MYSELF IN YOUR EYES - LAYERED TRANSPARENCY, OPAQUE AND REFLECTION: the Implication of Polarization in Architecture

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Abstract

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The thesis seeks to explore the different possibilities in the interaction between architectural experience and light in terms of its scientific properties. With an understanding of the complex nature of light, the goal is to focus on polarization as the main property to be studied. The thesis experiments on polarization reveal a new perception of “walls” in architecture - the perception of transparency, opaqueness and reflection is due to the orientation and layered relationship of the “walls”. This effect of polarization defines the program, form and site of the design proposal.This “polarized building” provides different kinds of space for people to have different interactions with the space and relationships with each other and with themselves.

Acknowledgements

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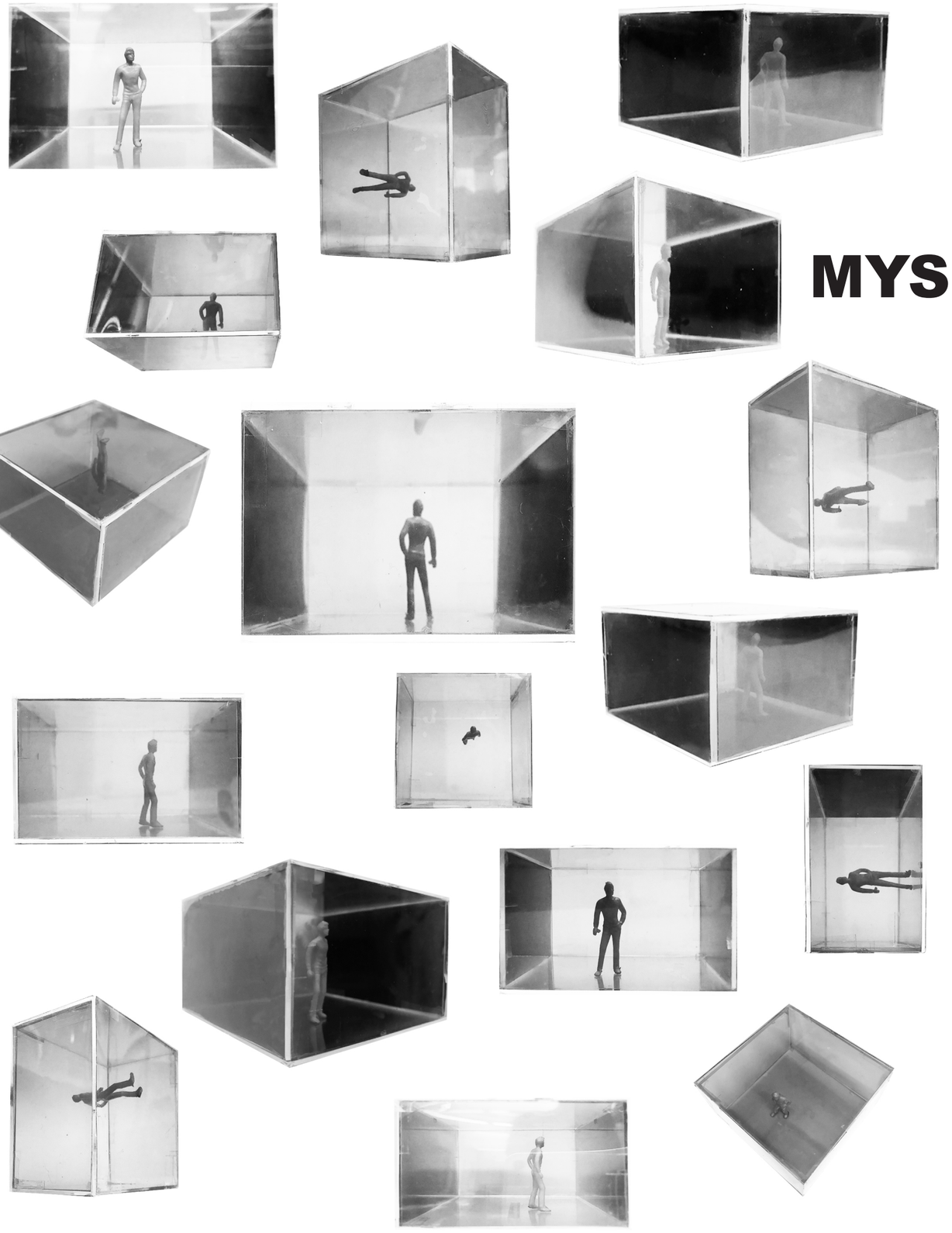

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Table of Contents

CHAPTER 1
INTRODUCTION

1.1 Topic and Issue

Light enables us to see the world around us. Our sense of sight provides us with direct information about space and time, the physical arrangement of the world, and how it changes. (Walmsey Inside cover page)

Light is one of the most fundamental elements that affects our perception of physical world around us. In architecture, the focus is often on the way geometric forms of light shape spaces. But much less attention has been given to the way light behaves as a force of energy with certain physical properties that affects the characteristics of space. In other words, the nature of light in architecture has been explored in a way that has barely changed. As Figure 1 shows, from pantheon to church of light and Louvre Abu Dhabi, the main property of light that impacts the experience is the same - transmission.

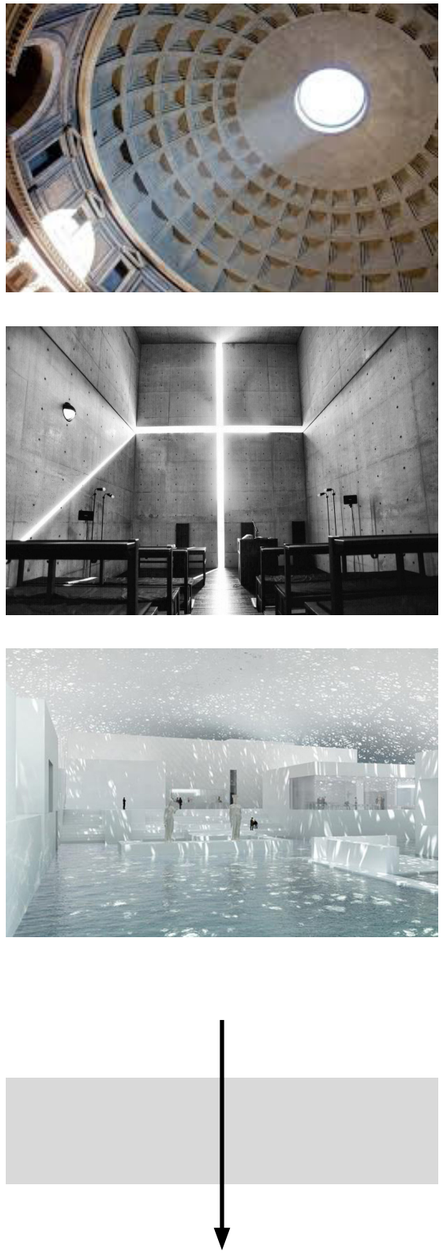
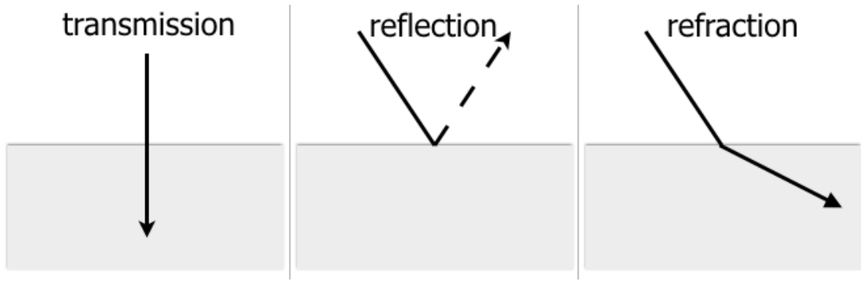
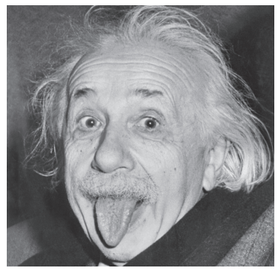


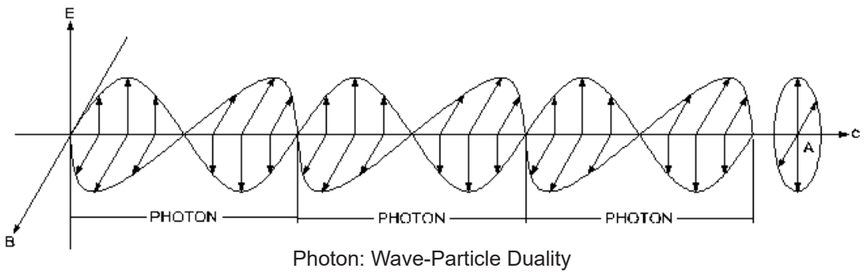
Figure 1. Transmission of Light in Architecure

(From the top: Pantheon, Rome, Italy; Tando Ando, the Church of Light, Osaka, Japan,1989; Jean Novel, Louvre Abu Dhabi, United Arab Emirates, 2017)



Particle or Wave?





