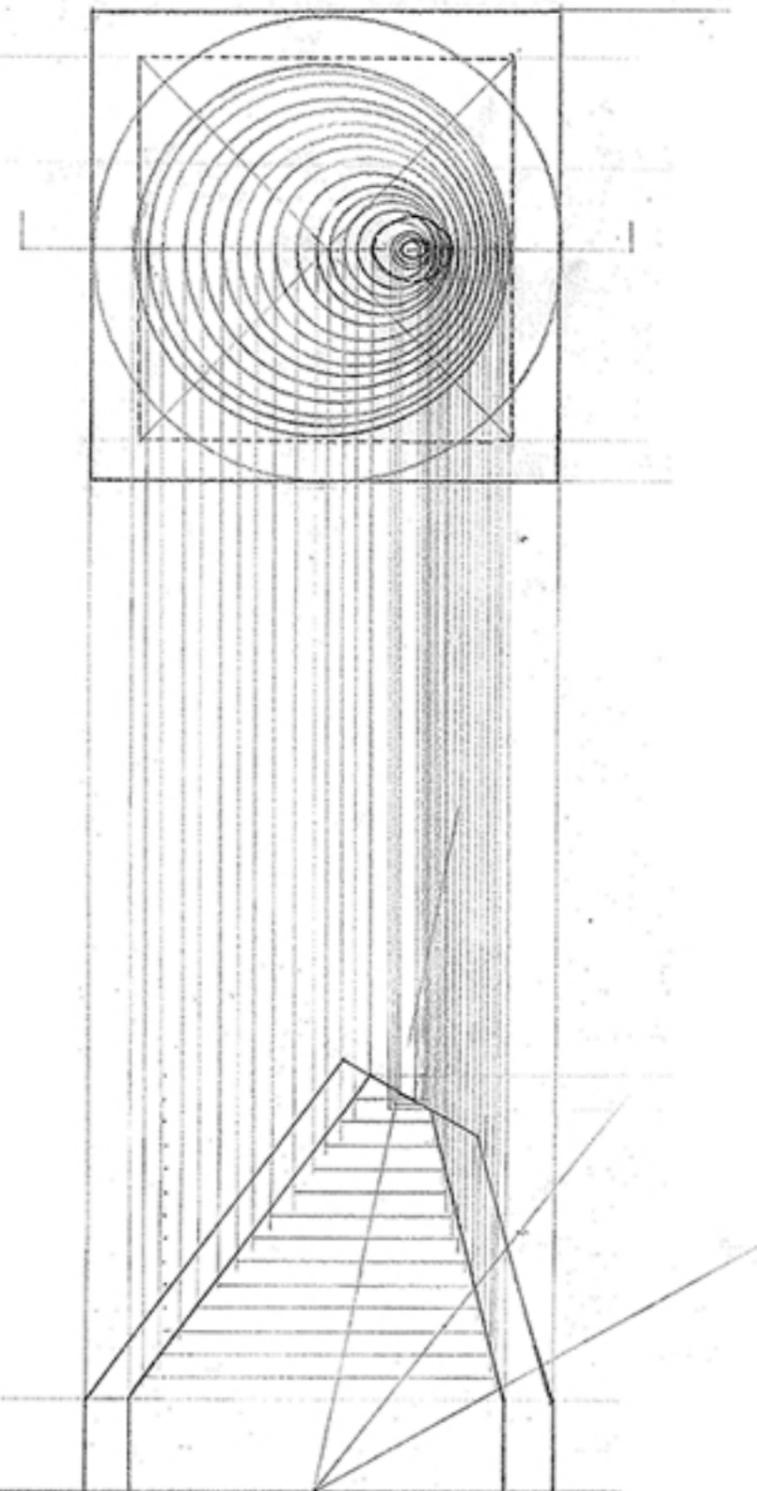


Figure 23

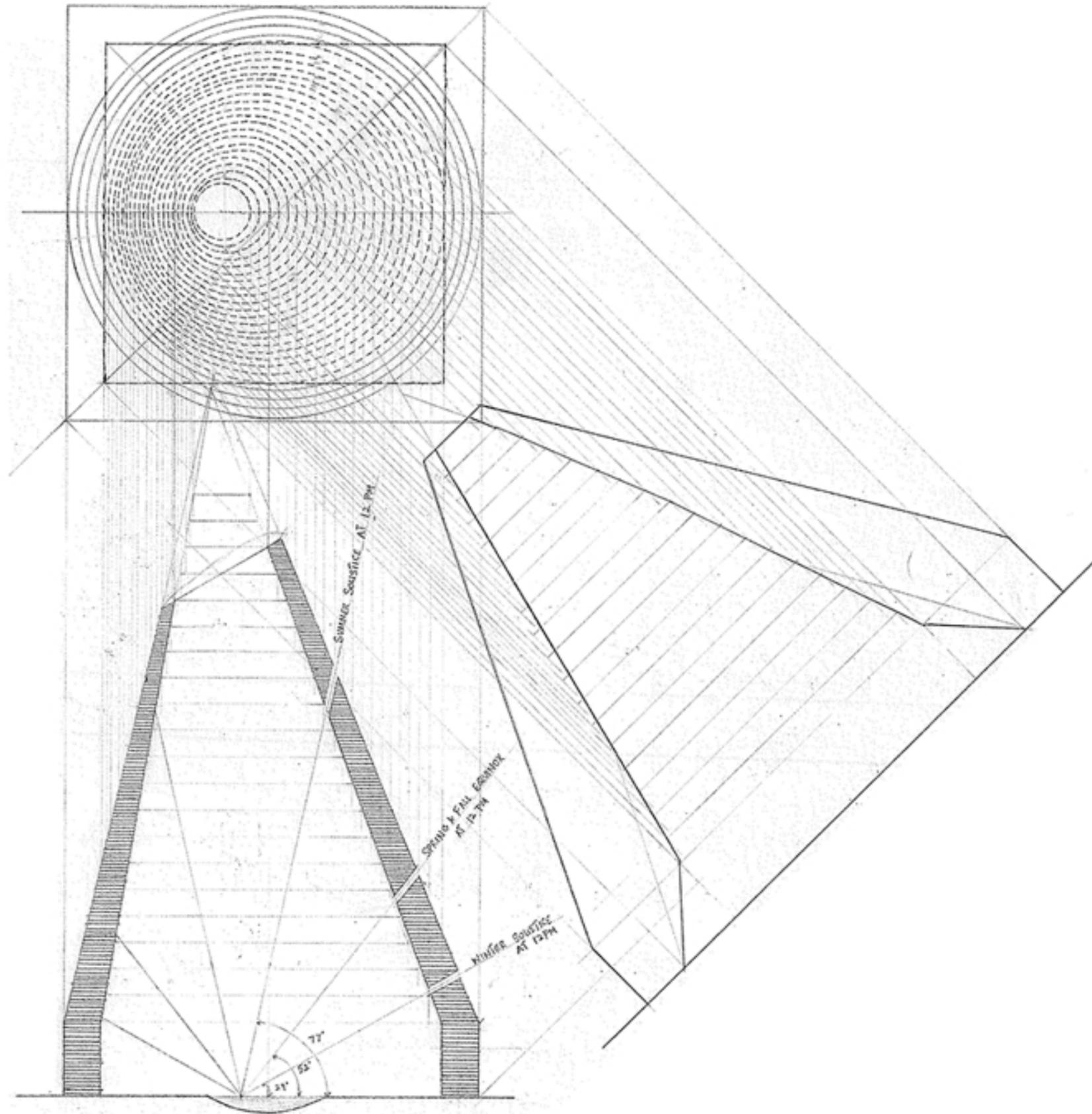


Figure 24

This attempt at the inclined cone with an angled oculus uses the same defining geometry, but accomodates the slits on the south wall and attempts to resolve the intersecting geometry between the cubical base and the conical top.

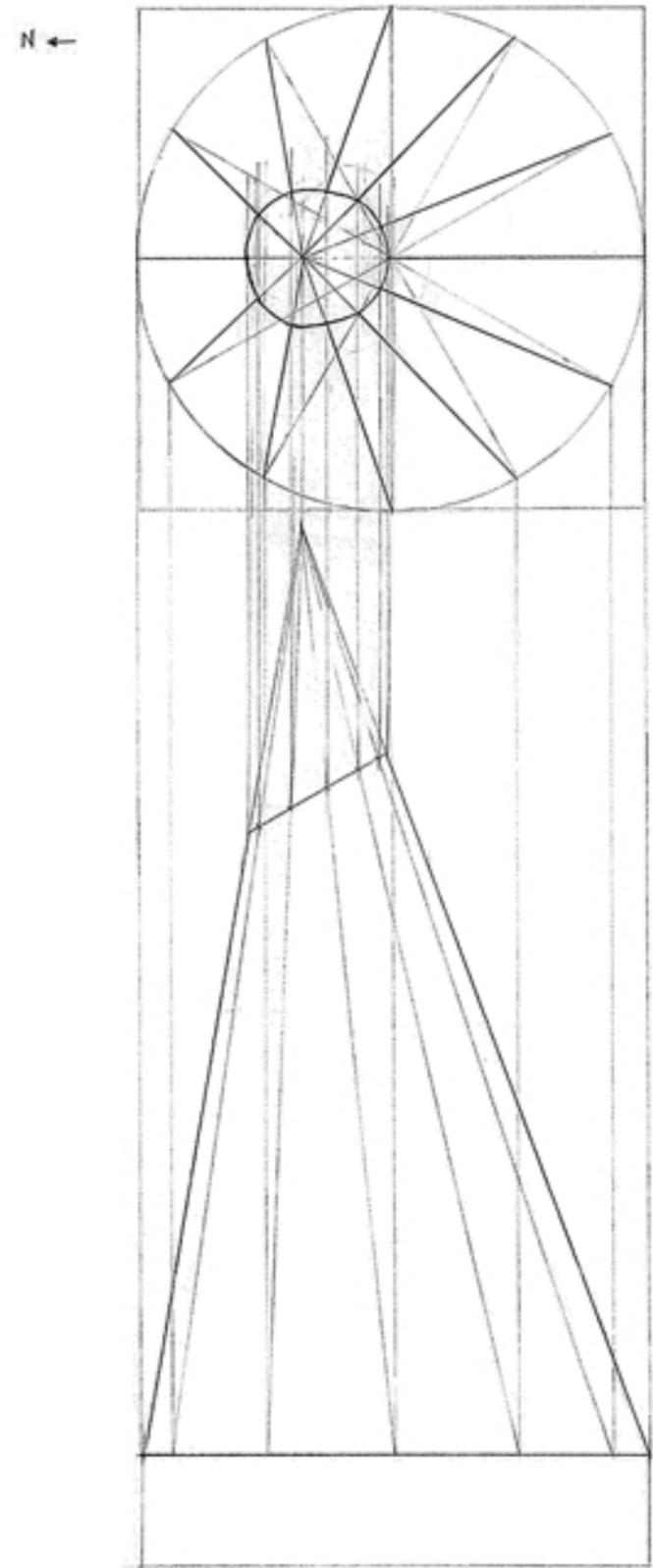


Figure 25

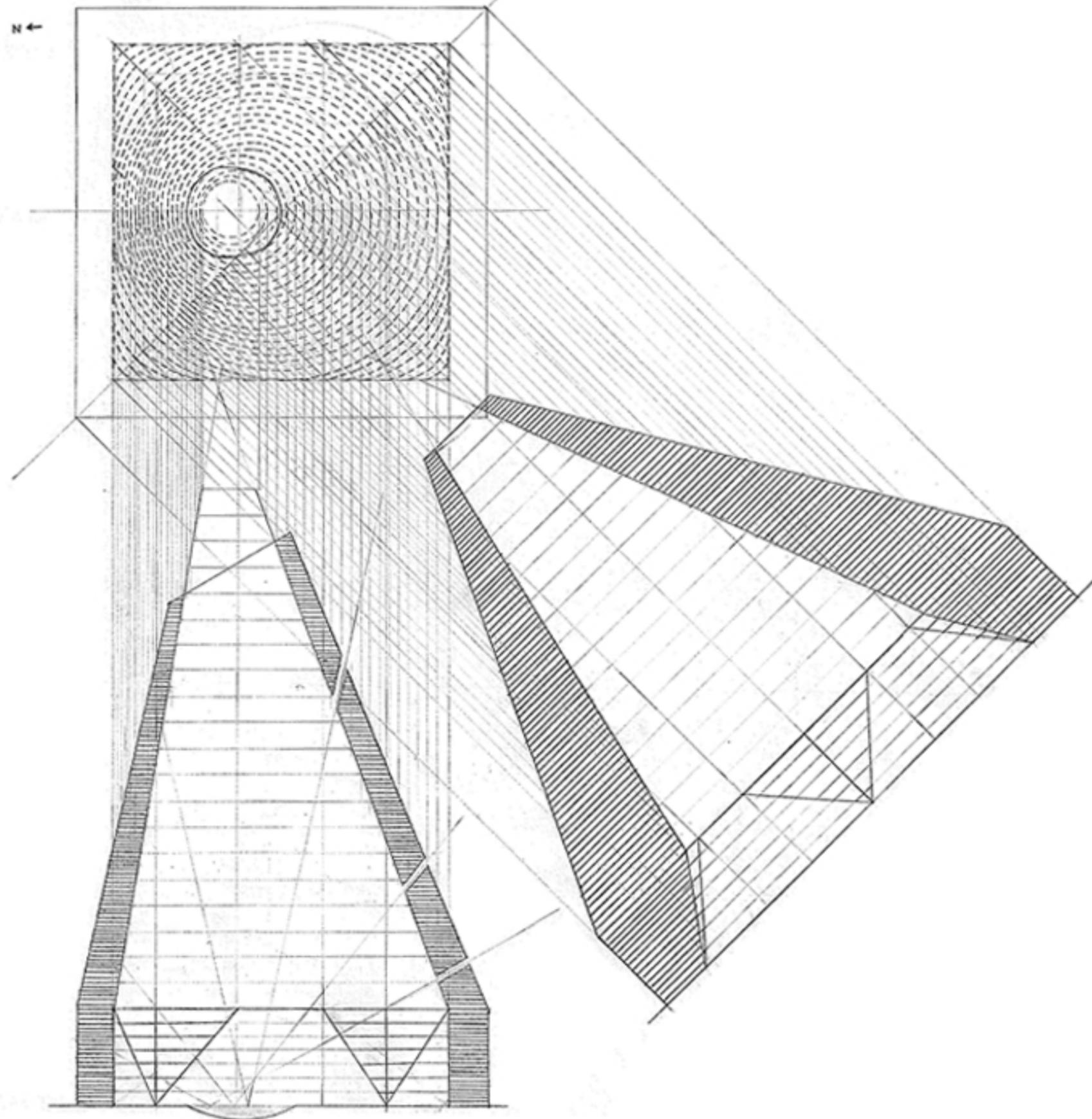
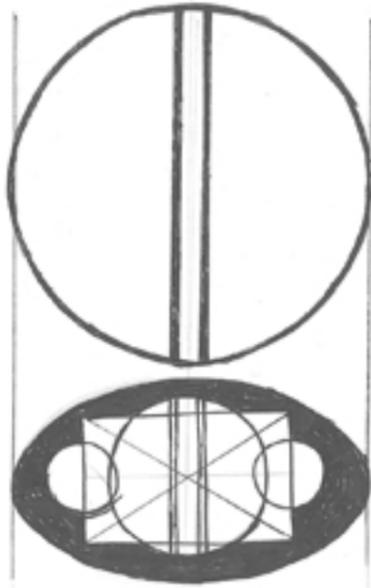


Figure 26

The demonstrative basis of these studies is the use of rectilinear logic through circular constructions. This drawing uses descriptive geometry to resolve issues discovered in the previous drawing. It resolves the intersecting geometry between the cubic base and the conoid.

Church of San Giovanni Battista (1966-1996) Megève, Switzerland
 Mario Botta

March 9, 2020



Transformation of geometry → ellipse - rectangular - circle
 (form) - (floor) (roof)

- cylindrical form of the church rises above the surrounding village → the vertical axis expresses the spiritual axis.
- The interior walls demonstrate the transformation of geometry of the building form :-
 * a rectangle inscribed within an external ellipse that ultimately changes into a circle at roof level.