Photon: Wave-Particle Duality

Figure 2. Scientific Understanding of Light

Figure 3. 3D Movie

On the other hand, our understanding of light has been fundamentally changed in scientific research from Newton to Einstein (Figure 2). Light has many other important properties in addition to the basic ones of intensity and color that are most often used in architecture. For example, polarization which relates to the wave-like behavior of light has been used in the optical and entertainment industries in ways that have changed our daily life. (Figure 3) But can these properties of light that have not been explored enough in architectural design actually influence our perception of architectural space?

transmission

reflection

refraction

color

POLARIZATION?

Figure 4. Effects of Properties of Light in Architecture

1.2 Thesis Statement

Light is the medium that connects the physical world and the perceptual realm. Different properties of light have different effects on the perception of architectural space. Architecture often relies on the most tangible properties of light such as transmission, reflection,refraction and color. But our improved scientific understanding of light reveals other aspects of the behavior of this force of energy. This thesis argues that architectural design can take advantage of the properties of light that are less tangible - specifically the character of polarization will be explored in order to expand our understanding of the impact of light on the experience of the architectural space.(Figure 4)

In addition this thesis will also examine the materials that help light to achieve its impact on the perception of space. In architecture, the focus is often on the treatment of the surfaces of the geometric forms that contain light, but the goal here is to focus on the connection between the physical and perceptual understanding of light.

1.3 Project Overview

As Figure 5 shows, the project begins with research on the scientific properties of light and its relationship to architectural experience. The literature review will first define the more widely used properties of light like transmission, reflection and refraction using case studies to show how they affect spatial experience. Then characteristics of light not typically used in architecture will be examined such as diffraction, duality, speed and time. The thesis then focuses on the characteristic of polarization to understand how it alters the perception of space in a unique way. The proposed thesis project will use the idea of “Layered Transparency, Opaque and Reflection” to these experiment with perception of space and interactions between the people who occupy it. Through experiments,the characteristics of polarization will be shown to define human behavior, inspire the site and generate the form and spatial organization of the design proposal.

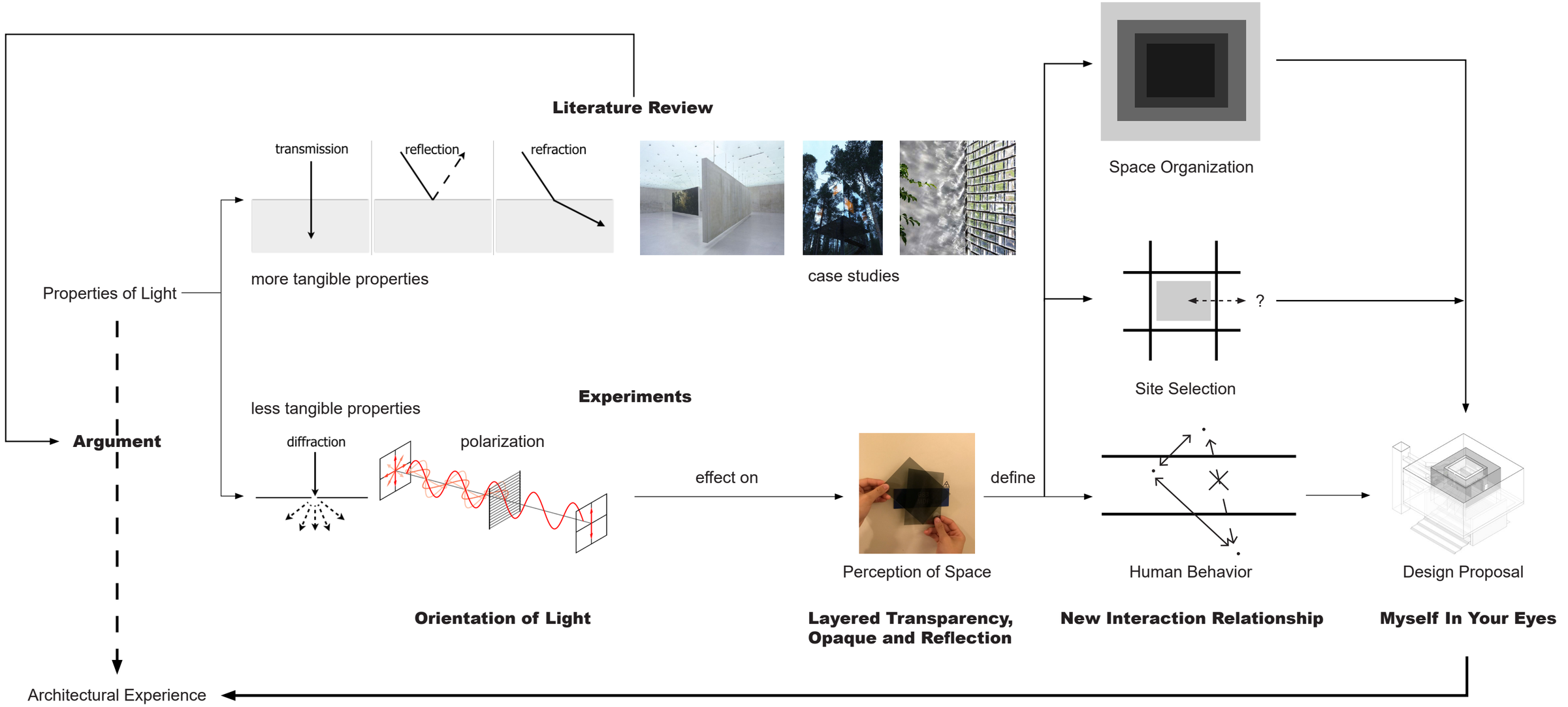


Figure 5. Project Overview

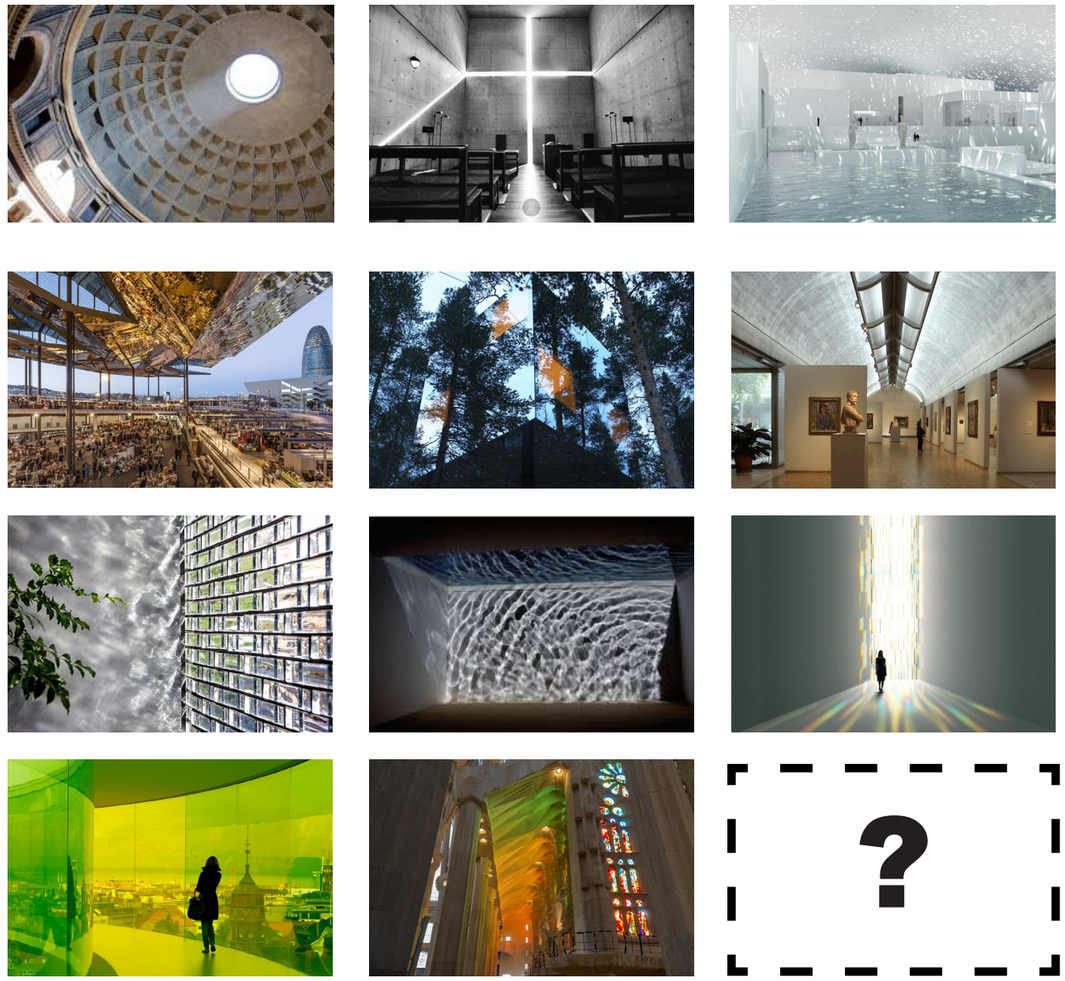


Figure 6. Light in Architecture

CHAPTER 2
LITERATURE REVIEW AND EXPERIMENTS

2.1 Brief Introduction

The thesis is seeking to explore the complex relationship between architectural experience and light in relation to scientific properties. With an understanding of the complex nature of light, the goal is to focus on polarization as the main property to be studied. The experiments in polarization reveal a potential architectural experience related to the orientation and transparency of the surfaces. It will be shown that the perception of transparency and opaqueness is due to the orientation of the “walls”. This effect of polarization defines the program, form and site of the design proposal.This “polarized building” provides different kinds of space for people to have different interactions with the space and with each other.

2.2 Properties of Light Widely Explored in Architecture

According to the International Lighting Vocabulary, “light is electromagnetic radiation within a certain portion of the electromagnetic spectrum.” (CIE) Basically, light is a form of energy that enables us to see and communicate with the physical environment around us. Ian Walmsley states that:“The capacity of light to carry and convey information is perhaps its most important, and remarkable characteristic.” (Wamsley 1) In order to understand how the properties of light shape the perception of architectural space, the research begins by studying the main properties of light which are already widely explored in architectural design through case studies.(Figure 6) Literally speaking, almost all buildings use some of the basic properties of light such as transmission and reflection. However, the case studies will show that there are other aspects of light that have a crucial impact on architectural experience.

Figure 7. the Church of Light (Osaka,Japan, 1989, Tadao Ando)

Transmission

As David Wood describes, light moves like a wave, making the objects it strikes visible. If light passes through a surface, it is called transmission. (Transmission of Light) This characteristic is very common in architectures seen in the Church of Light designed by Tadao Ando. As seen in Figure 7, a beam of light passes through a cross-shape gap of the wall to create a strong contrast between light and shadow. The amount of light that is transmitted depends on the type of light and the transmittance of the surface it passes through.

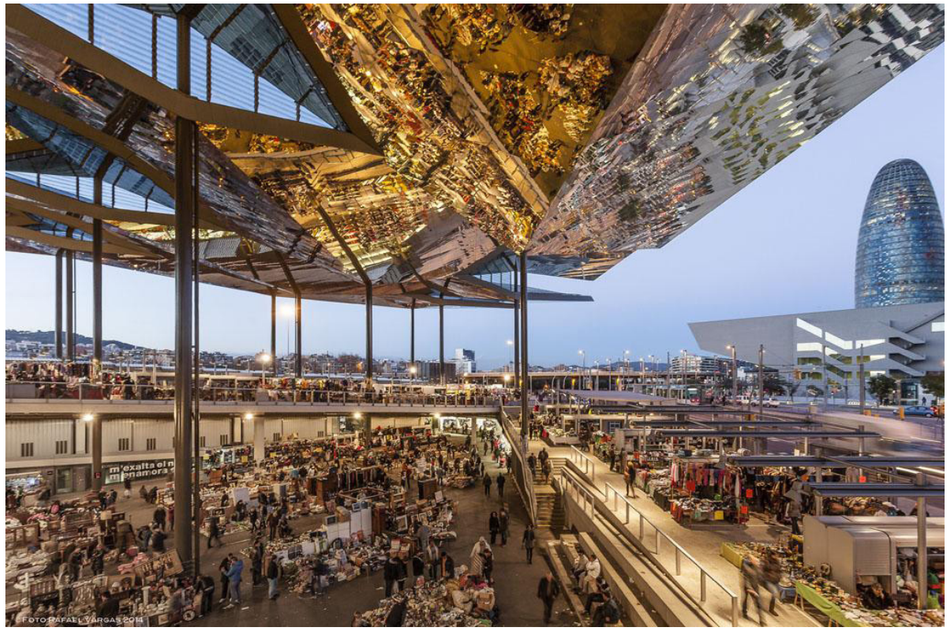


Figure 8. Encants Bellcaire Flea Market (Barcelona, Spain, 2013, b720 Fermín Vázquez Arquitectos)

Reflection

Another way that light can react when it hits a surface is reflaction. There are two types of reflection depending on the conditions of the surface. One is specular reflection that happens when light strikes on a smooth surface and the reflected light rays travel in the same direction. An example of specular reflection in architecture is shown in the Encants Vells Flea Market in Barcelona designed by b720 Fermín Vázquez Arquitectos (Figure 8). The huge roof of the market reflects the activities underneath, and creates a relationship between people who are even far away and the activities happening in the market. In this way, the market can attract more people to visit because of the specular reflection.

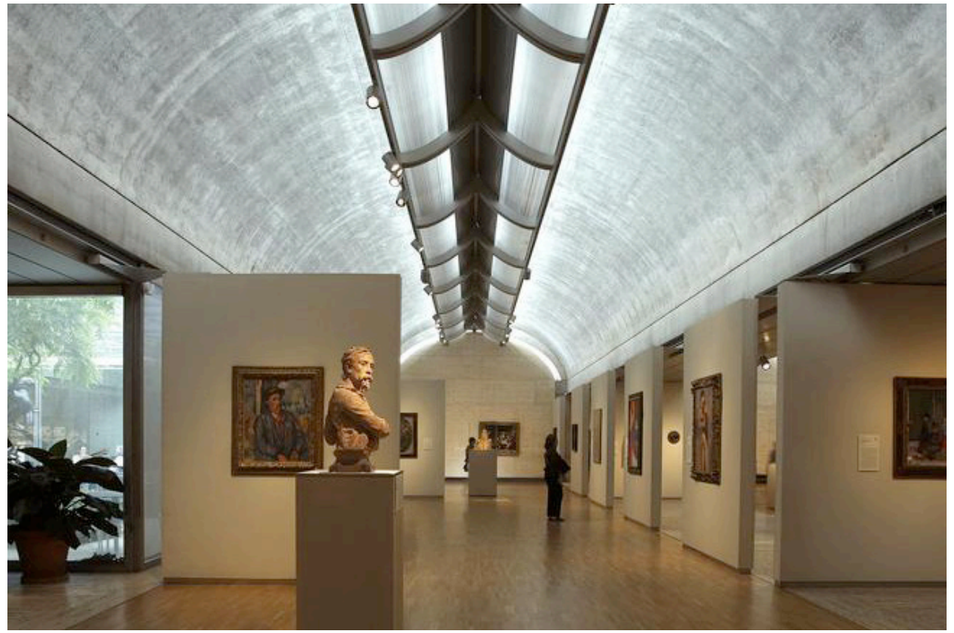


Figure 9. Kimbell Art Museum(Texas, United States, 1972, Louis Kahn)

The other type of reflection is called diffuse reflection that happens when light rays diffuse in all directions if the surface is rough. (Reflection of Light) Kimbell Art Museum designed by Louis Kahn (Figure 9) is a good example of diffuse reflection. Light is scattered when hitting on the arched roofs which creates a soft light condition underneath.