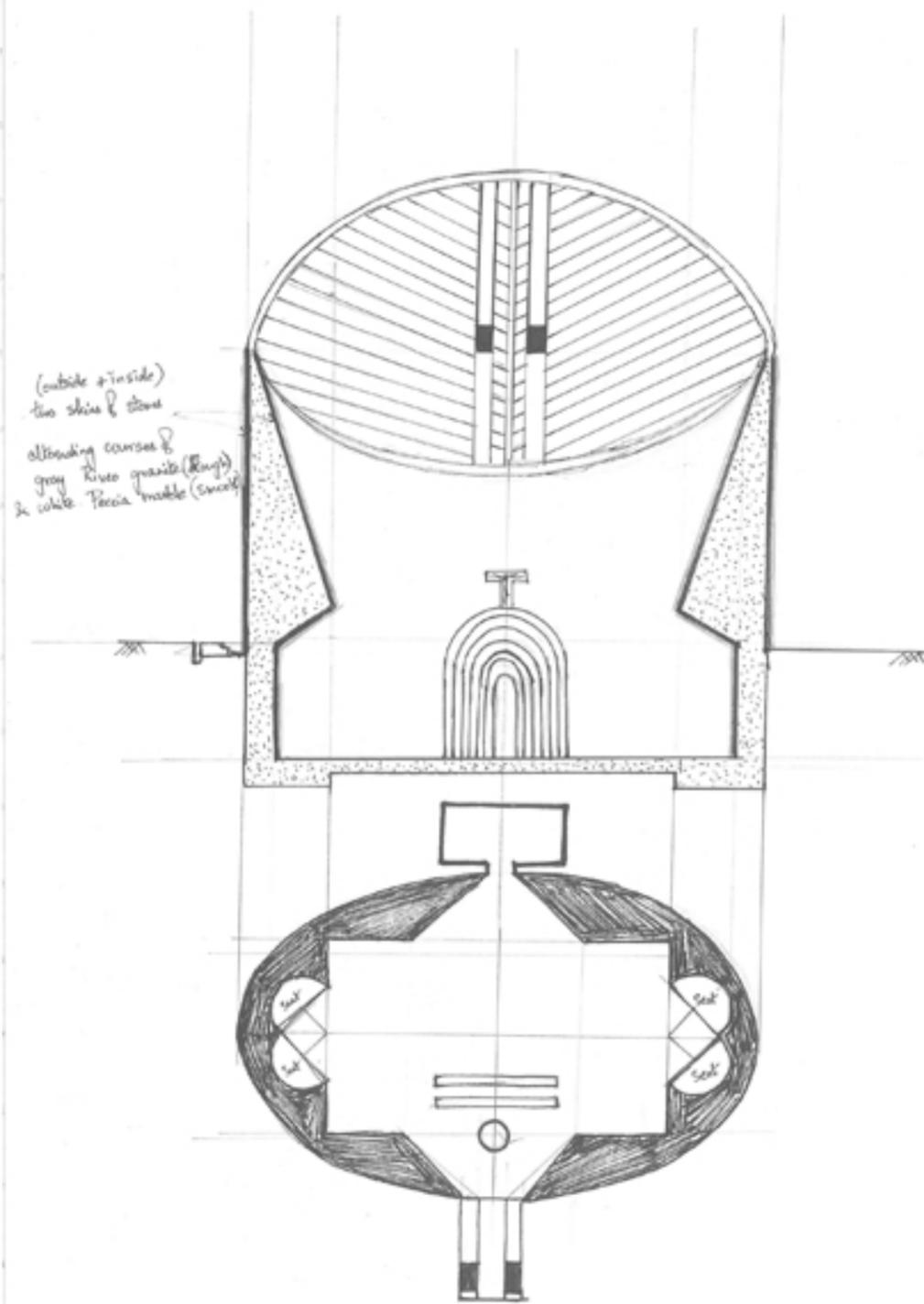
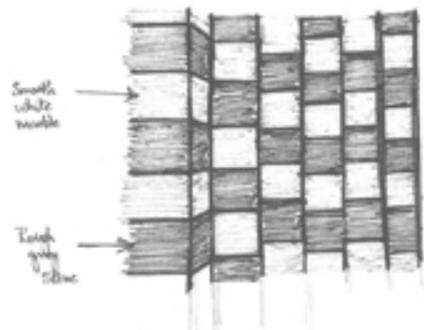


Figure 27

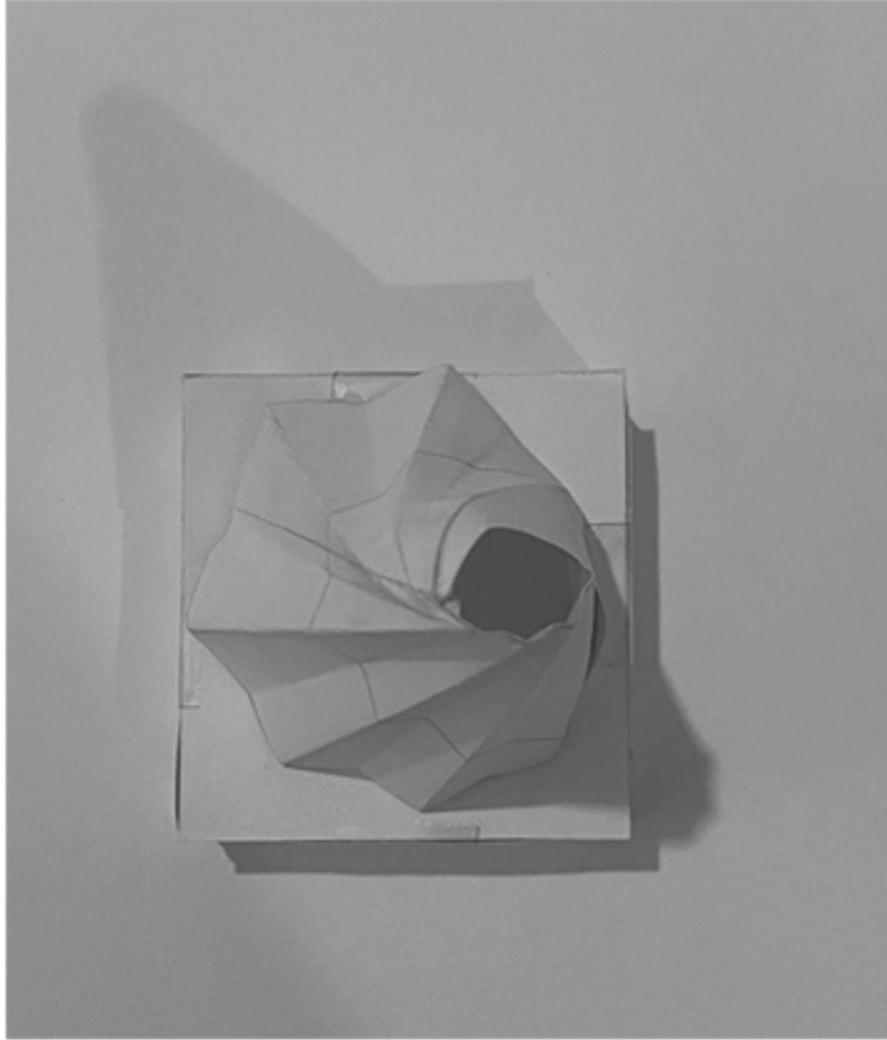


Figure 28

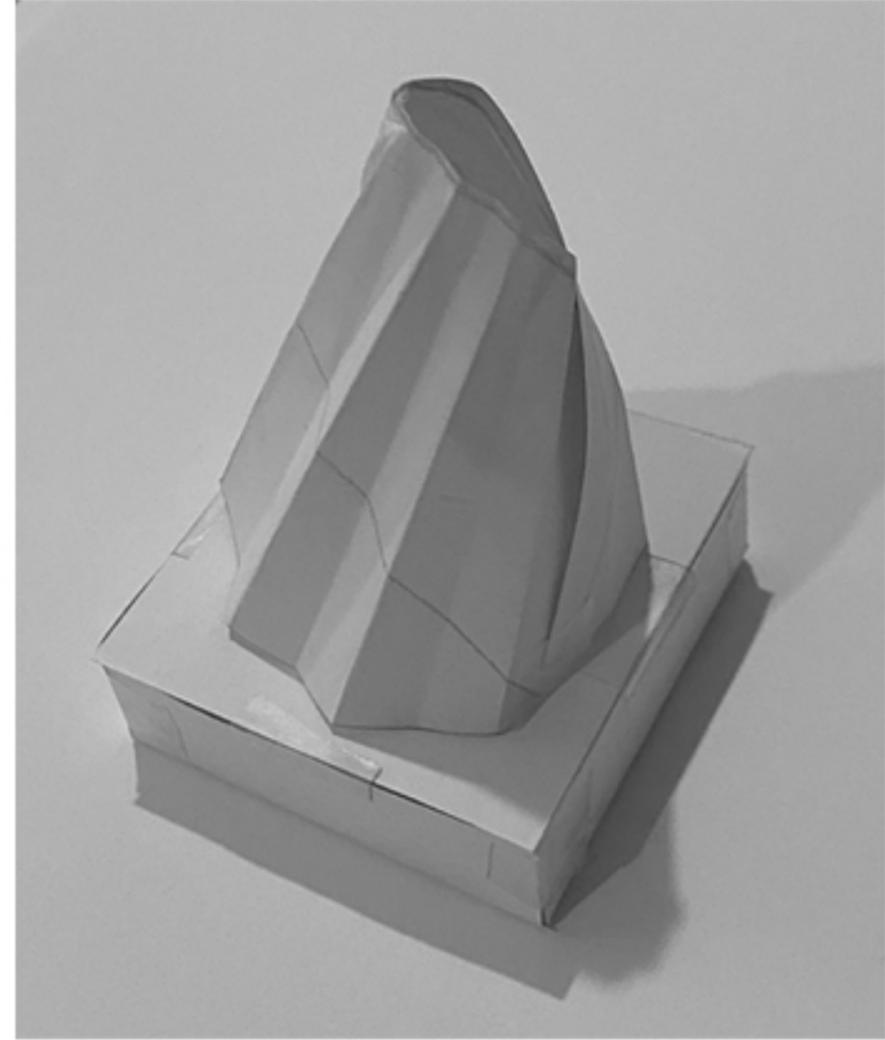


Figure 29

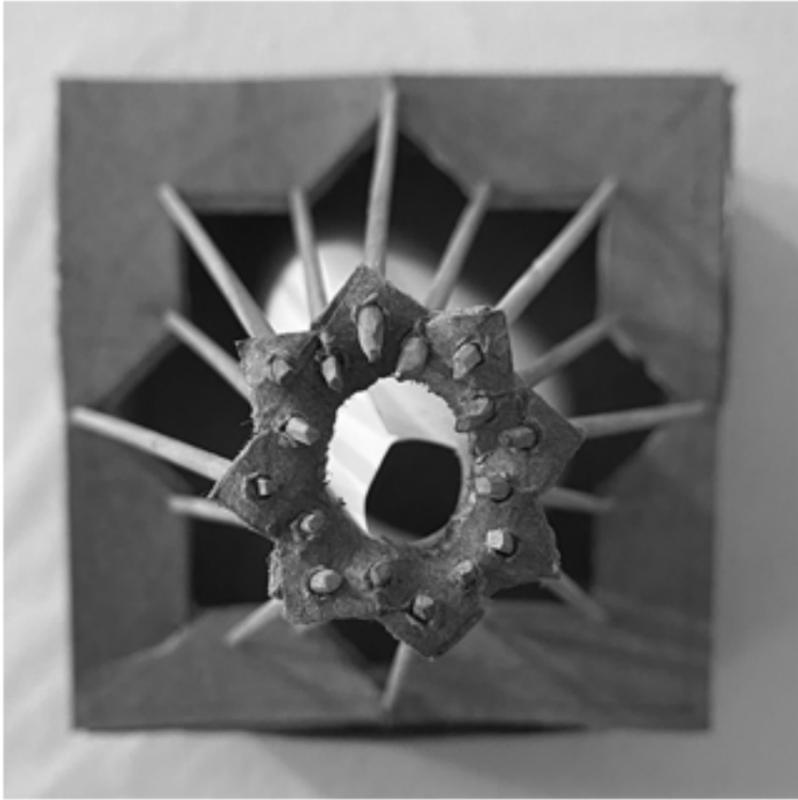


Figure 30



Figure 31

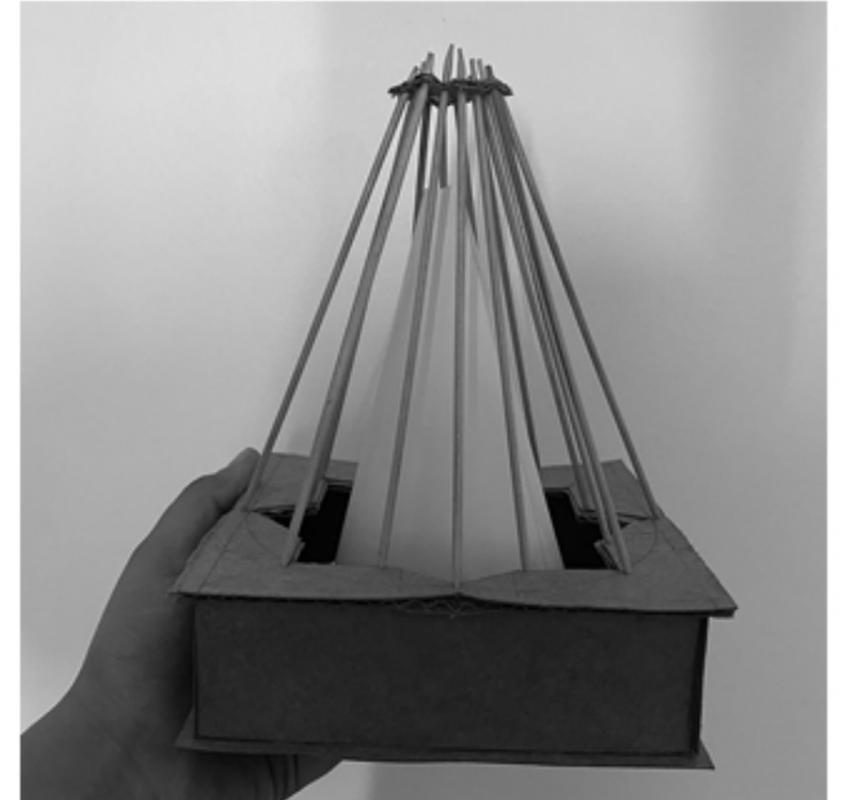


Figure 32

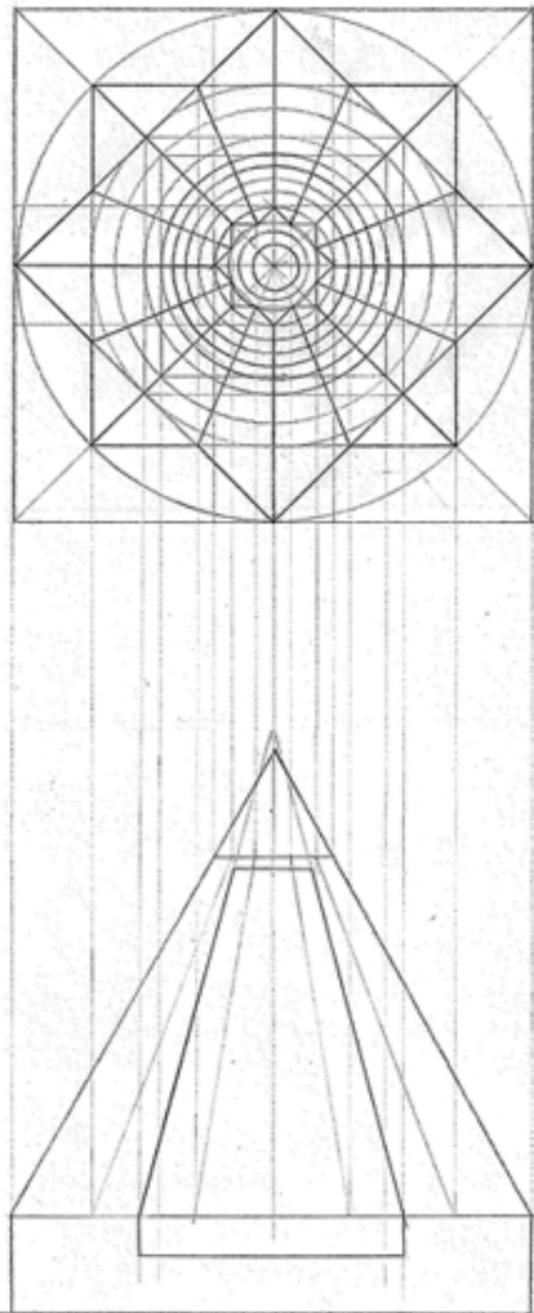


Figure 33

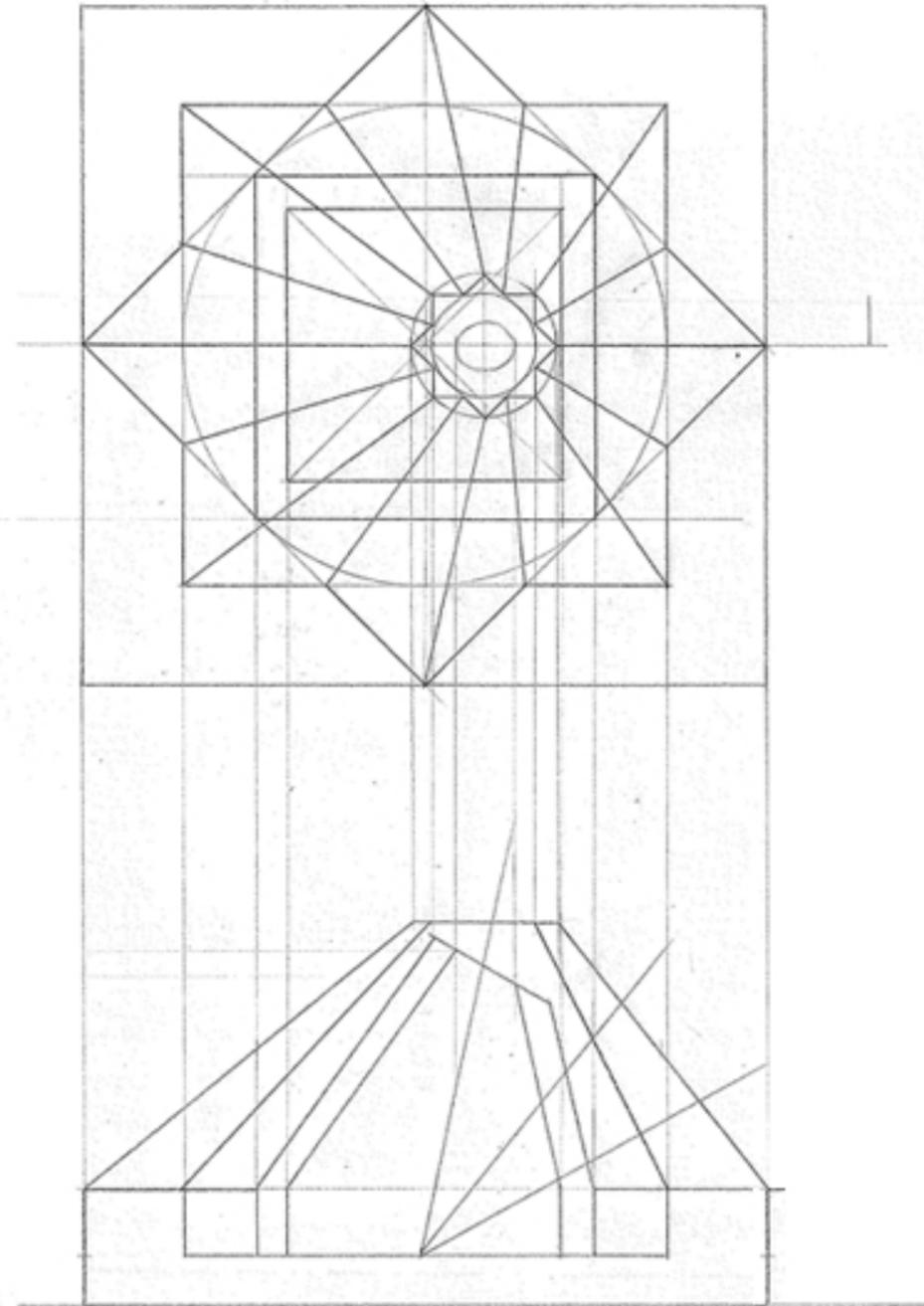


Figure 34

These geometric projections explore the interplay of the interior conic form and the outward crystalline form.



Figure 35

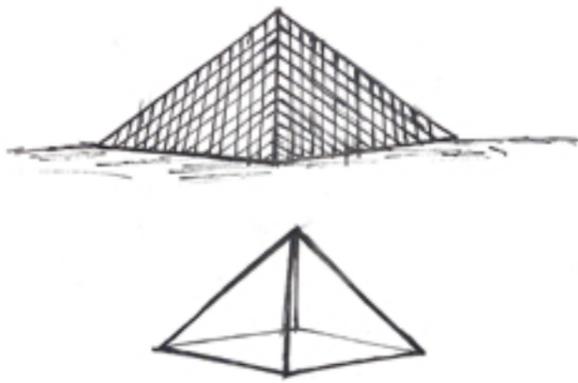
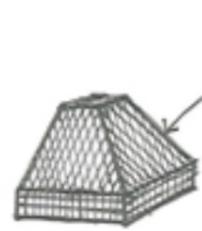


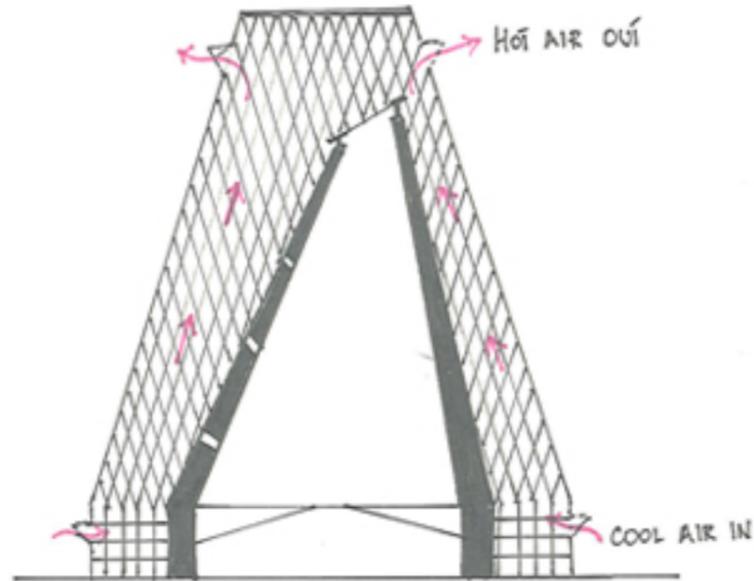
Figure 36



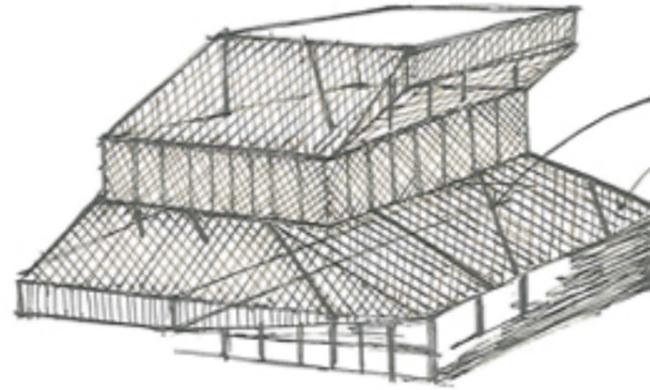
Low-emissivity (Low-E) Coated glass - reduces heat gain & heat loss

Emissivity of clear glass is 0.84
 Emissivity of low-e coated glass is 0.15
 -15% of heat is absorbed & re-emitted, rest is reflected.

For ventilation:



Seattle Public Library - Crystalline diagrid form



diagonal steel columns provide additional support
 Glazing supported diagrid

The exterior diagrid frame carries lateral wind loads efficiently, creating stiffness that is complemented by the axial action of the diagonal member.

Glass enclosure - diagrid

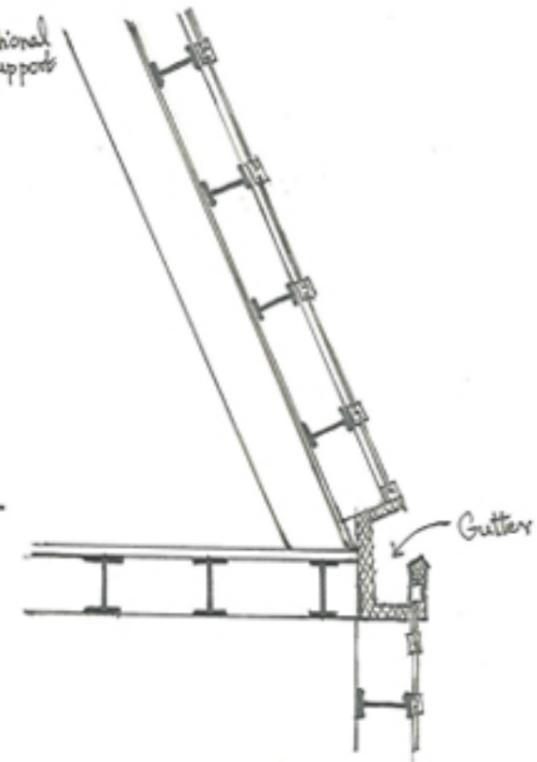
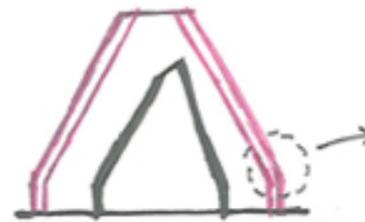
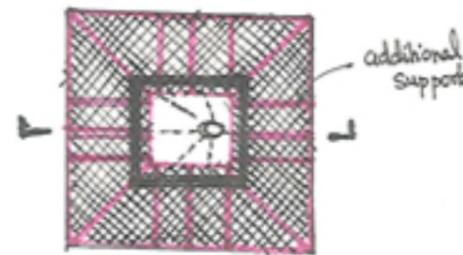
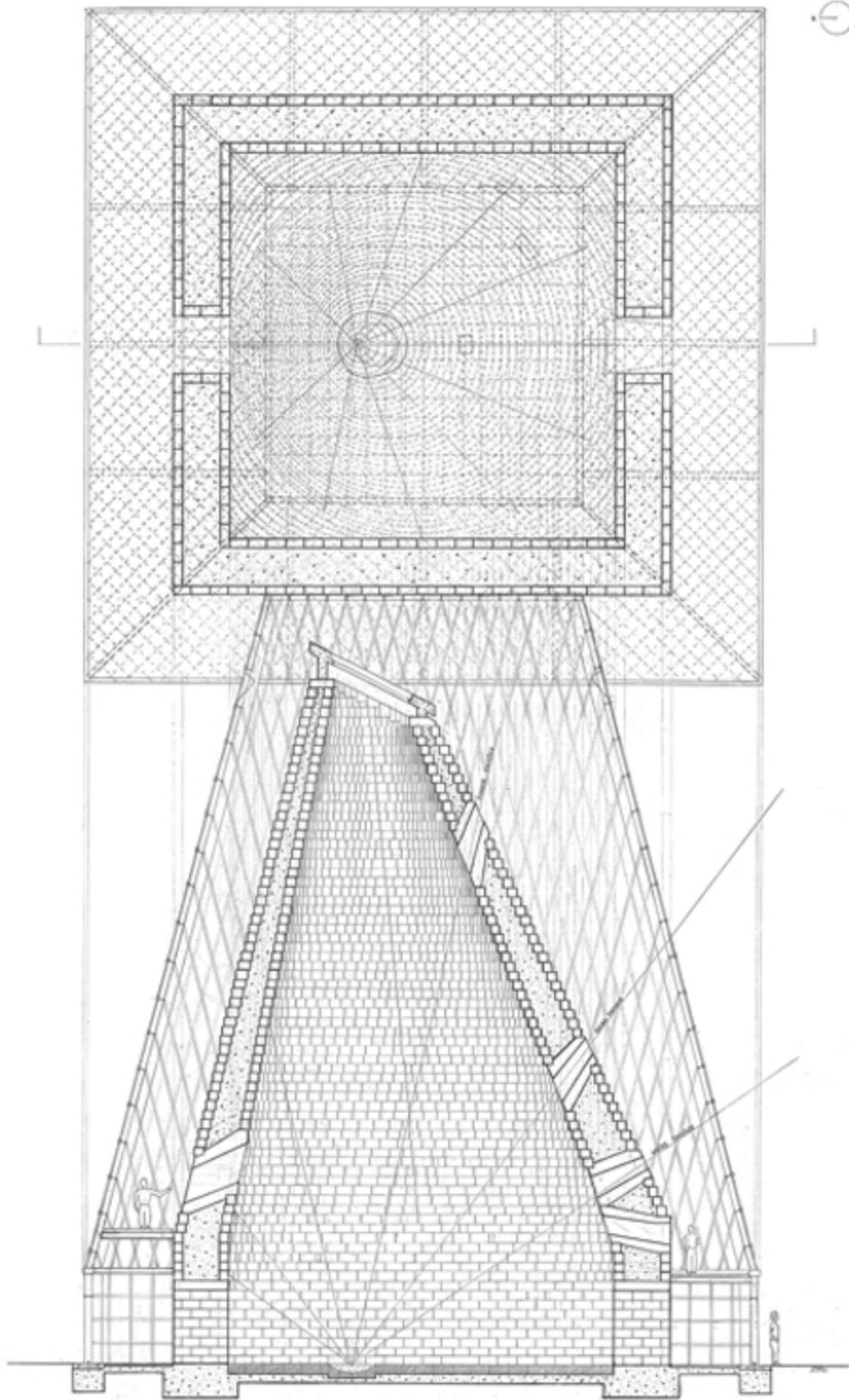


Figure 37



①

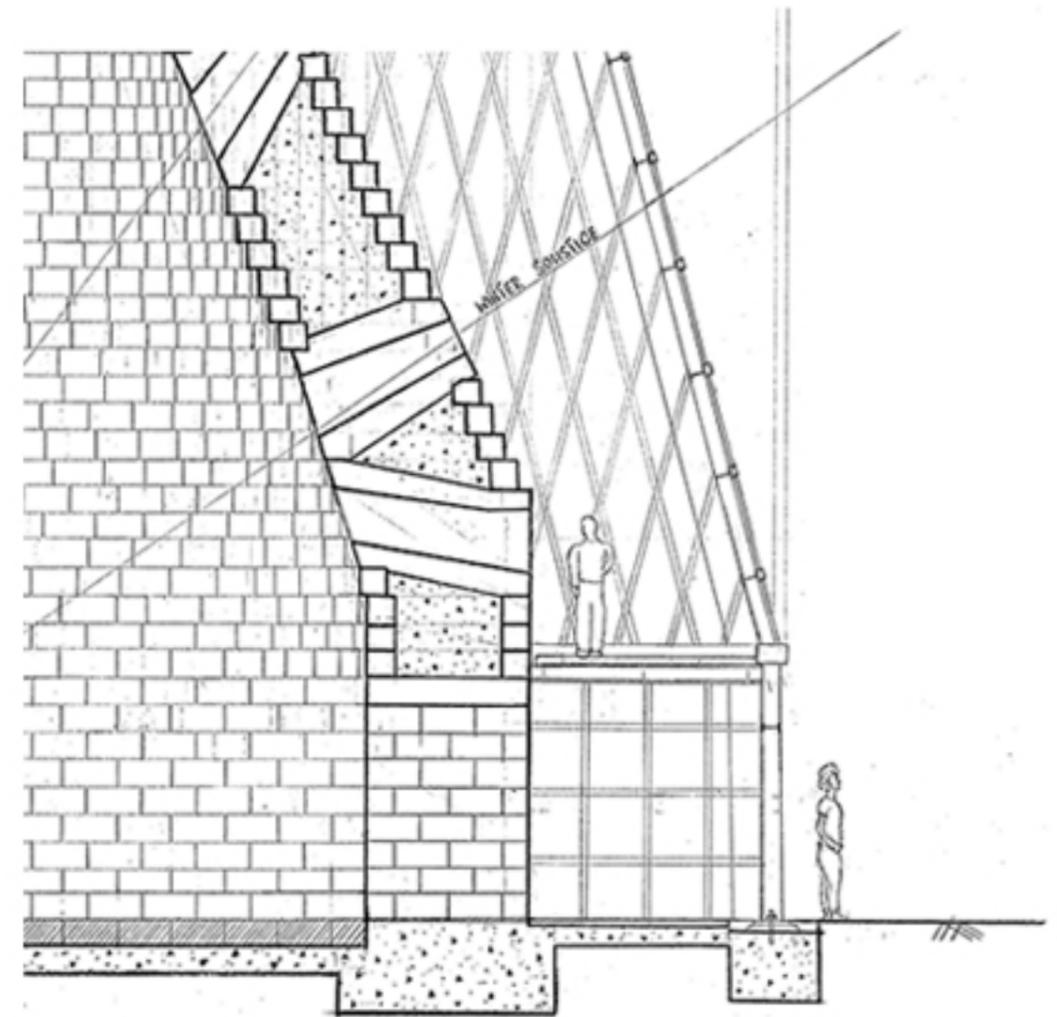
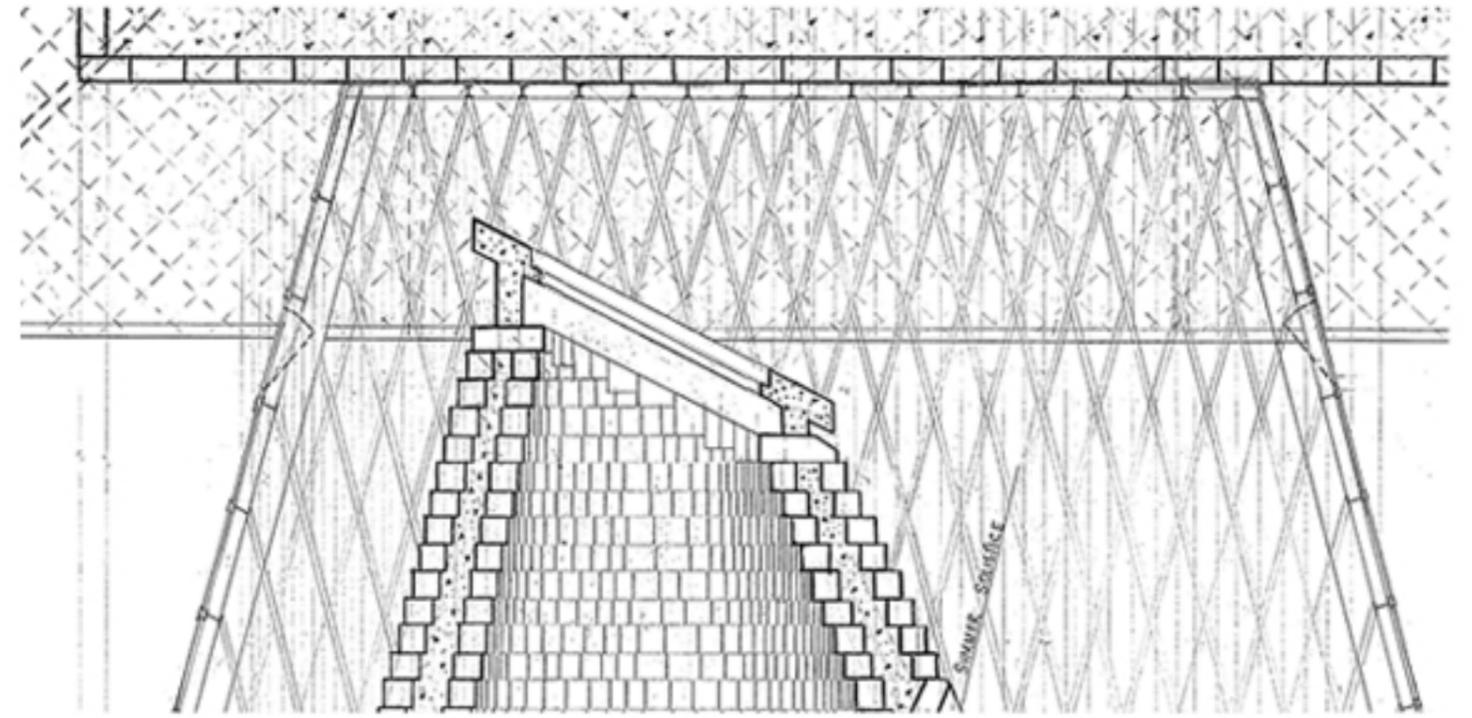