Figure 10. Optical Glass House (Hiroshima, Japan, 2012, Hiroshi Nakamura & NAP)

Refraction

Refraction of light is less commonly used in architecture because it is hard to control. Light changes its direction when it passes through two transparent substances with different optical densities. “This change of direction is caused by a change in speed.” (Refraction of Light) Opcal Glass House designed by Hiroshi Nakamura shows the possibilities of refraction of light on reshaping the architectural experience if it is controlled accurately. (Figure 10)

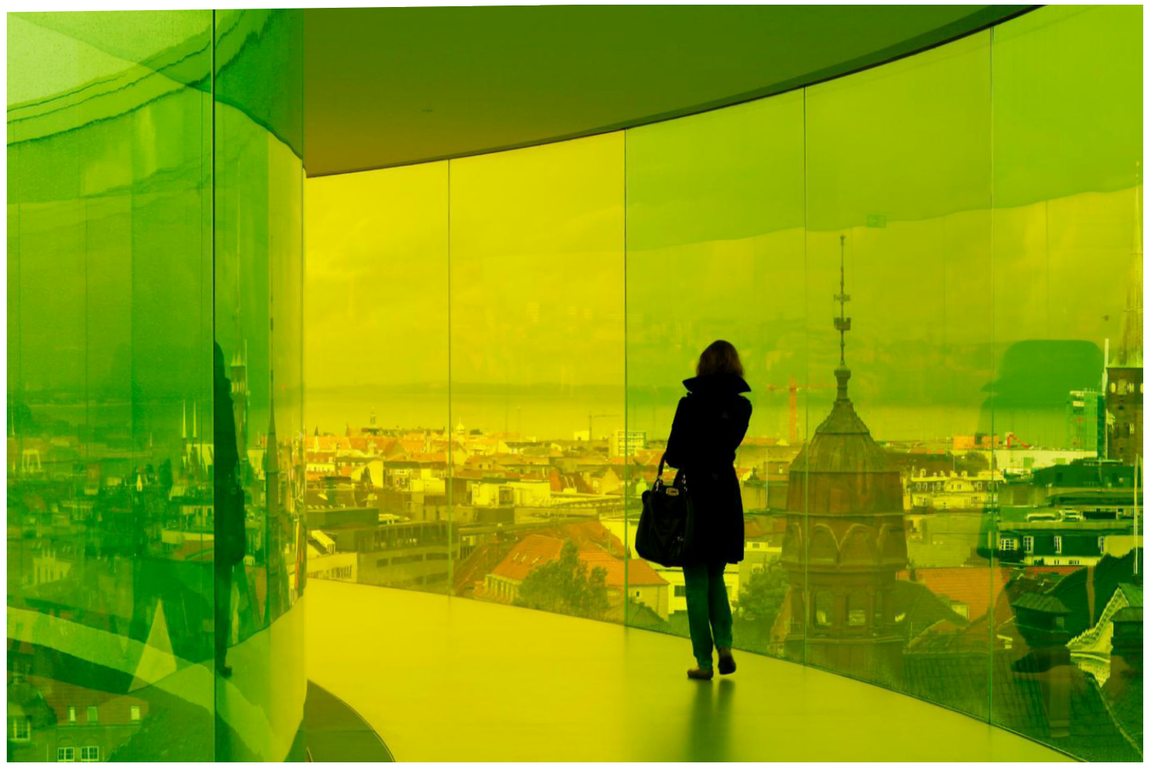


Figure 11. Your Panoramic Rainbow (Aarhus, Denmark, 2011, Studio Olafur Eliasson)

Color

The behaviors of light in these basic ways of transmission, reflection and refraction are often visible in architectural space. Often color is also evident because light is made up of different wavelengths that have different colors. The color we see is small part of the spectrum that human eyes are sensitive to and can detect. (Colours of Light) For example, when walking along “Your Panoramic Rainbow” designed by Olafur Eliasson, the perception of the surrounding environment varies because of the changing of the colors. (Figure 11)

2.3 Experiments on Other Properties of Light in Architecture

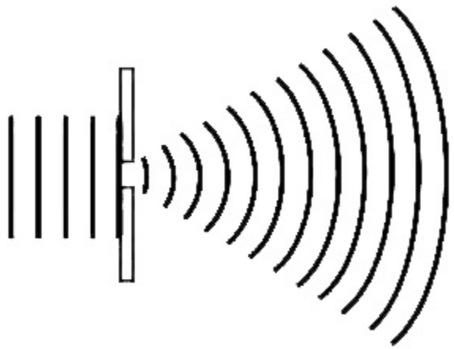


Figure 12. Diffraction

Diffraction

Light also behaves in ways that are more difficult to see in relation to architectural space. As seen in Figure 12, diffraction occurs when light transmits a barrier or gap whose size is similar to the wavelength of the light. (Behaviour of waves)

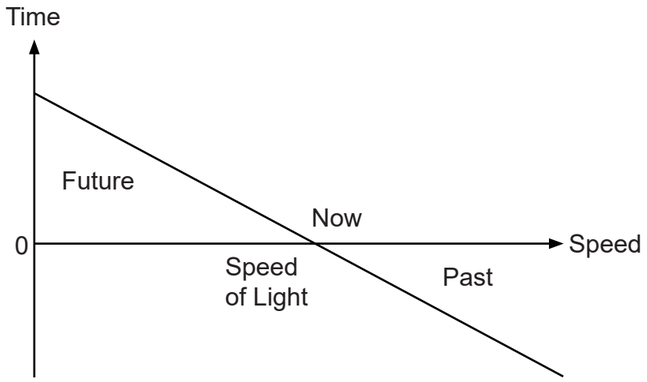


Figure 13. Speed of Light and Time Travel

Speed of light and Time Travel

Einstein places light at the center of space. (Figure 13) For him, space and time are defined by the speed of light. Space and time is inseperatable because our perception of space and time is based on the distance light travels. “These measures appear differently to those moving relative to us, because of the speed of limit imposed by light.” (Walmsley,84)

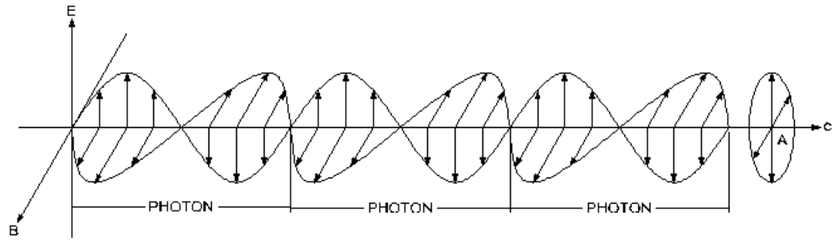


Figure 14. Duality

Duality

Light exhibits properties of both waves and of particles. (Figure 14)“A central concept of quantum mechanics, duality addresses the inadequacy of conventional concepts like ‘particle’ and ‘wave’ to meaningfully describe the behavior of quantum objects.” (Wave-particle duality)