Figure 38

DETAIL SECTION

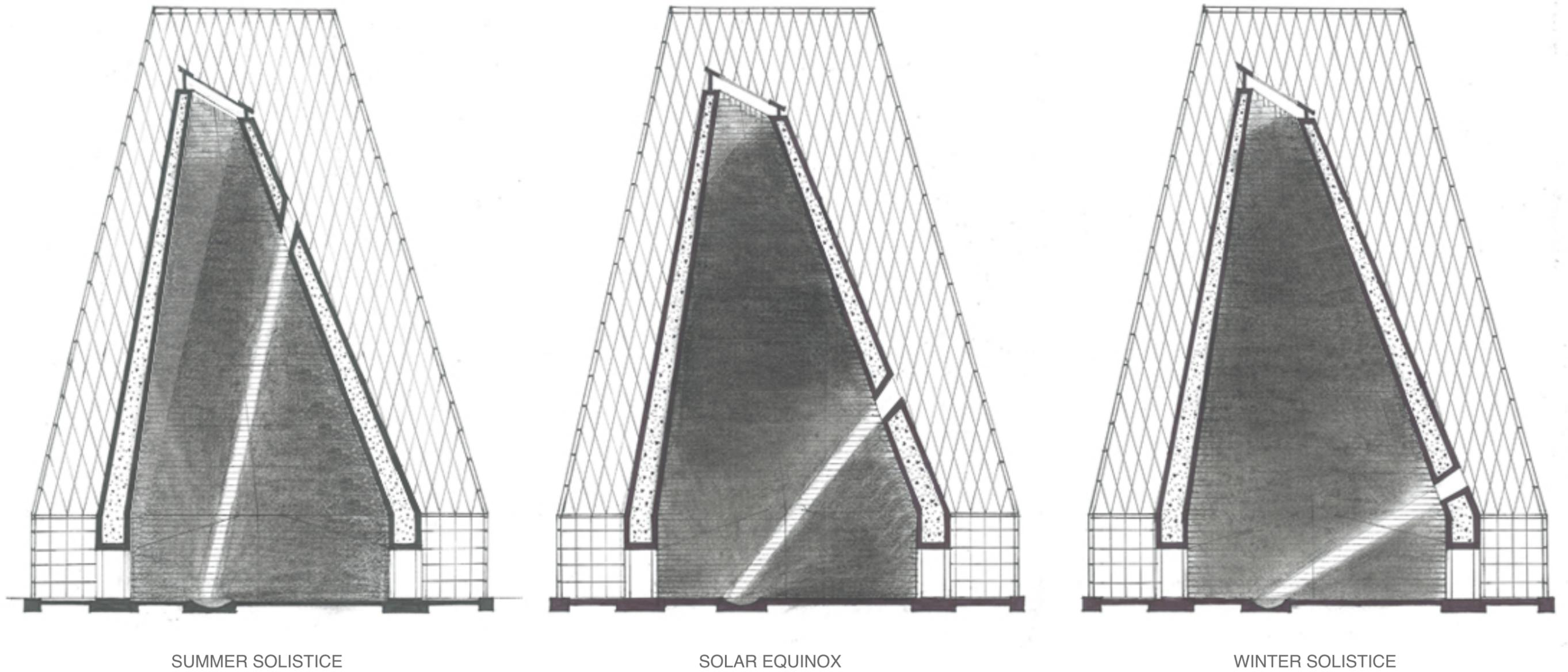
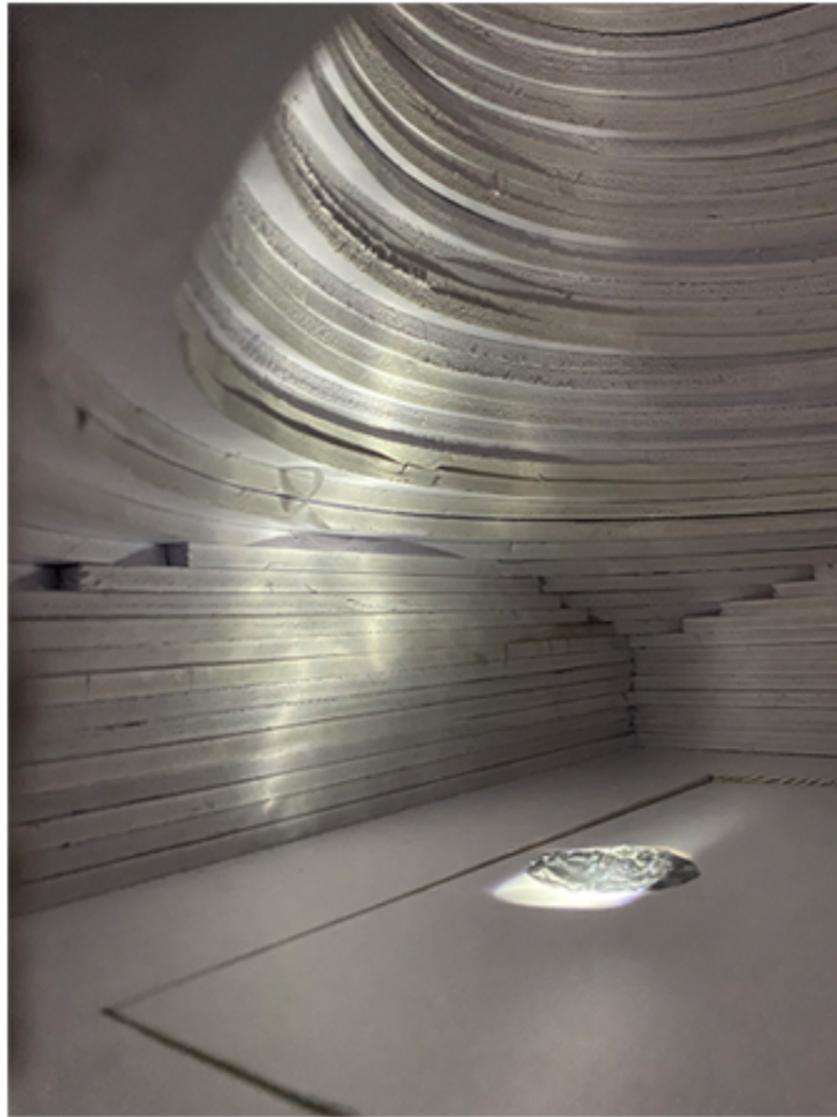
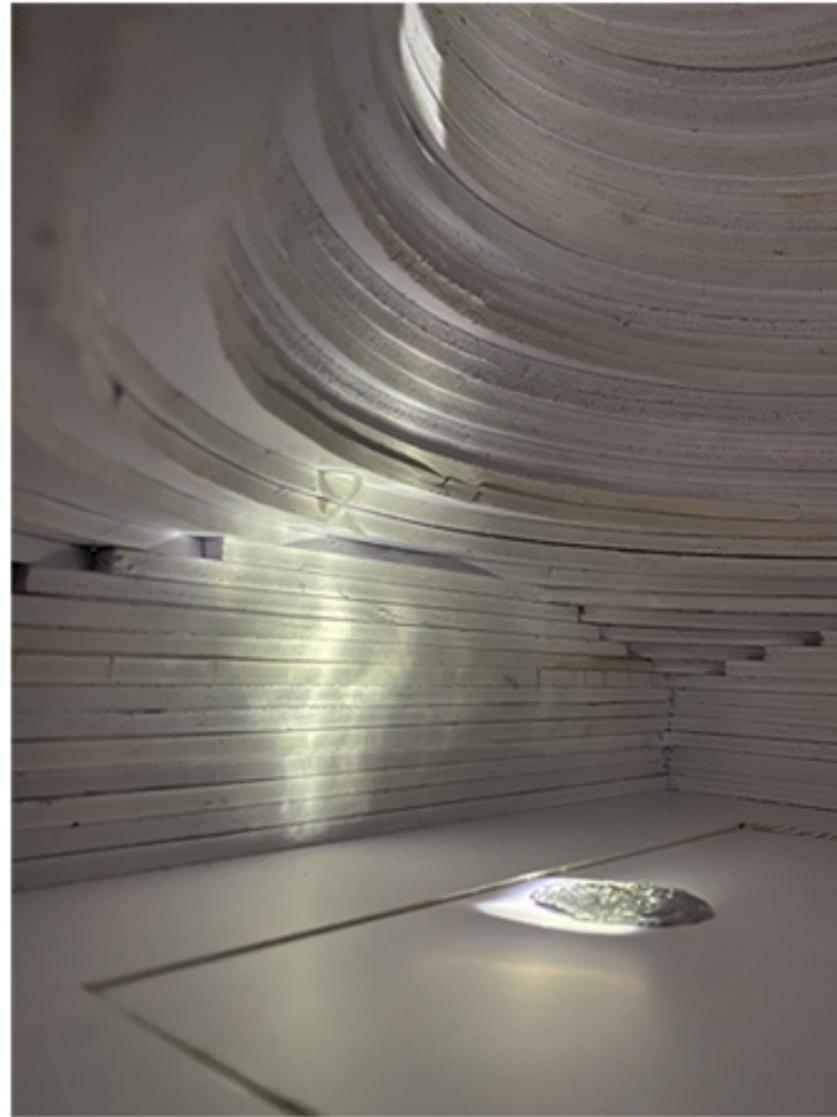


Figure 39

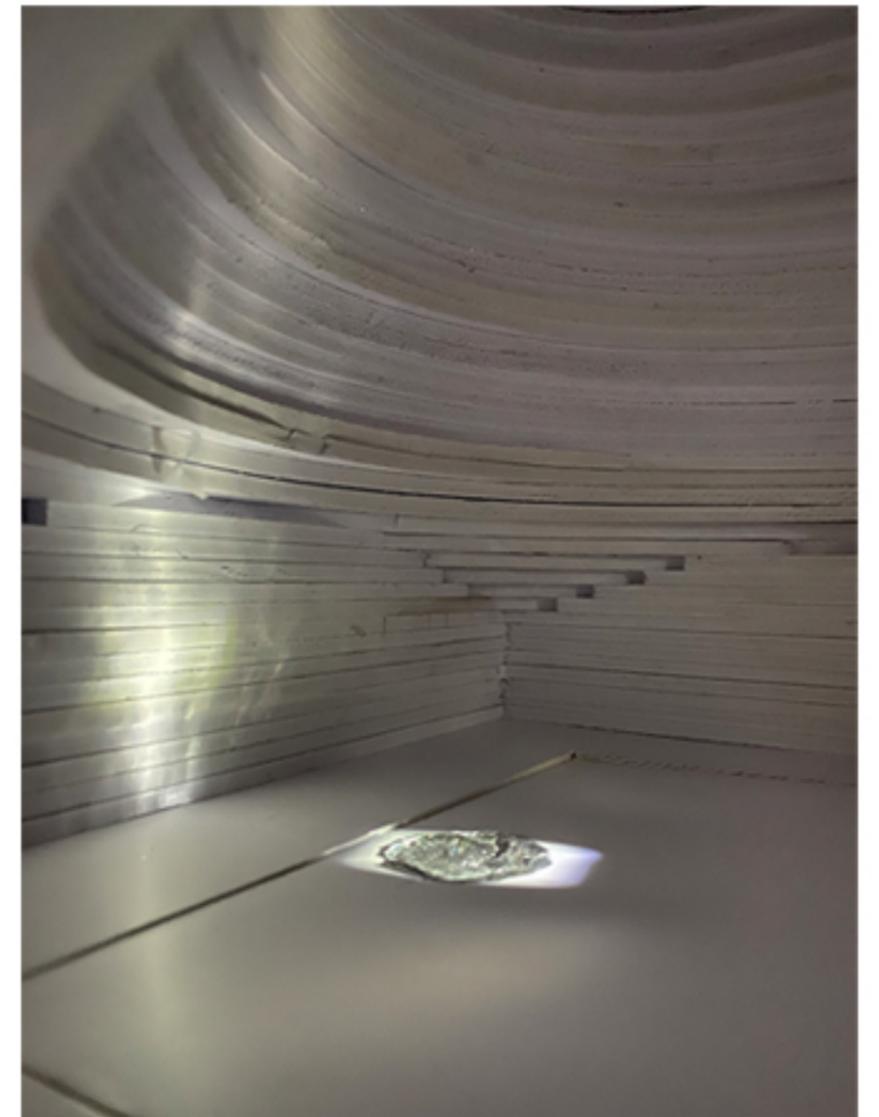
The charcoal drawings represent the desired effect to be created with the three conditions - bringing in daylight at solar noon on summer solstice, equinox and winter solstice. The slits cut in the cone allows one to experience the passing of time and making of time in a sense.



SUMMER SOLISTICE



SOLAR EQUINOX

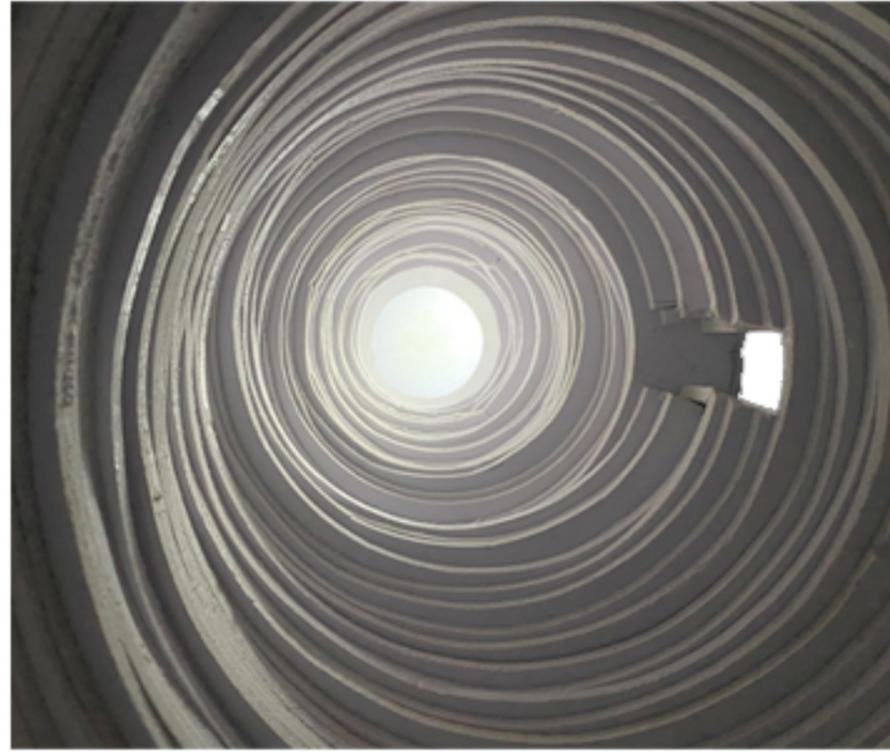


WINTER SOLISTICE

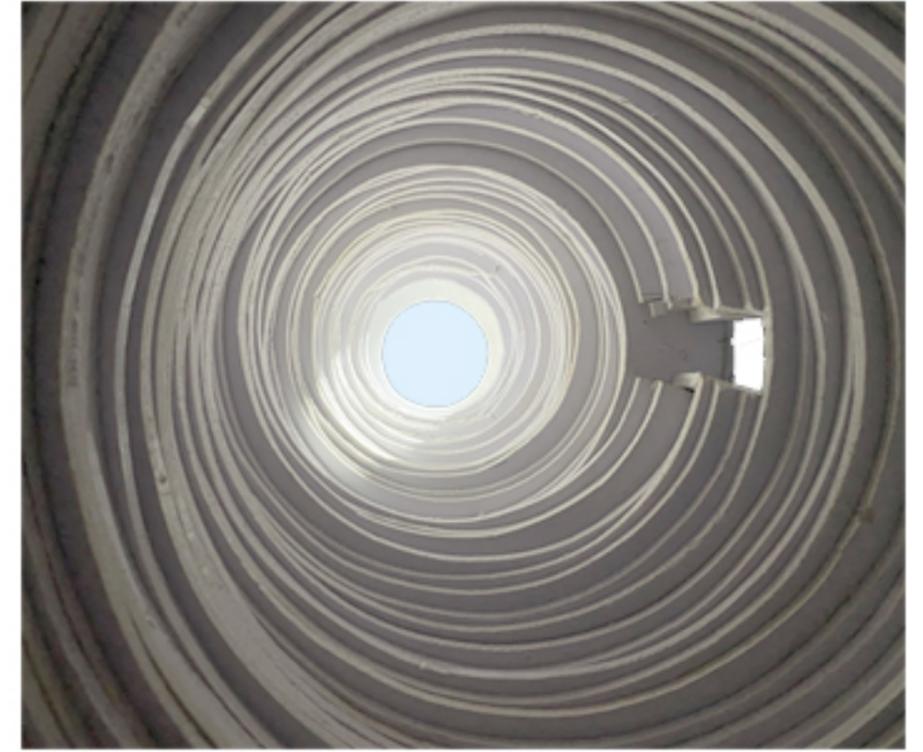
Figure 40



OPAQUE



TRANSLUCENT



OPEN TO SKY

Figure 41

TREATMENT OF THE CROWN

The exploration for the treatment of the crown lead to the decision of the openness to the sky due to the spiritual connections to the heavens that it brings.

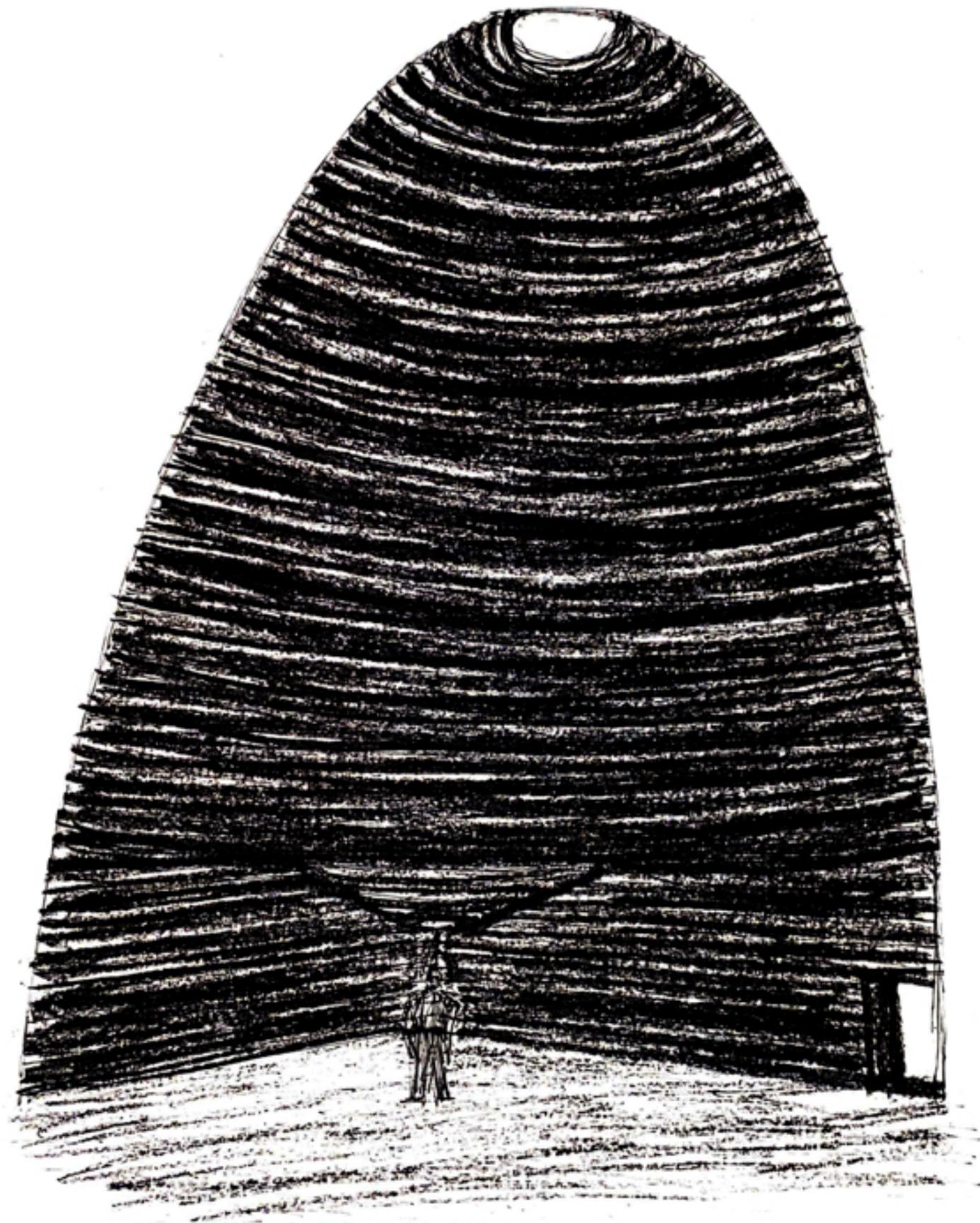


Figure 42

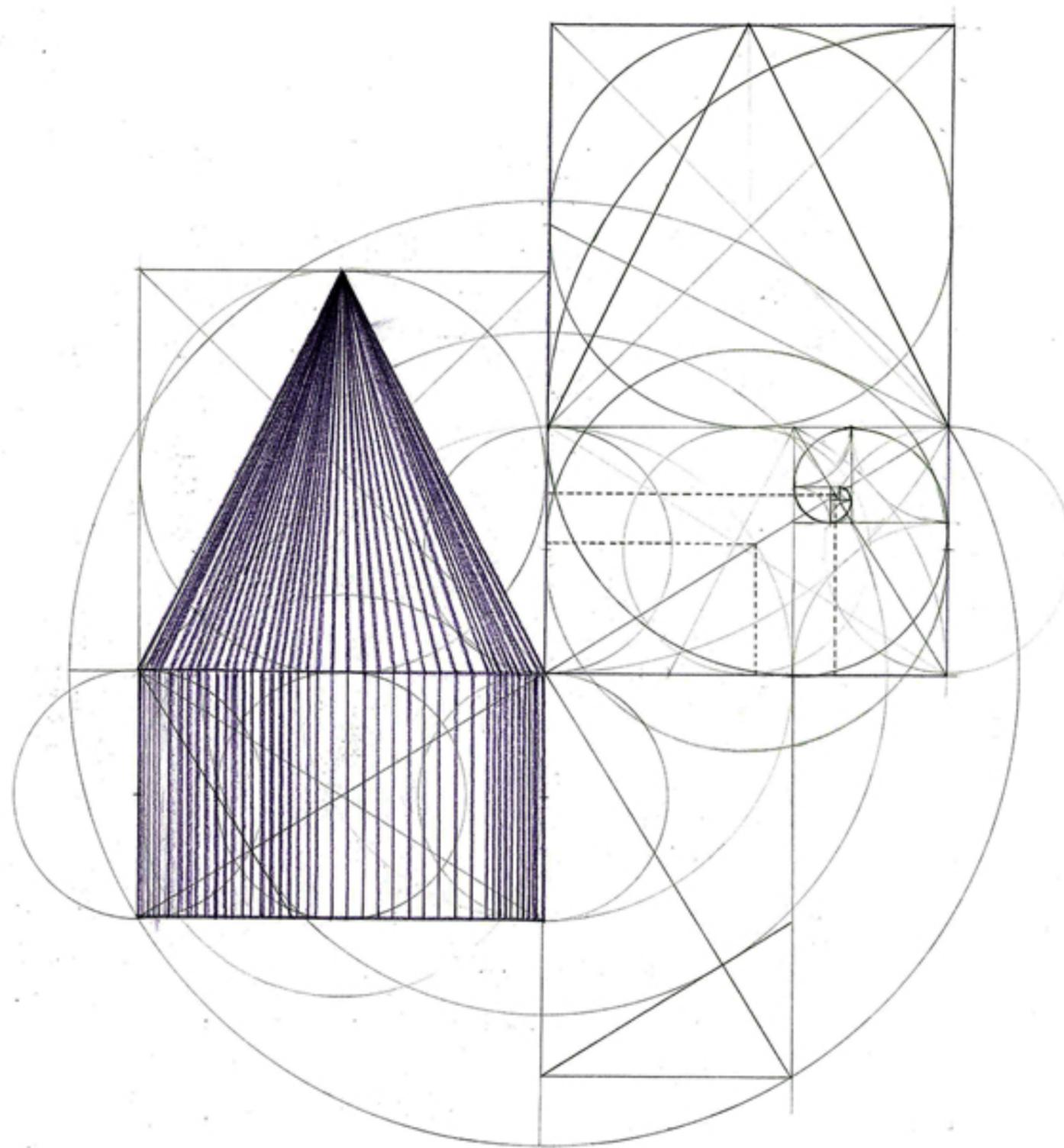


Figure 43

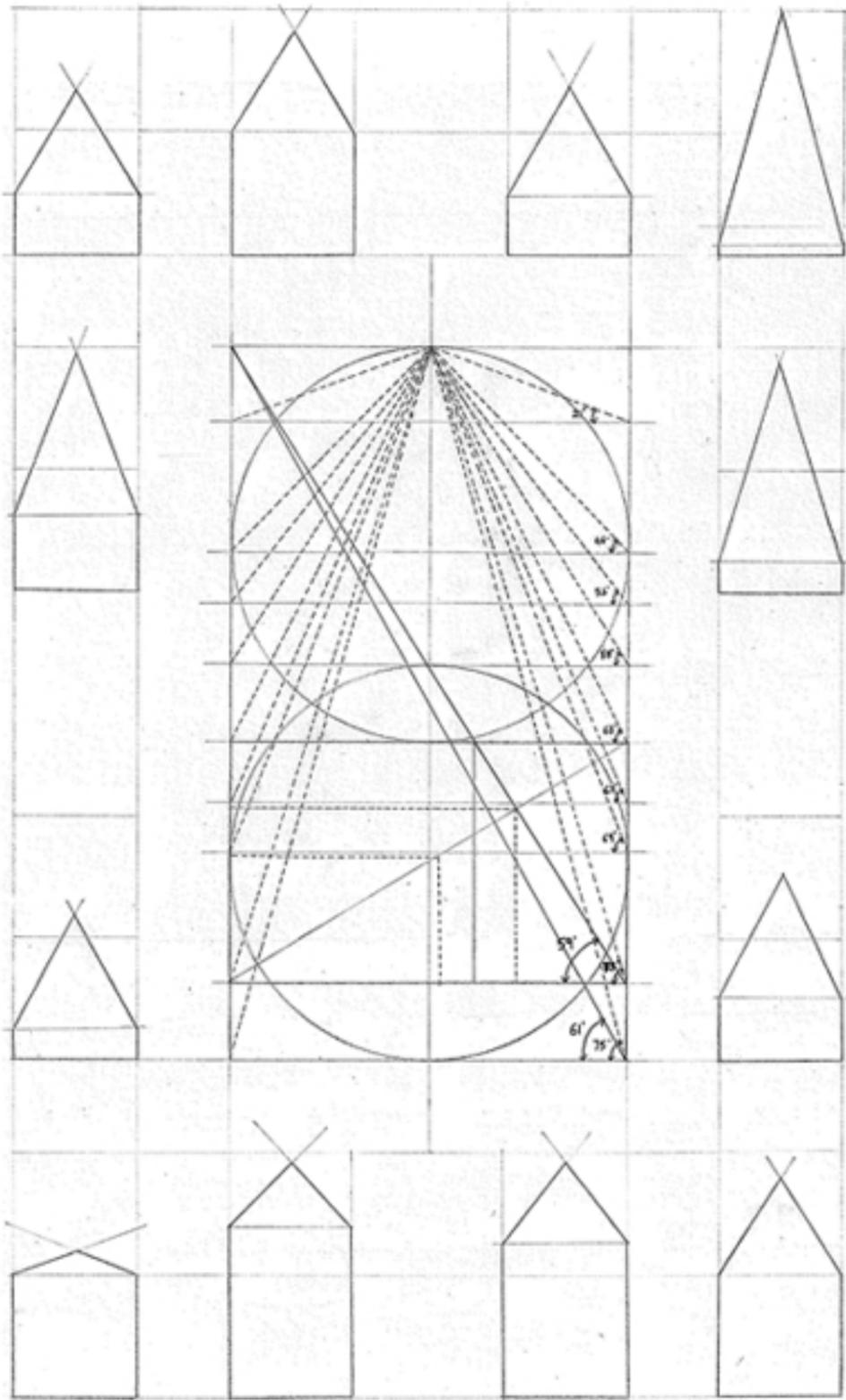


Figure 44

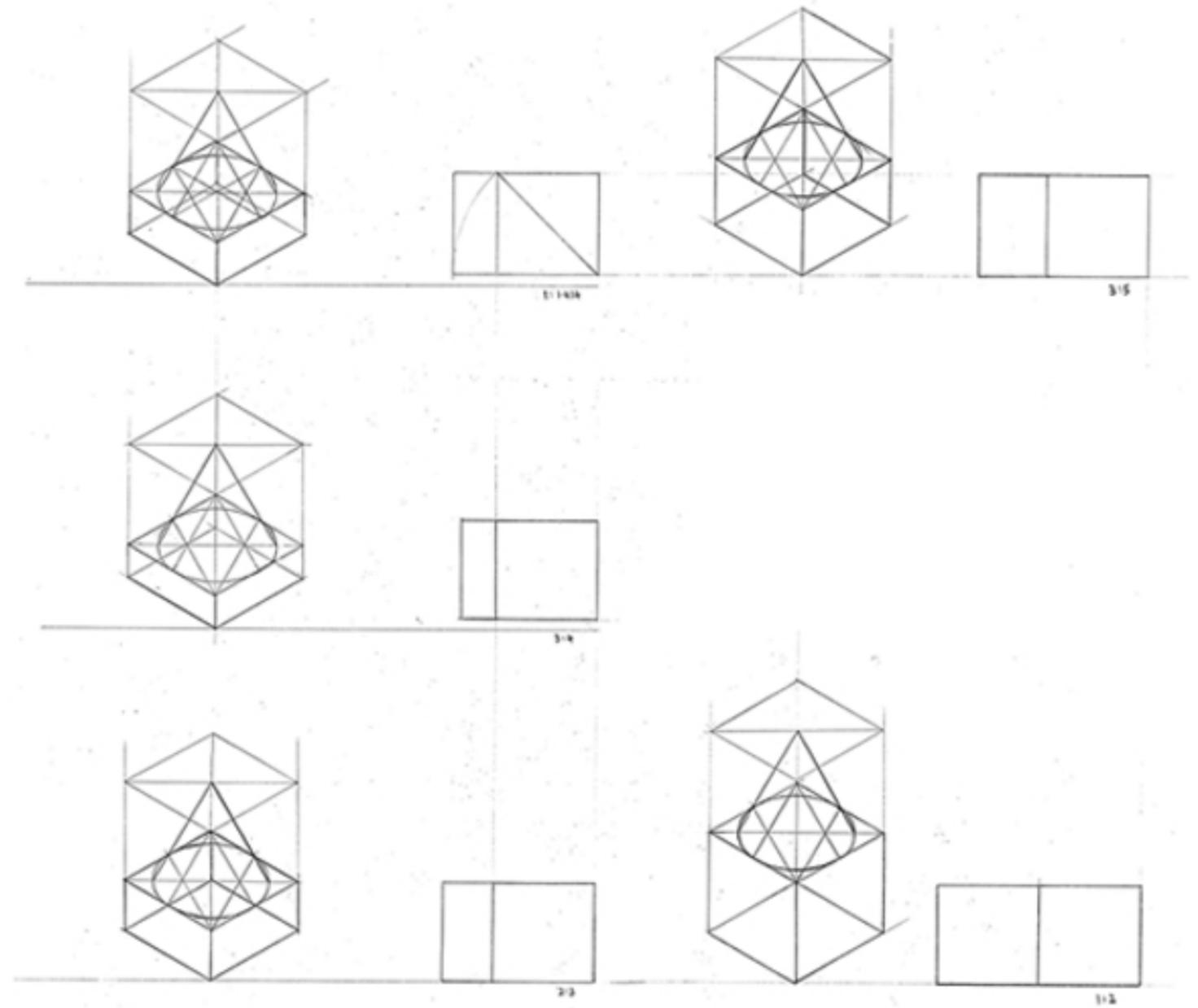


Figure 45