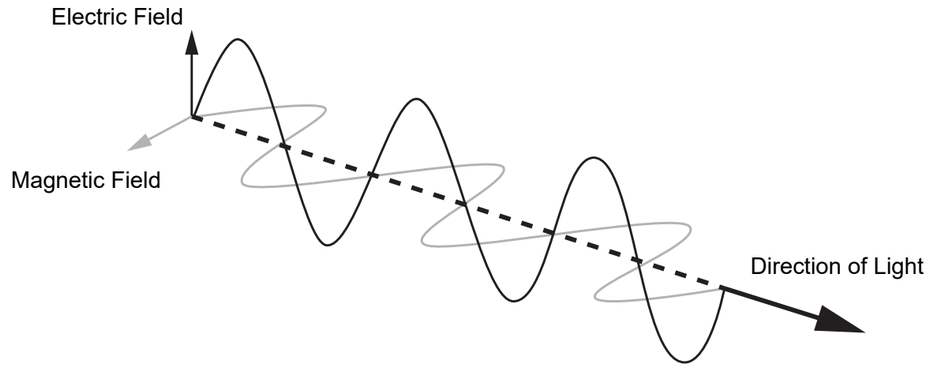
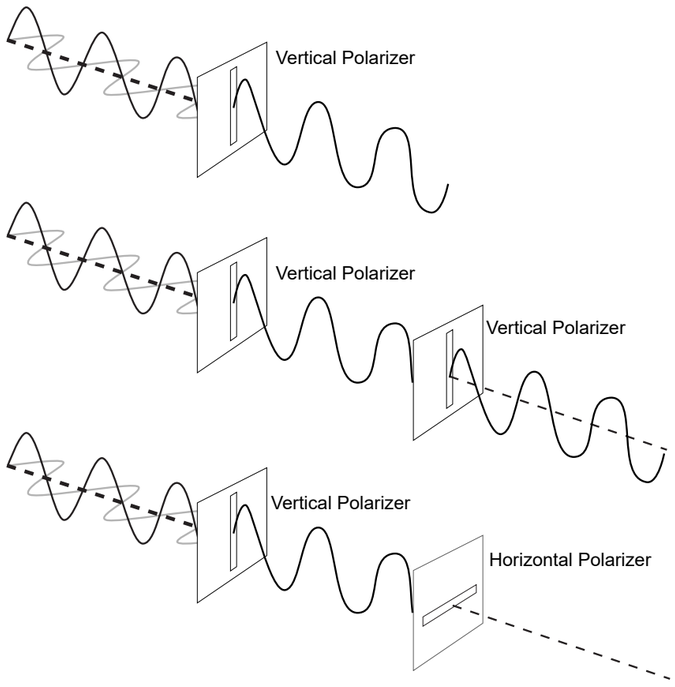
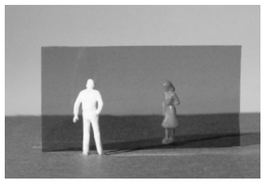


Figure 15. Light as Waves

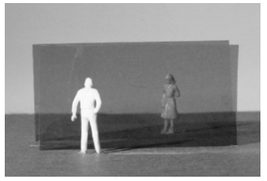
Polarization

Light can act like a wave as it moves through spaces. (Figure 15) When light acts as a wave, it is typically visible in all directions. But if these oscillations are orientated in a certain direction, the light is partially polarized. “The polarization allows only the components in a specific plane to pass through.” (Shipman et al. 187)

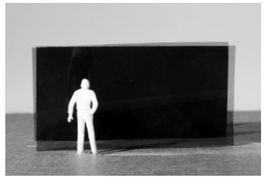




transparent



layered transparent



opaque+reflective

Figure 16. Polarization

A New Perception of Wall

The common way to polarize light is to use a polymer sheet called a polarizer. A single piece of polarizer looks transparent like glass. Two pieces of polarizers with the same orientation look transparent ike double layered glass as well. But two pieces of polarizer placed in perpendicular directions look opaque and reflective ike a black reflective wall.(Figure 16) The orientation of the polarizers can change the transmission of light creating an alteration in the perception of transparency,opaqu and reflection. (Figure 17) Because of its connection to orientation and transmission, polarization reveals a new perception of “a wall” of architecture. The thesis explores this different perception of “a wall” through the concept of “Layered Transparency, Opaque and Reflection”. The design project of “Myself In Your Eyes” examines how the “walls” move in relationship to how people move. As people take on the leading role of the space, the “polarized space” becomes a medium for people to interact with each other. The spatial experience which is “generated” by the polarization of light defines the program, the form of the space and the site of the proposed project, which will be discussed in chapter 3.

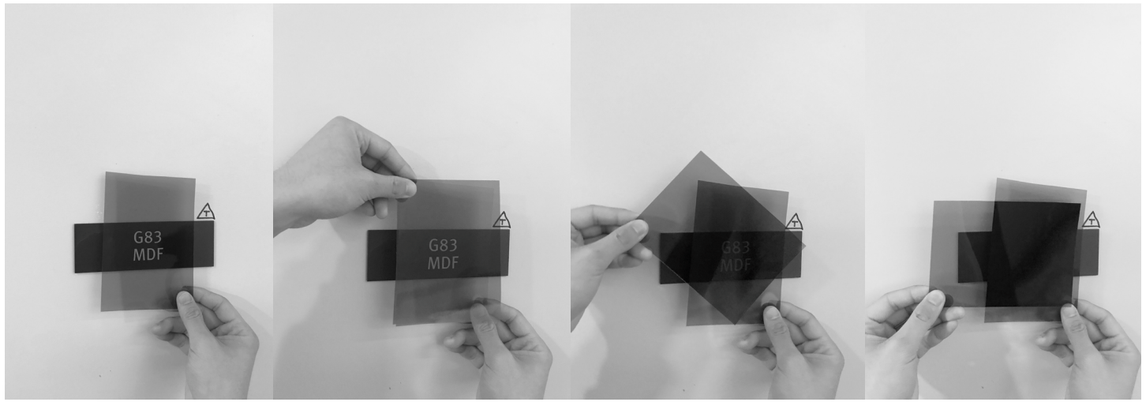


Figure 17. Layered Transparency,Opaque and Reflection

2.4 Conclusion

These case studies showing the use of light in architecture show that certain properties of light are more tangible and commonly used - transmission, reflection,refraction and color can have a direct and crucial influence on shaping the perception of space. However a closer look at the varied properties of light reveals other characteristics of light that are less tangible and overlooked. The phenomenon of polarization has particularly important implications, with the potential to be applied to architectural design. This thesis proposal demonstrates the unexplored aspects of light in architectural design.

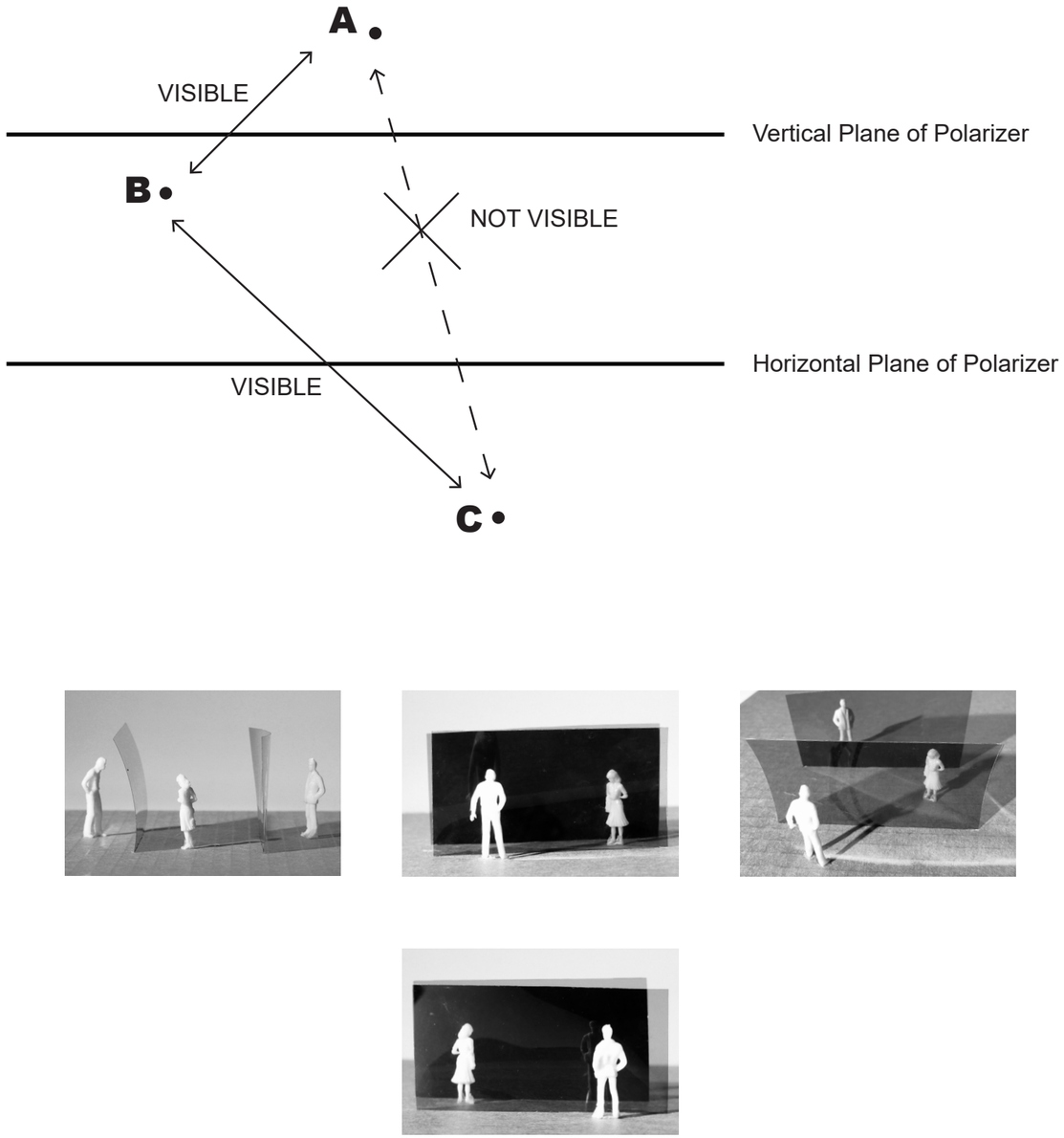


Figure 18. Polarization Changes Interaction Relationship

CHAPTER 3
METHODOLOGY

3.1 Define Program

As seen in Figure 18: A and B can see each other, B and C can see each other, but A and C can not see each other. A and B are watching each other, but to C, B is looking toward a black wall. This phenomenon can trigger different kinds of reaction and behavior, which changes the interaction between people. The design proposal explores this new interaction according to three types: relation in space, relation in movement and relation in time .(Figure 19).