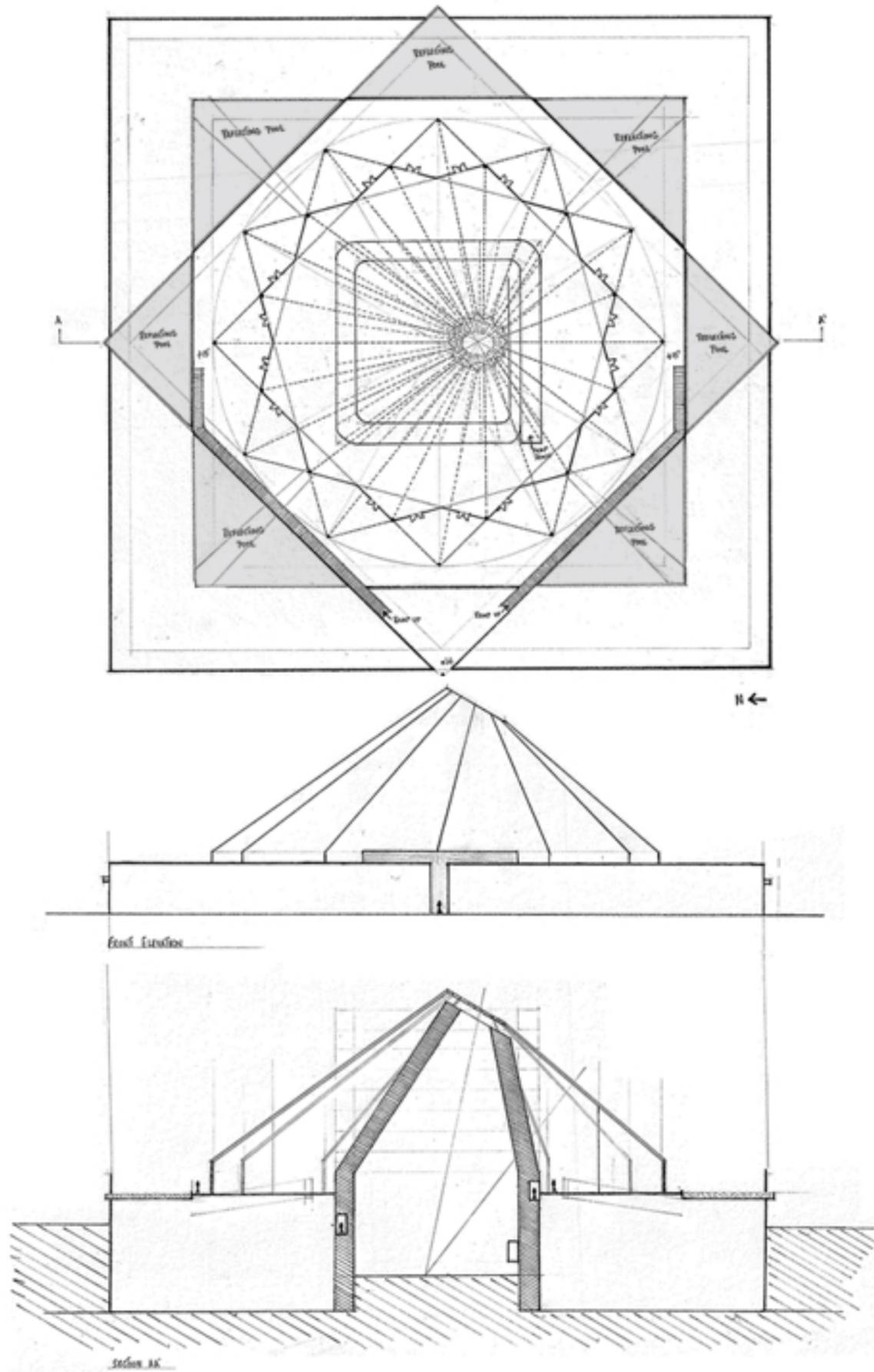


Figure 46

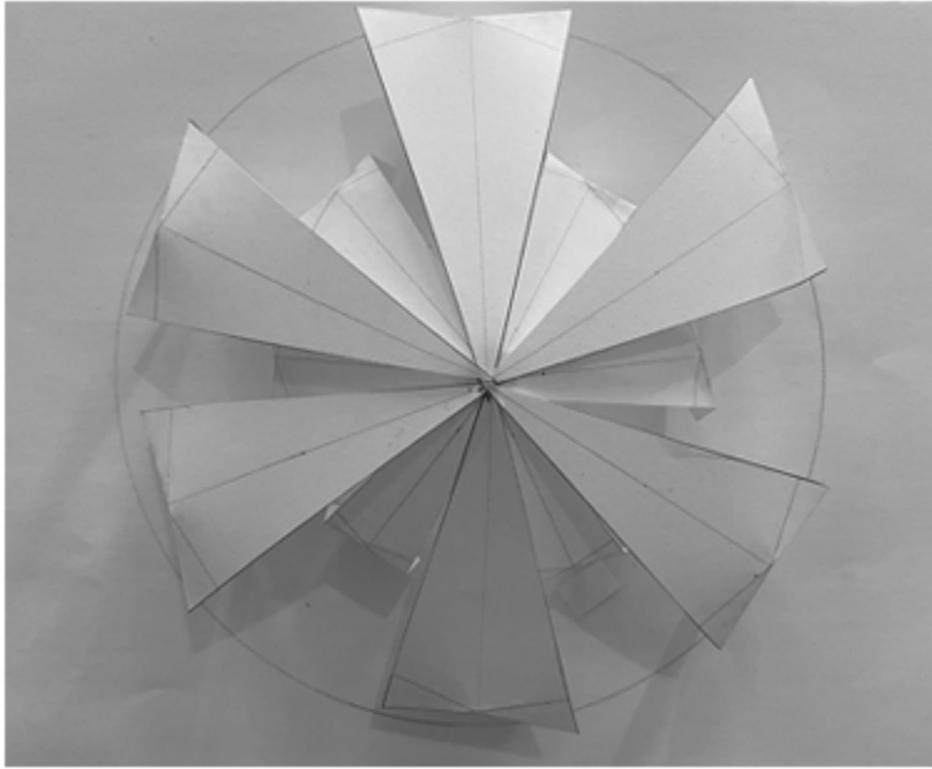


Figure 47

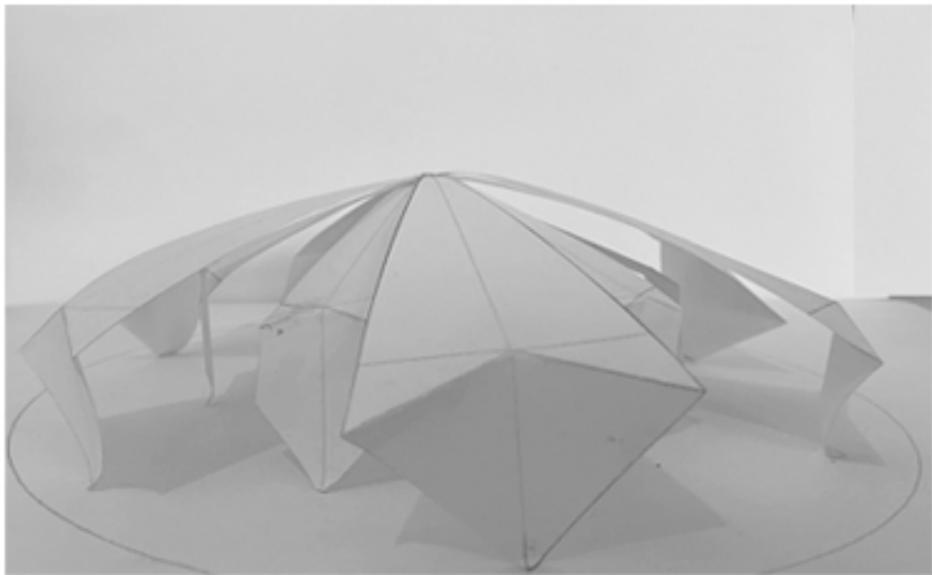


Figure 48

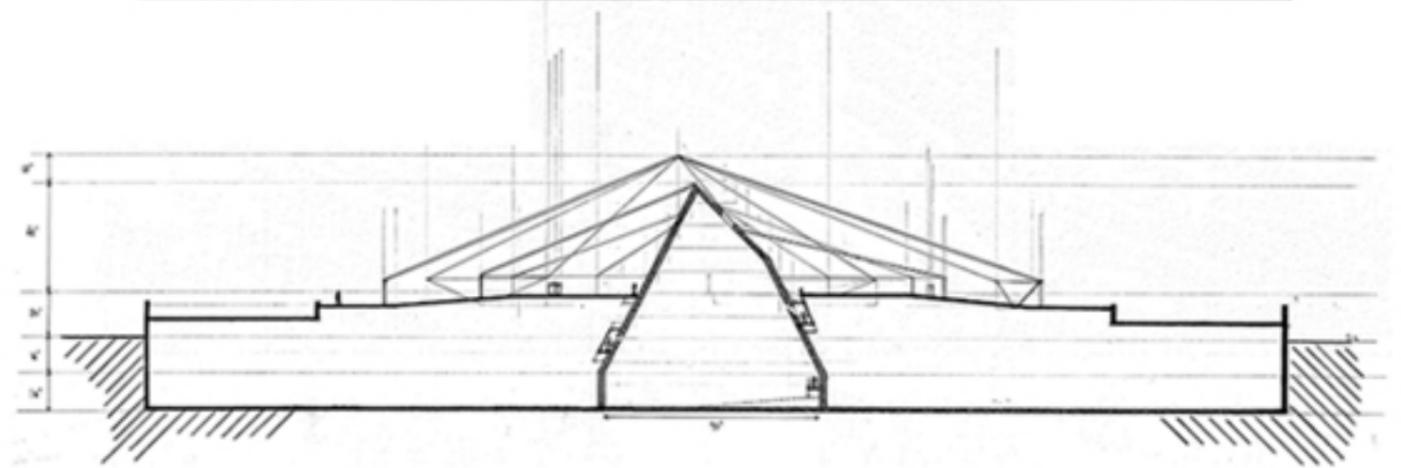
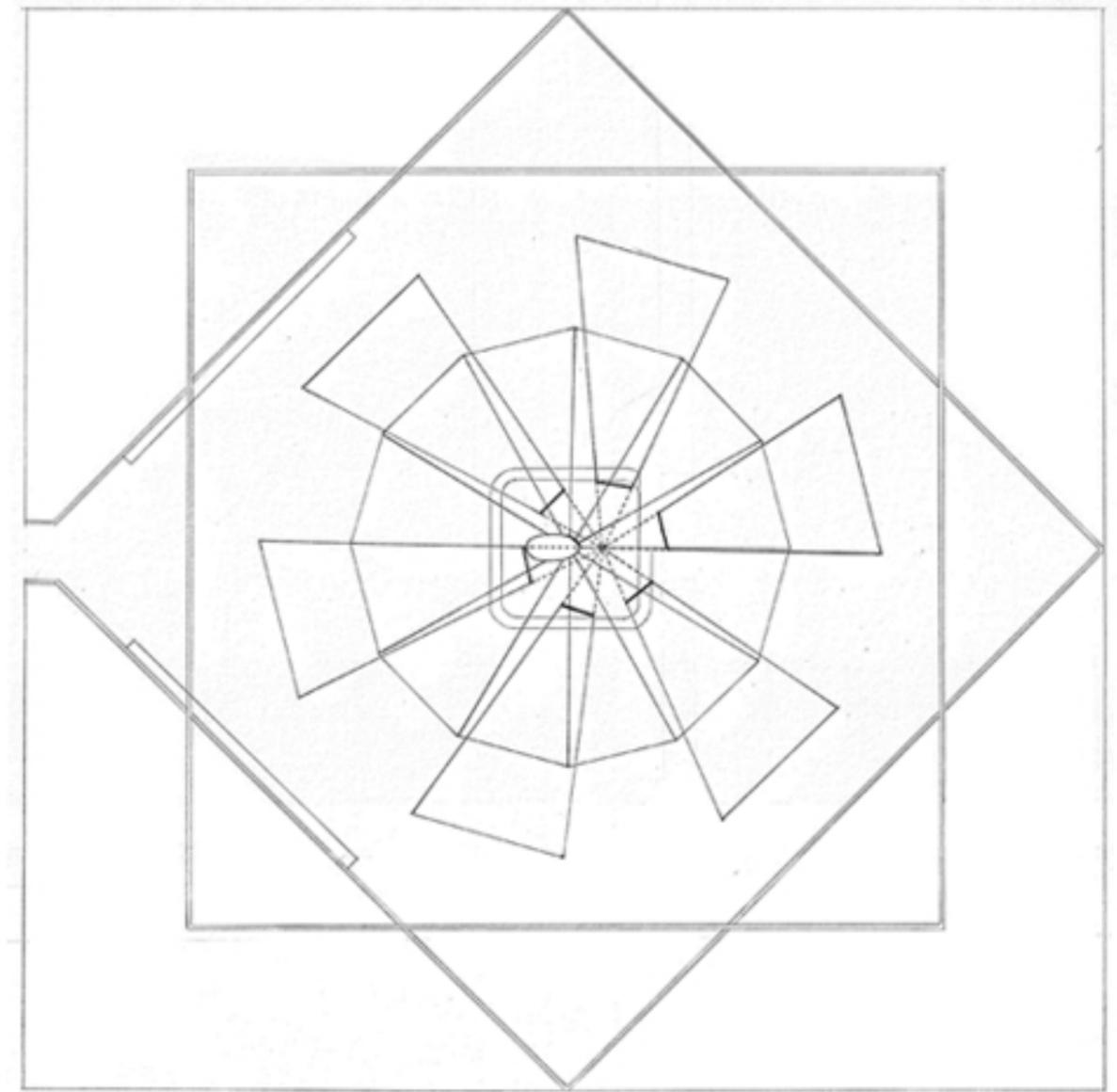