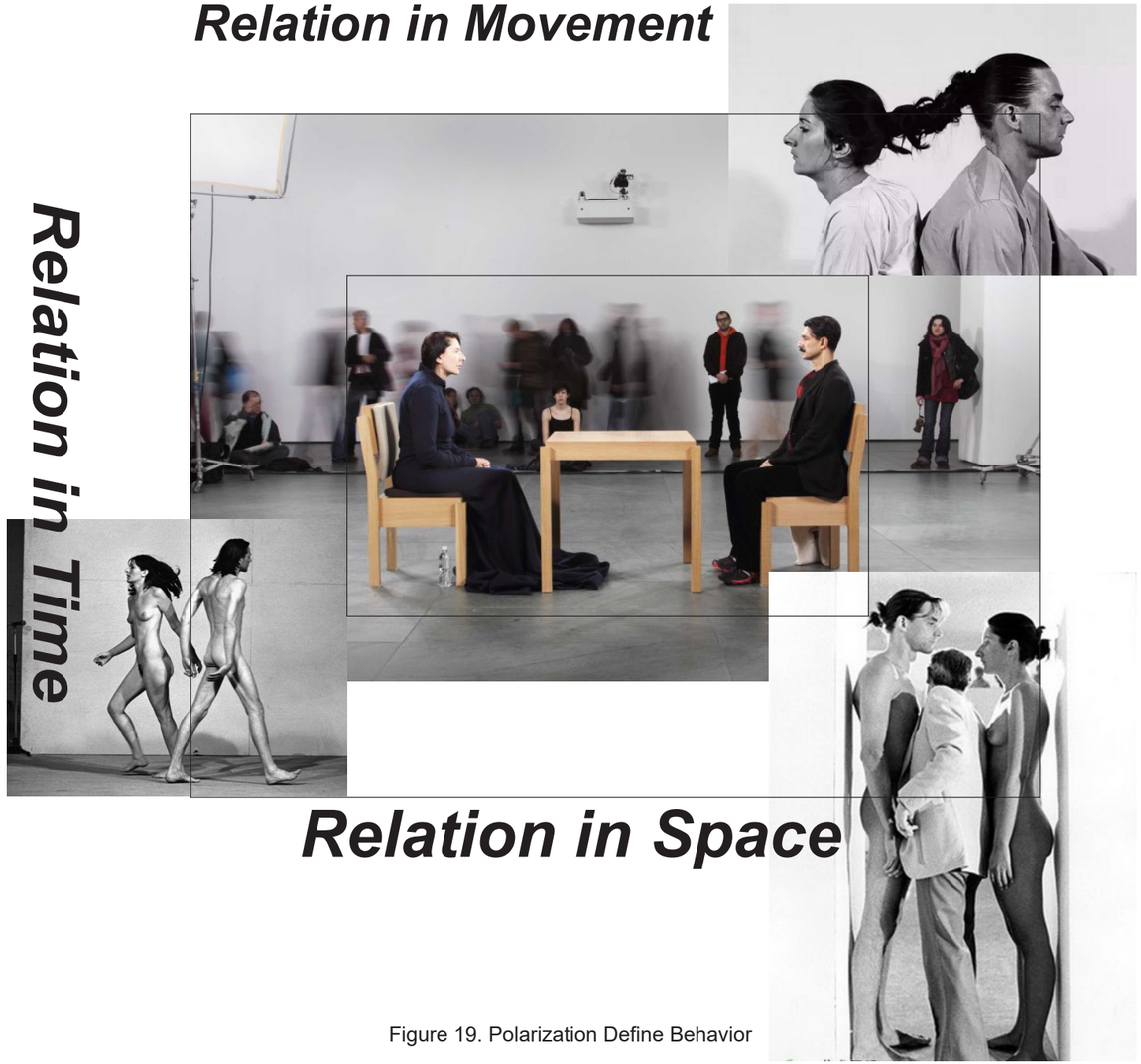


Figure 19. Polarization Define Behavior

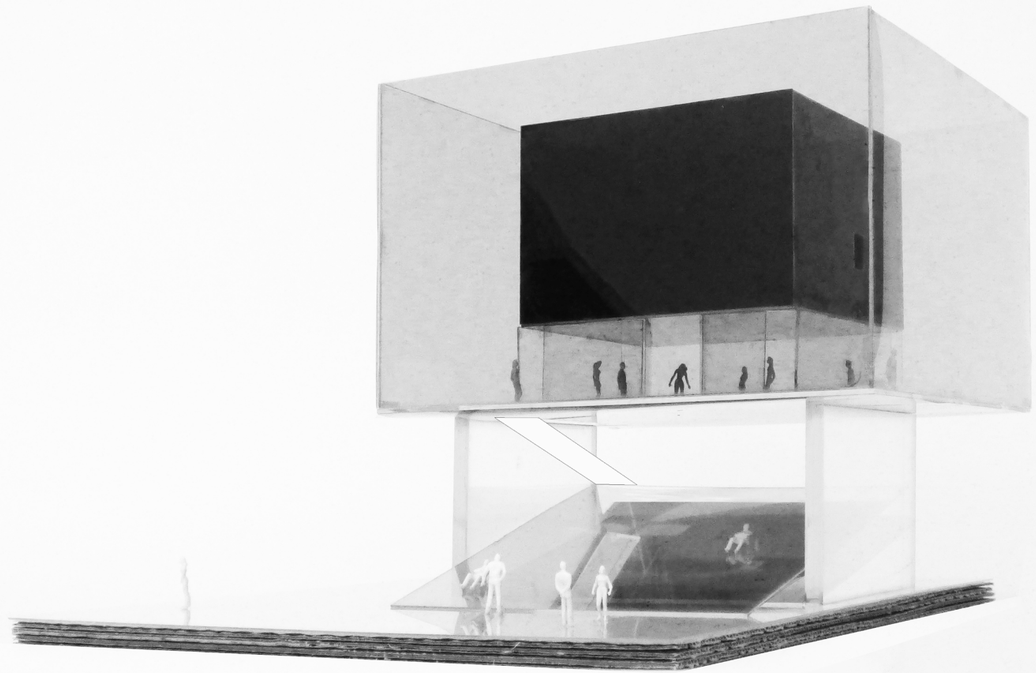


Figure 20. Physical Model

3.2 Generate Form

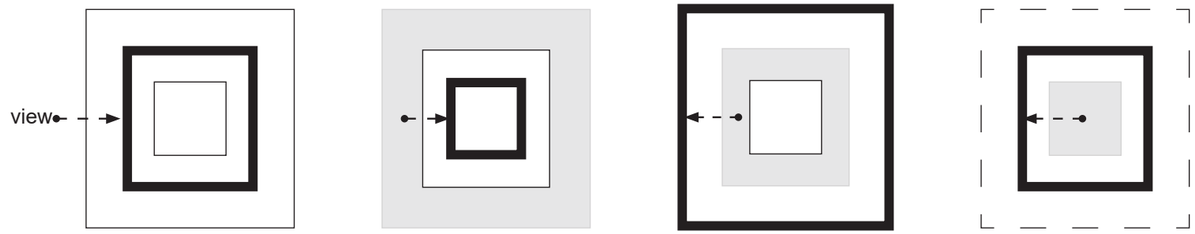
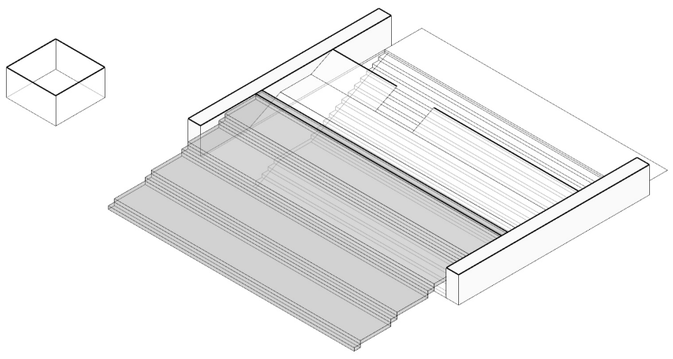


Figure 21. Layered Organization of Space: Both Plan and Section

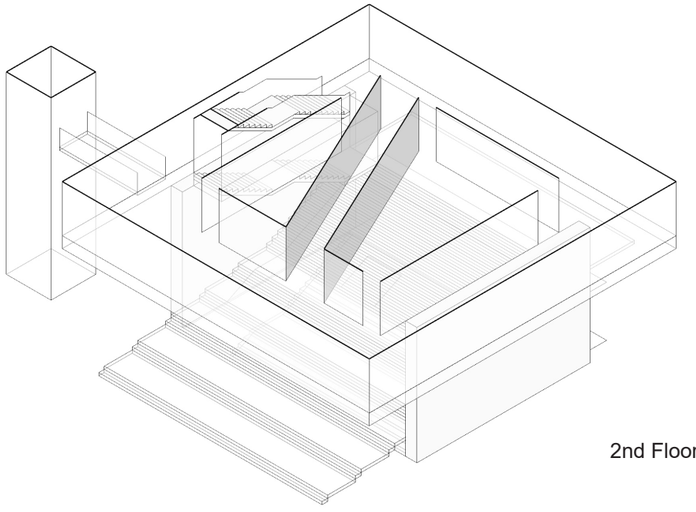
The general form of the proposed building is “box inside box”(Figure 20), in which the plan and section are organized by layers. (Figure 21) Each layer has a different perception of transparency and reflection because of the effect of polariation. The perceptions of space trigger different kinds of activities and behaviors of the visitors. As Figures 22 and 23 shown, the spacial organization and the arrangement of the polarized glass work together to create the place for exploring the three types of interaction between the people: relation in space, relation in movement and relation in time .