Figure 49

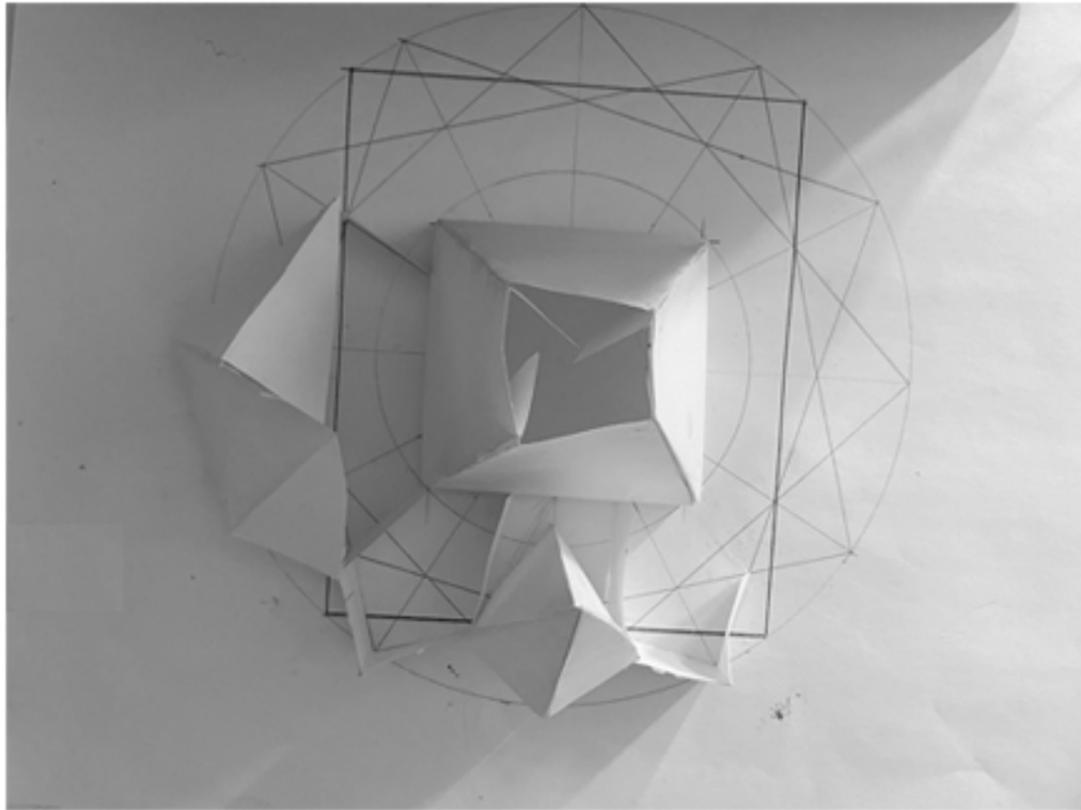


Figure 50

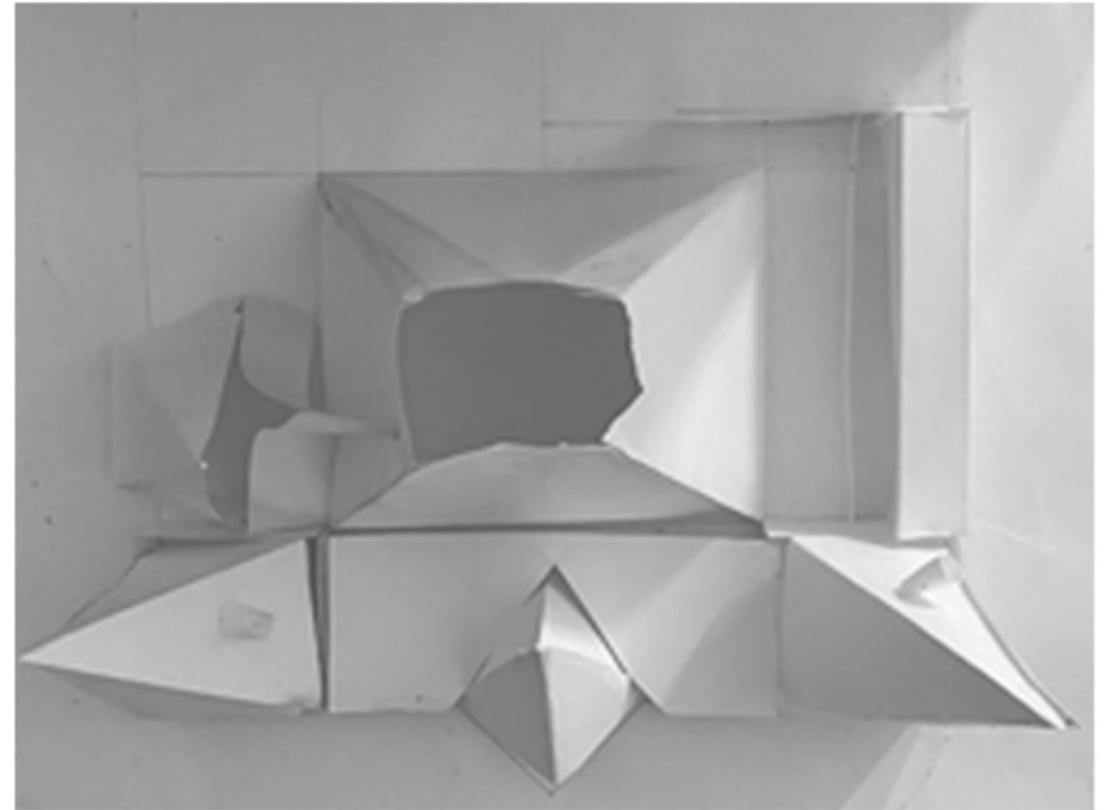


Figure 52



Figure 51

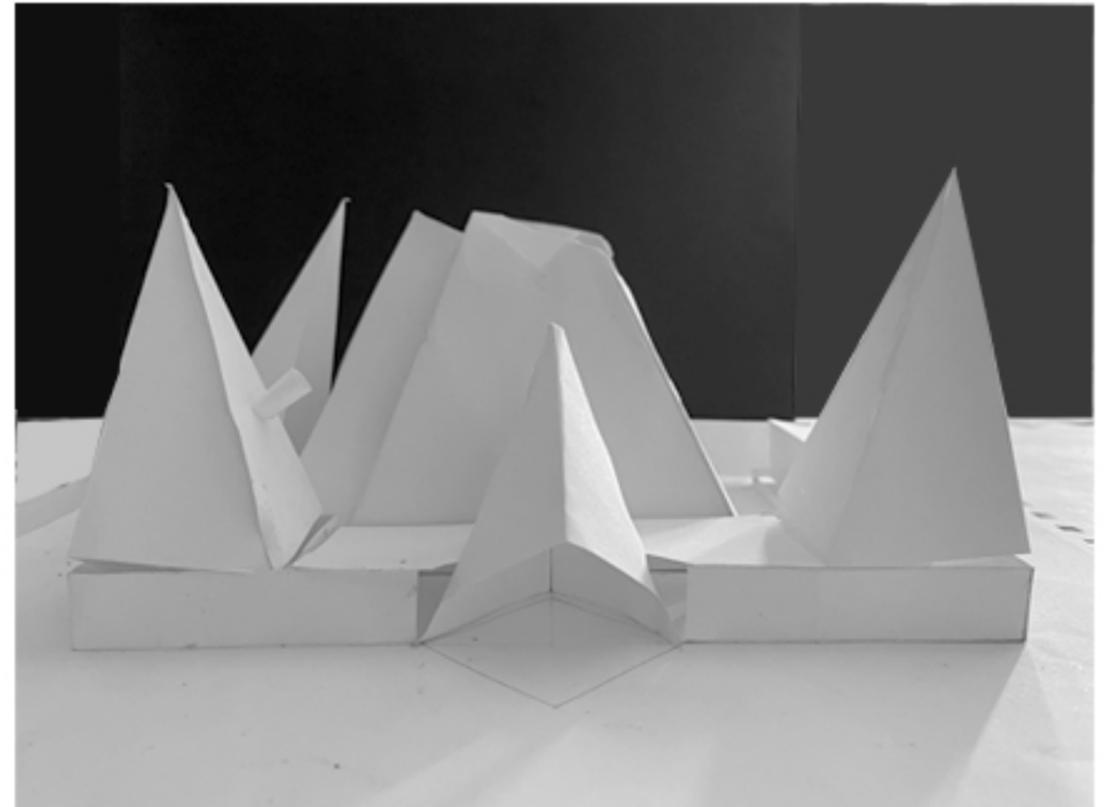


Figure 53

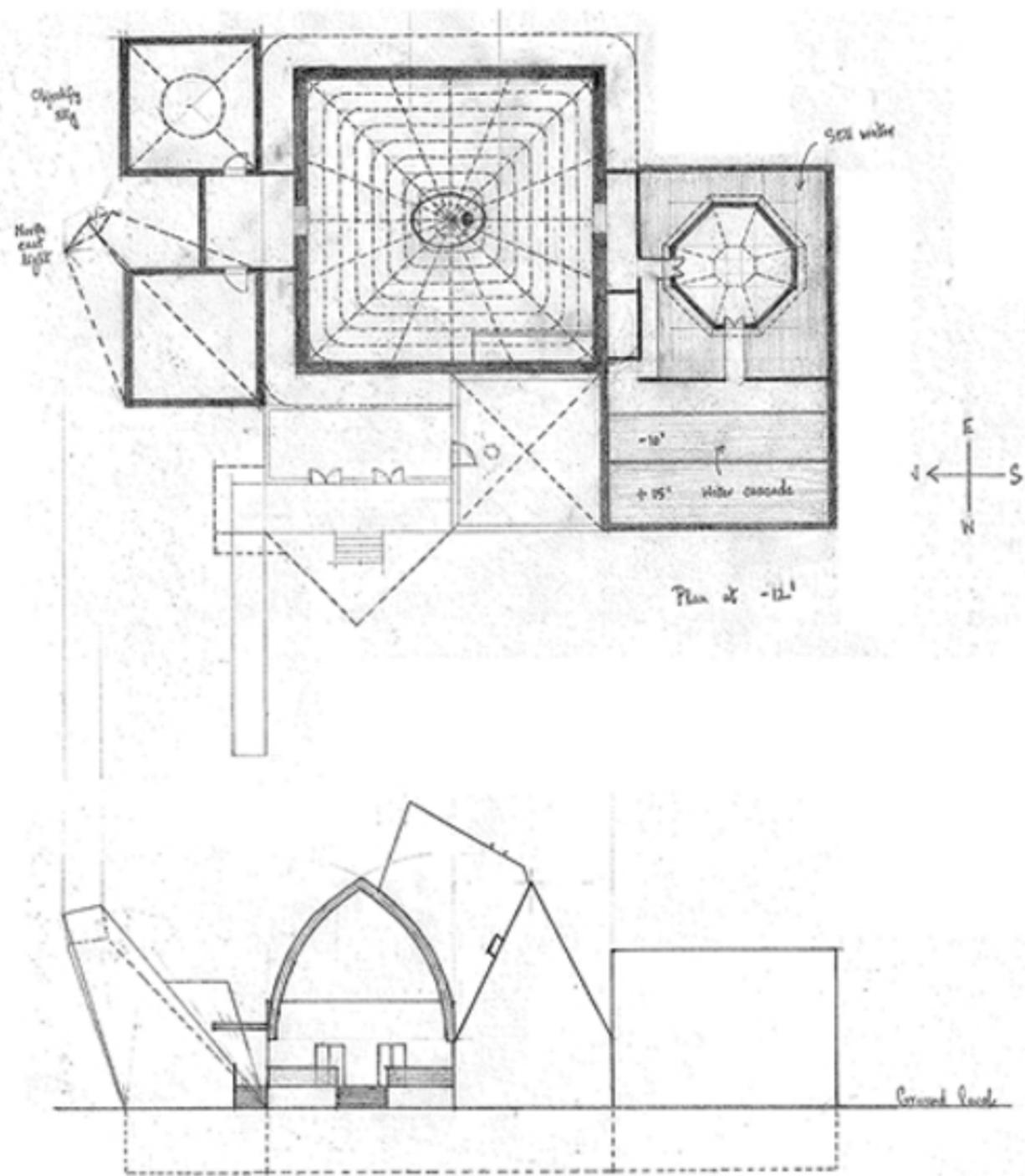


Figure 54

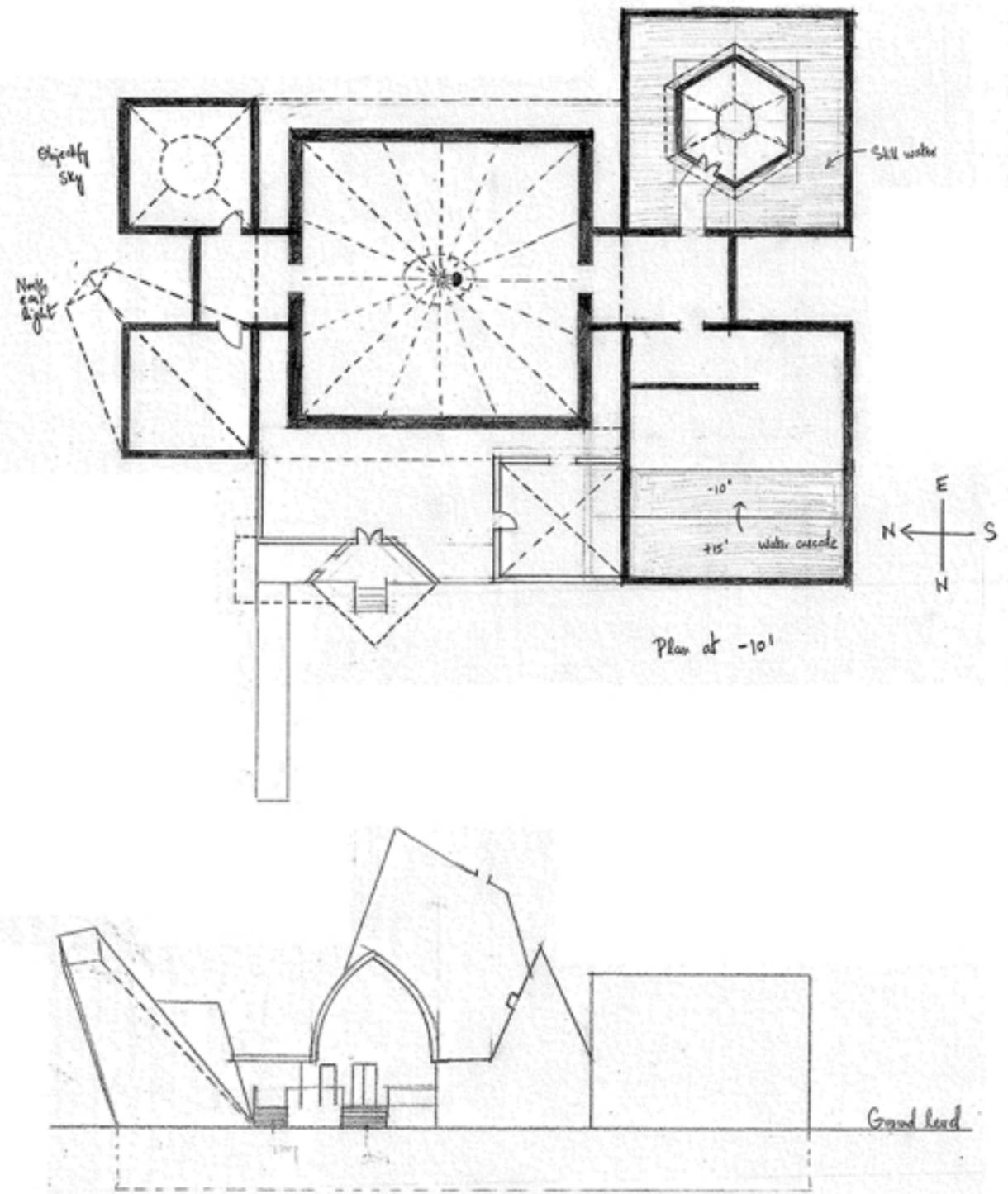
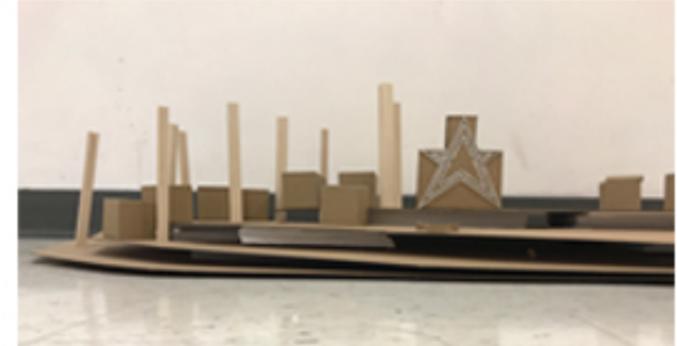
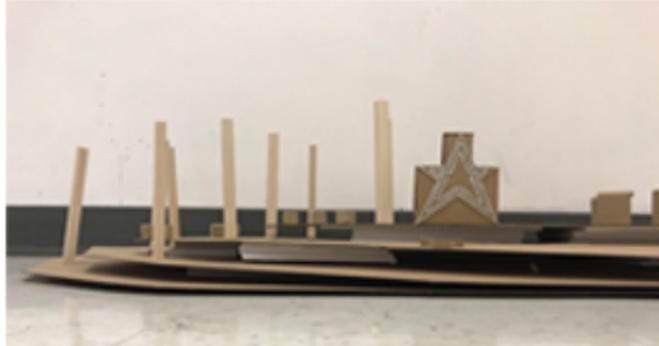
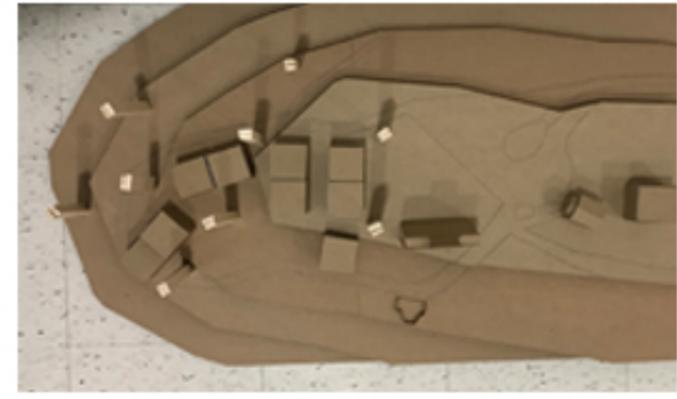
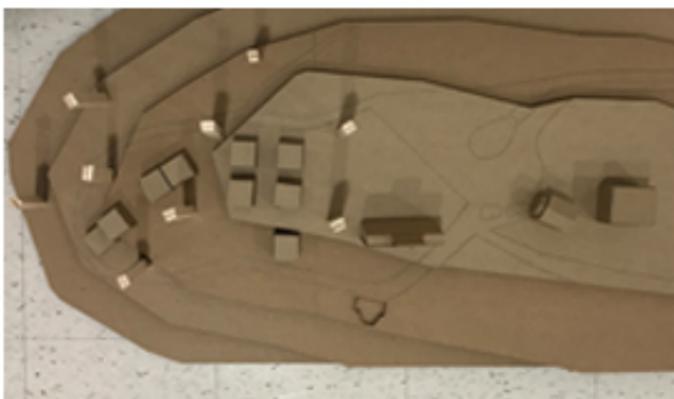
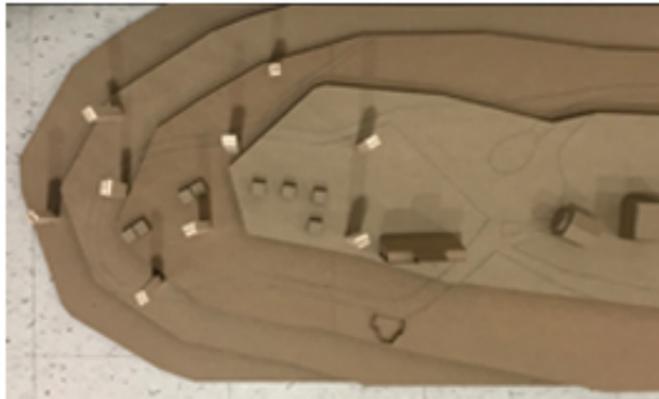
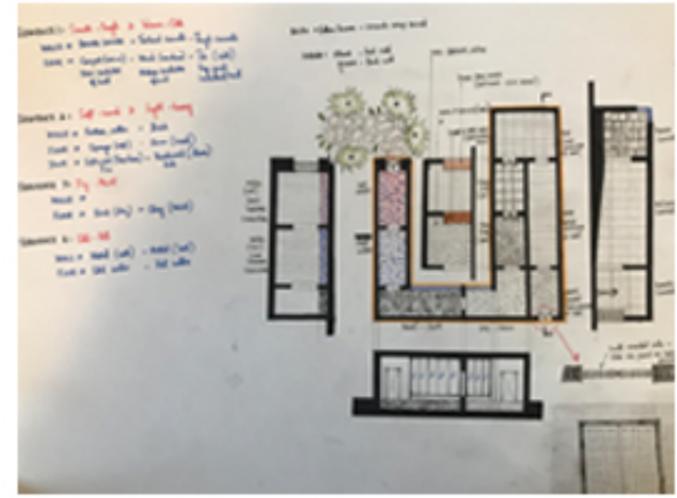
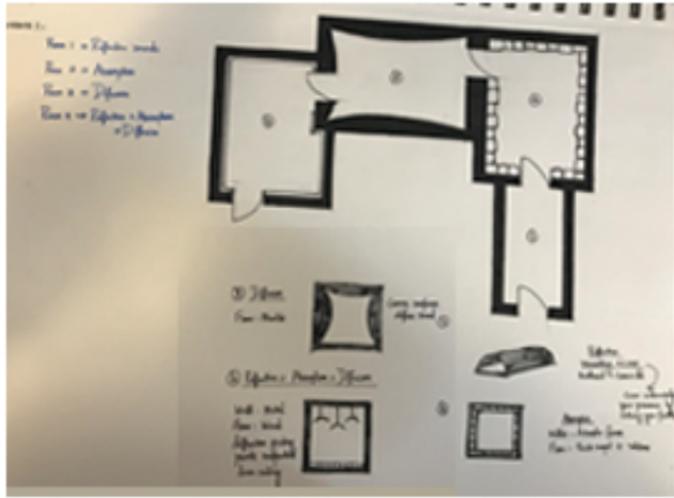
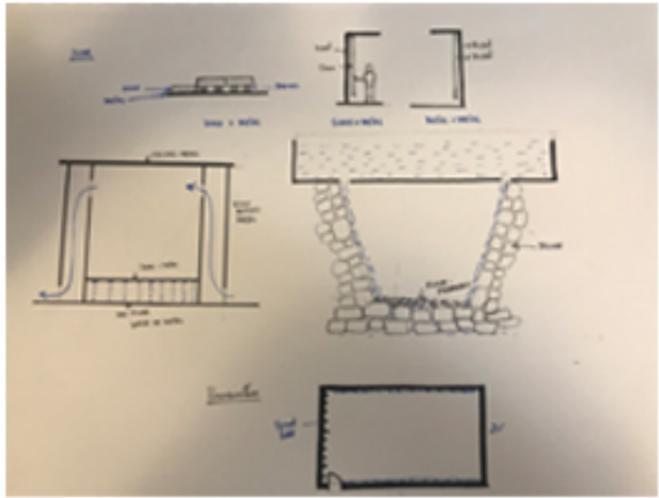
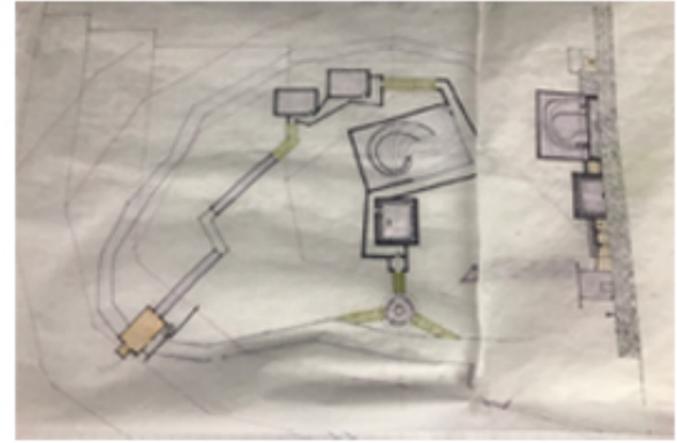
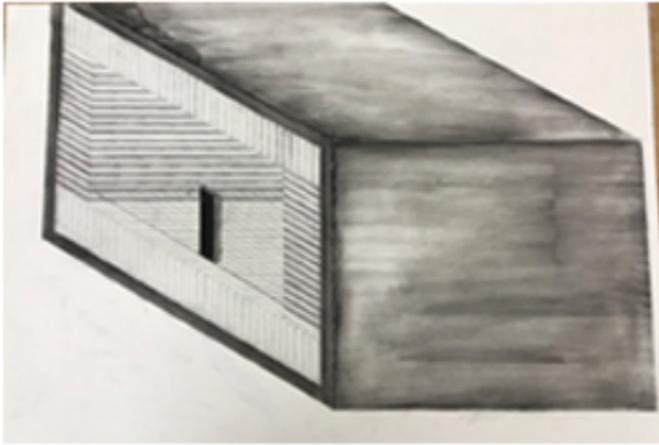
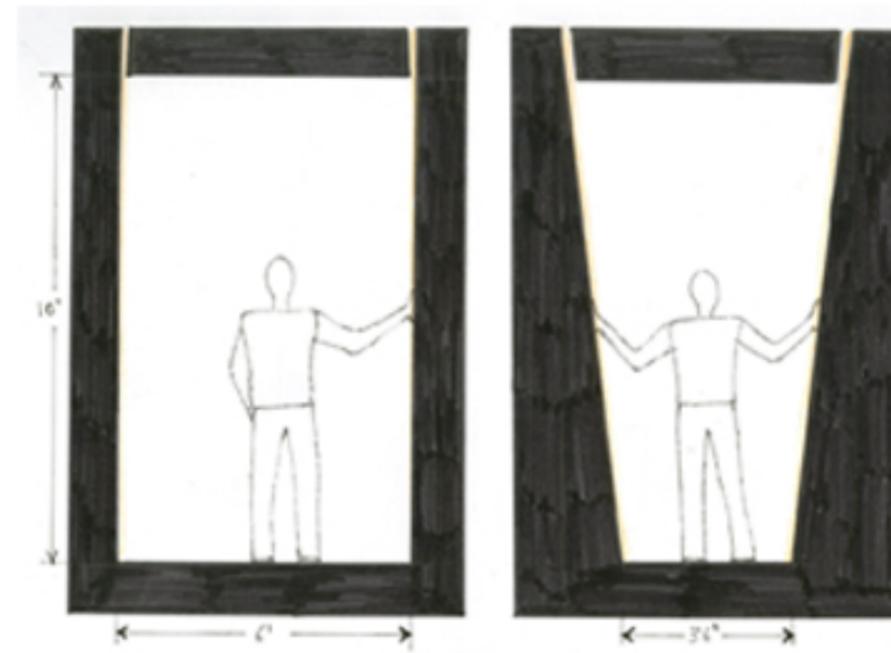
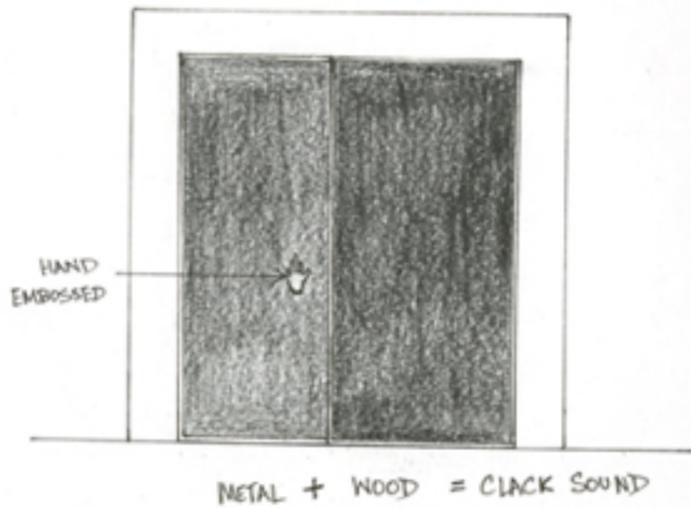
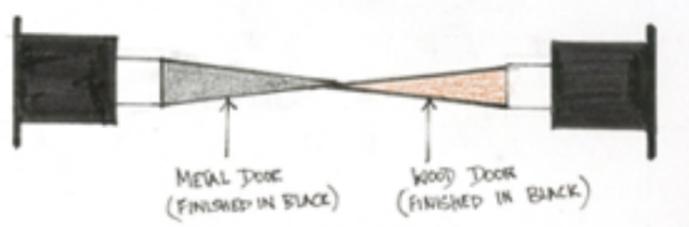
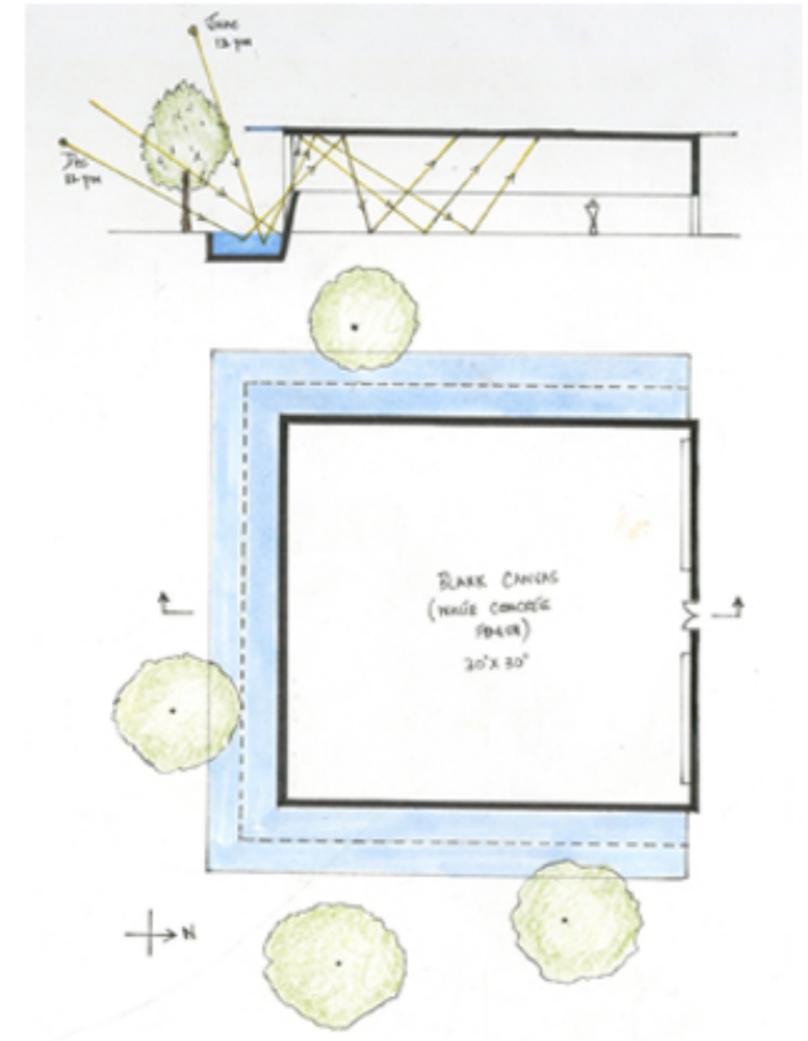
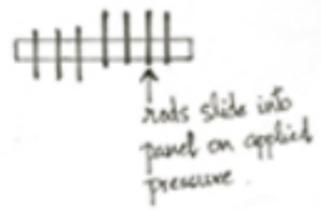
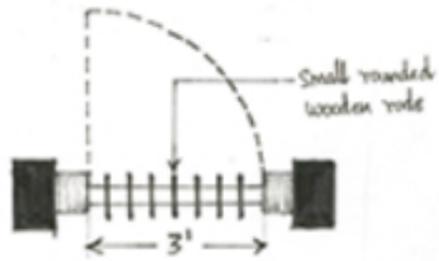
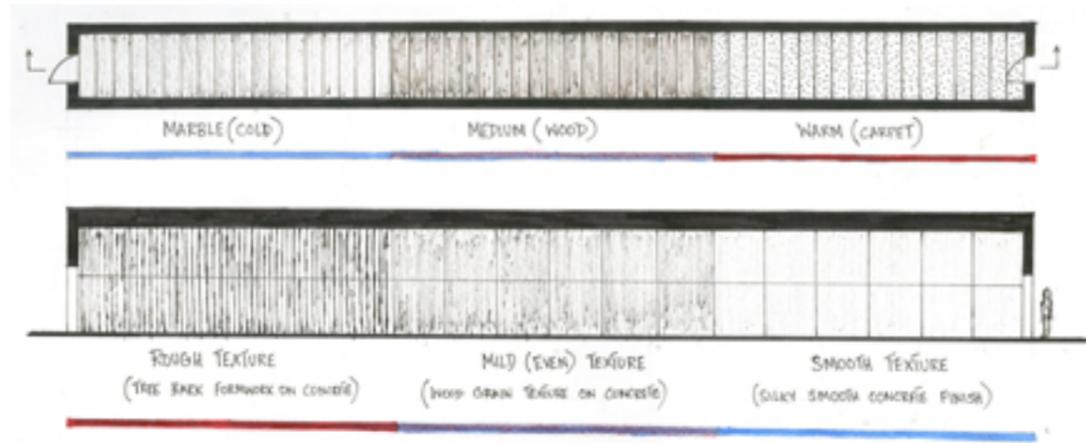
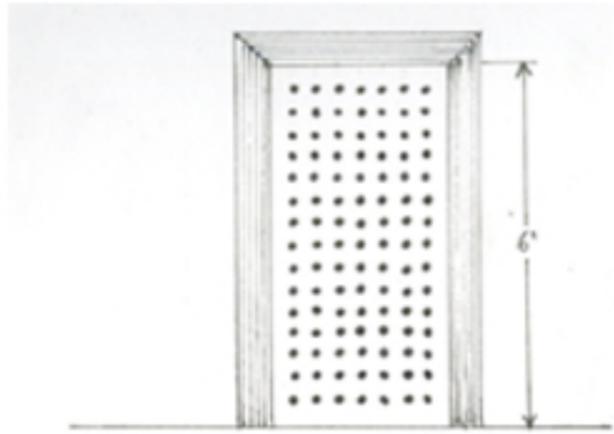


Figure 55





List of Figures

- Figure 1 Bird's eye view of the building | Ink on Paper | Light and Shadow rendering using Charcoal
- Figure 2 Mill Mountain star Photograph | L.Higgins, Casey. Photograph of "Iconic Mountains: Mill Mountain in Virginia's Blue Ridge". Virginia's Blue Ridge. 18 Nov 2019, <https://www.visitroanokeva.com/blog/post/iconic-mountains-mill-mountain-virginia-blue-ridge-roanoke-star-park/>. Accessed 10 October 2020.
- Figure 3 Screenshot of Google Earth Satellite Image
- Figure 4 Hand drafted Site plan drawing | Ink on Paper | Rendered on Photoshop
- Figure 5 Hand drafted Site section drawing | Ink on Paper | Rendered on Photoshop
- Figure 6 Sun Path Diagram | SketchUP Model | Rendered on Photoshop
- Figure 7 Hand drafted section drawing | Ink on Paper | Rendered on Photoshop
- Figure 8 View from the oblique path leading to the building | Sketchbook page
- Figure 9 View of the waterbody from the bridge | Sketchbook page
- Figure 10 Photograph of the texture of granite | Grabowiecki, Tomasz. "Seamless Granite Texture". Wild Textures, 23 May 2016, <http://www.wildtextures.com/options/seamless/seamless-granite-texture/>, Accessed 28 November 2020.
- Figure 11 View of a person walking down the ramp in the steel+glass enclosure while experiencing the surface of the cone | Sketchbook page
- Figure 12 View of a person looking into the conoid through an opening while walking down the ramp | Sketchbook page
- Figure 13 Hand drafted section drawing | Ink on Paper | Rendered on Photoshop
- Figure 14 Hand drafted Ground floor plan drawing | Ink on Paper | Rendered on Photoshop
- Figure 15 Hand drafted Basement floor plan drawing | Ink on Paper | Rendered on Photoshop
- Figure 16 Plan and section drawing of the skewed cone on a cubic base | Hand drafted
- Figure 17 Plan and section drawing of the skewed cone on a cubic base | Hand drafted
- Figure 18 Church at Firminy, France | Photograph | iPhone 11 Pro max
- Figure 19 Church at Firminy, France | Sketchbook page
- Figure 20 Baptistery at Pisa, Italy | Photograph
Catarinella Massimo, *A photograph taken of the Campo dei Miracoli in Pisa*, 27 October 2006, 3456 x 2304 (2.81MB). <https://commons.wikimedia.org/wiki/File:CampodeiMiracoliPisa.jpg>
- Figure 21 Baptistery at Pisa, Italy | Sketchbook page
- Figure 22 Plan and Section drawing | Hand drafted
- Figure 23 Plan and Section drawing | Hand drafted
- Figure 24 Plan and Section drawing | Hand drafted
- Figure 25 Drawing for the truncated opening of the cone | Hand drafted
- Figure 26 Plan and section drawing | Hand drafted
- Figure 27 Church at Mogno, Switzerland | Sketchbook page
- Figure 28 Cube + Faceted cone model | Paper | iPhone 11 Pro max
- Figure 29 Cube + Faceted cone model | Paper | iPhone 11 Pro max
- Figure 30 Cube + Faceted cone | Chipboard + wooden sticks | iPhone 11 Pro max
- Figure 31 Cube + Faceted cone | Chipboard + wooden sticks | iPhone 11 Pro max
- Figure 32 Cube + Faceted cone | Chipboard + wooden sticks | iPhone 11 Pro max
- Figure 33 Cube + Crystalline cone - Plan and section drawing | Hand drafted
- Figure 34 Cube + Crystalline cone - Plan and section drawing | Hand drafted
- Figure 35 Louvre Museum, Paris | Photograph
Lieu Song Benh, *Courtyard of the Museum of Louvre, and its Pyramid*, 8 October 2010, 6740 x 2832 (2.83MB). https://commons.wikimedia.org/wiki/File:Louvre_Museum_Wikimedia_Commons.jpg
- Figure 36 Louvre Museum, Paris | Sketchbook page
- Figure 37 Seattle Public Library, Seattle | Sketchbook page
- Figure 38 Hand drafted Plan and section drawing
- Figure 39 Hand drafted section drawings | Ink on Paper | Light and Shadow rendering using Charcoal
- Figure 40 Interior pictures of the hand model with light reflecting/refracting/diffusing off the reflecting pool at particular days and times of the year | PVC Foam board & Aluminium foil | iPhone 11 Pro max
- Figure 41 Interior pictures of the hand model - conical skylight using 3 different coverings | PVC Foam board | iPhone 11 Pro max
- Figure 42 View of the interior | Sketchbook page
- Figure 43 Study of golden proportion in the cube + cone with the use of golden rectangle and spiral | Hand drafted
- Figure 44 Cubic base + cone proportion study using golden rectangle and spiral | Hand drafted
- Figure 45 Cubic base + cone proportion study using Palladio's theory of proportions | Hand drafted
- Figure 46 Early Study - Plan, Elevation and Section drawing | Hand drafted
- Figure 47 Plan view of the Faceted cone model | Paper | iPhone 11 Pro max
- Figure 48 Side view of the Faceted cone model | Paper | iPhone 11 Pro max
- Figure 49 Early Study - Plan and section drawing | Hand drafted
- Figure 50 Plan view of the model | Paper | iPhone 11 Pro max
- Figure 51 View of the model | Paper | iPhone 11 Pro max
- Figure 52 Plan view of the model | Paper | iPhone 11 Pro max
- Figure 53 View of the model | Paper | iPhone 11 Pro max
- Figure 54 Plan and Elevation drawing | Hand drafted
- Figure 55 Plan and Elevation drawing | Hand drafted
- Page 38 Early Studies
- Page 39 Early Studies
- Page 40 Early studies

All photographs, models and drawings are the original work of the author unless otherwise specified.

Bibliography

Pallasmaa, Juhani. *The Eyes Of The Skin. Architecture And The Senses*. Chichester. John Wiley & Sons LTD, 2012.

Norberg-Schulz. *Genius Loci. Towards a Phenomenology Of Architecture*. New York: Rizzoli International Publication, Inc, 1980.

Zumphor, Peter. *Atmospheres*. Basel: Birkhauser, 2015.

Rasmussen, Steen Eiler. *Experiencing Architecture*. M.I.T Press Massachusetts Institute of Technology, 1962