Vertical Polarized Glass

Horizontal Polarized Glass

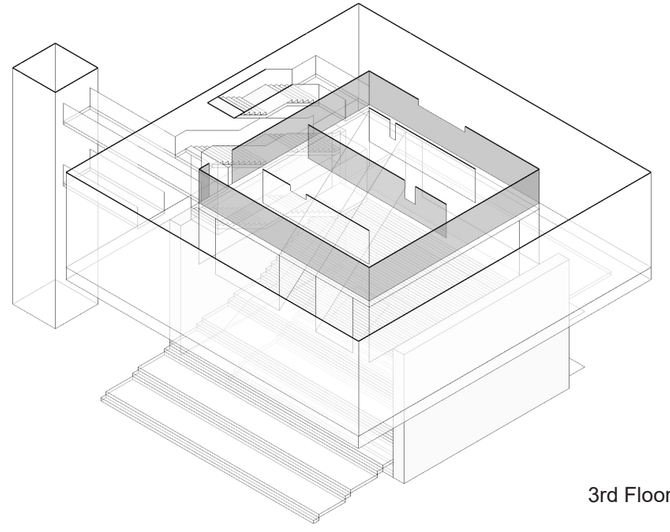


Ground Floor

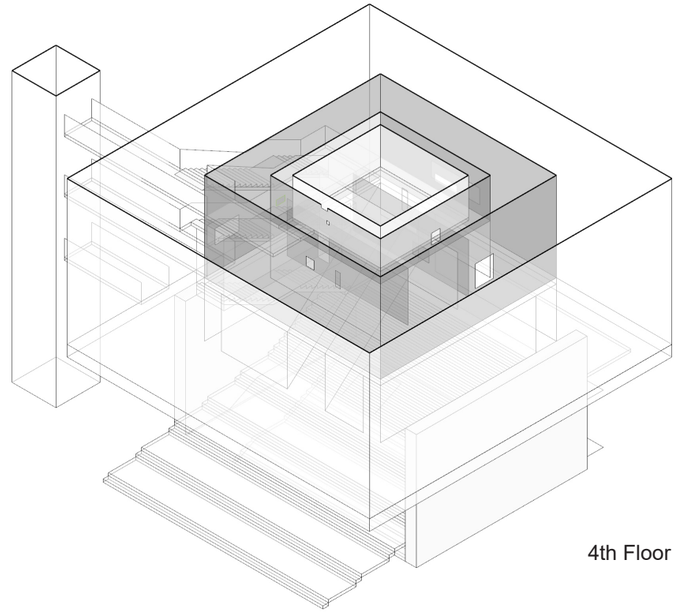


2nd Floor

Figure 22. Axonometric Drawing 1

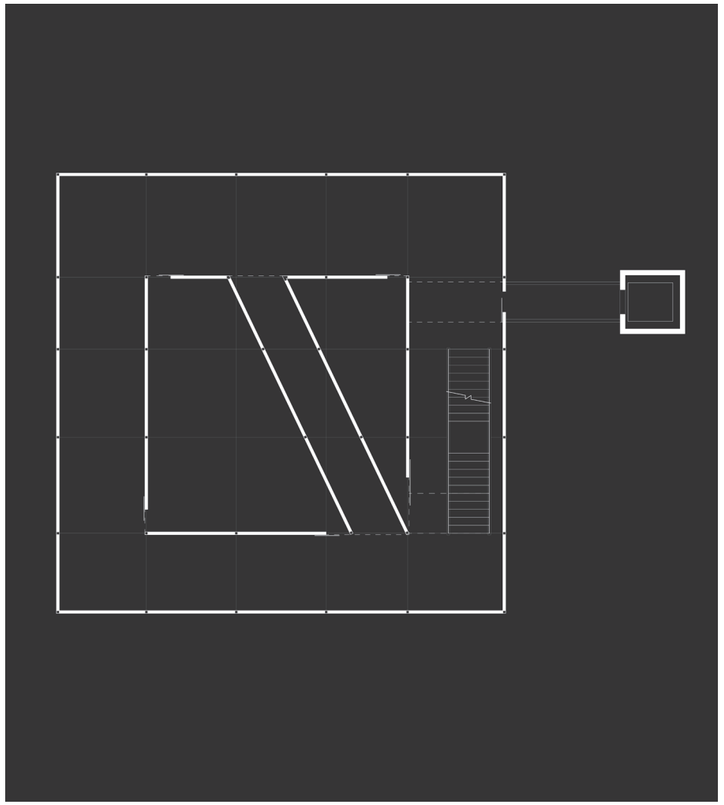


3rd Floor

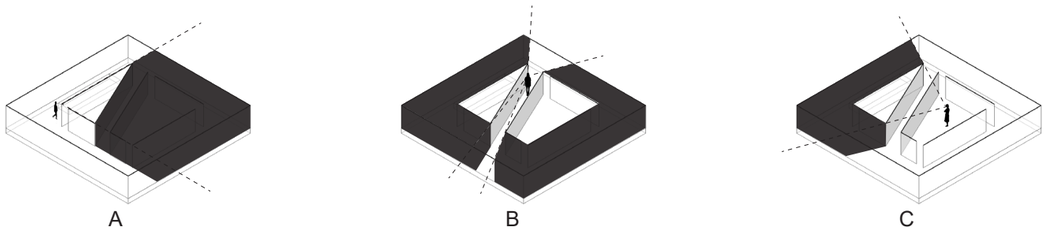


4th Floor

Figure 23. Axonometric Drawing 2



2F Plan

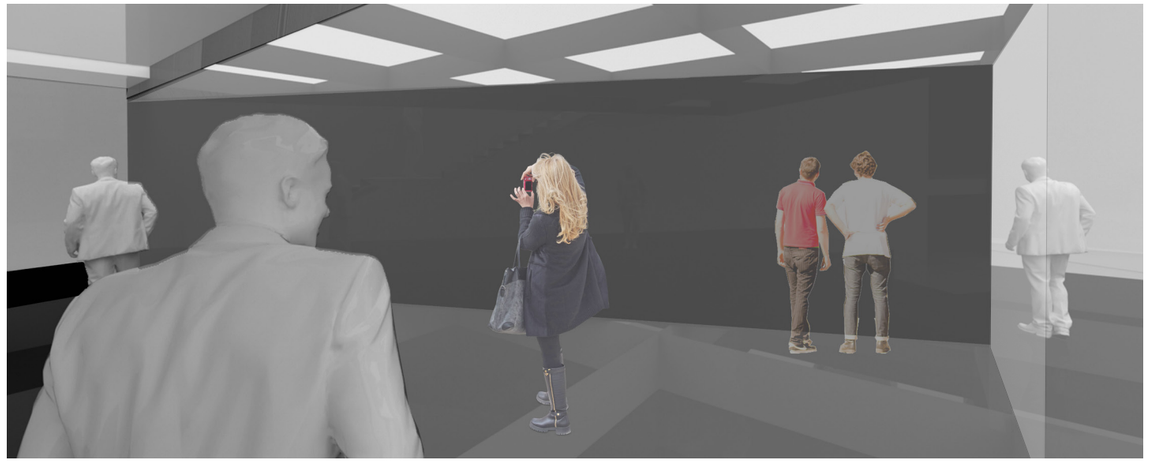


Perception of “Poche”

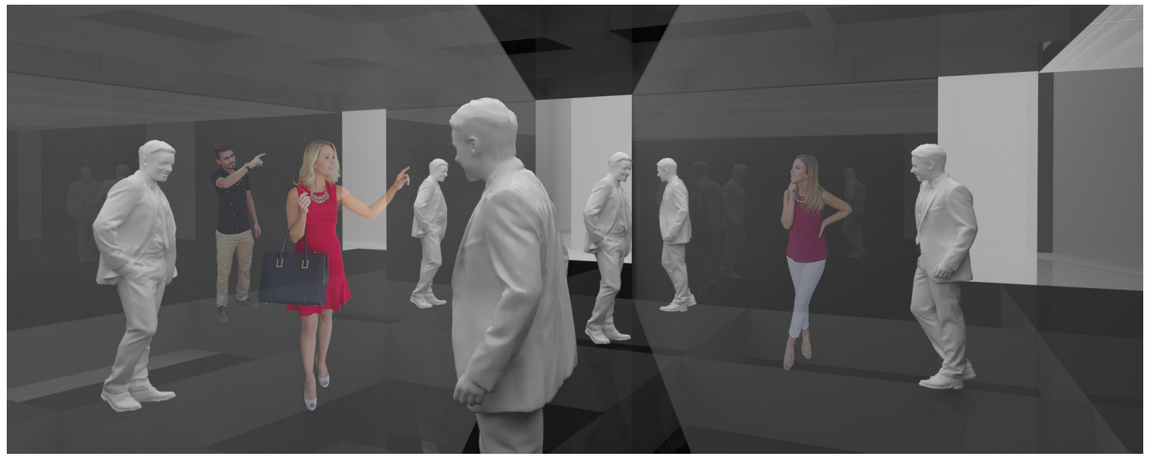
Figure 24. Plan and Diagram of Second Floor

Relation in Space

The second floor of the proposed building provides a way to explore the relation in space. As Figure 24 shown, the central space is divided into two sepeated rooms by a passageway in the middle. The perception of “poche” in the space changes when people move due to the effect of polarization, which triggers a series of psychological activities and interactive behavior between people.(Figure 25)



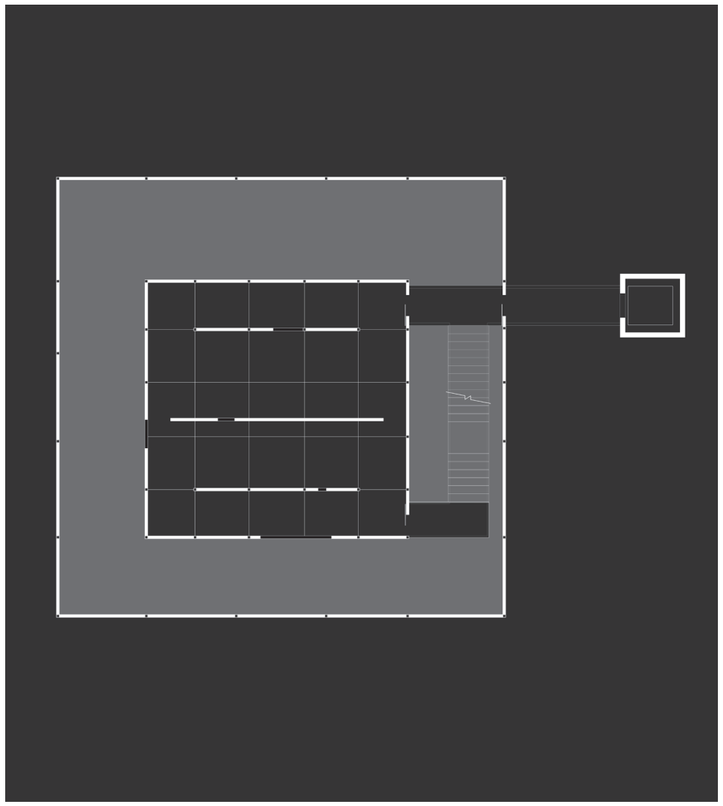
A- Why are people watching at a black wall?



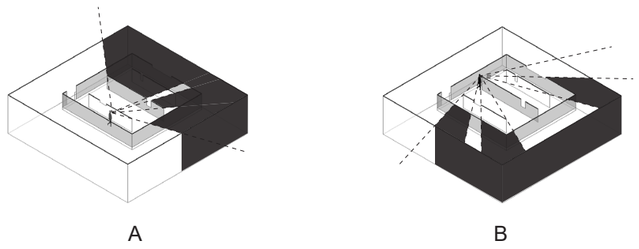
B- Why are people looking at me?

C - They might be looking at the reflection of themselves on the other side of the walls.

Figure 25. Perspectives of Second Floor



3F Plan



A B

Perception of “Poche”

Figure 26. Plan and Diagram of Third Floor

The third floor is to explore the relation in movement. As Figure 26 shows, people can see through different depths of the space while moving. People in this floor will “play” game of hide-and-seek because of the characteristic of polarization. (Figure 27)

A - Why can I see people in different depth?

B - Why can I see everyone in the room all of a sudden?

Figure 27. Perspectives of Third Floor

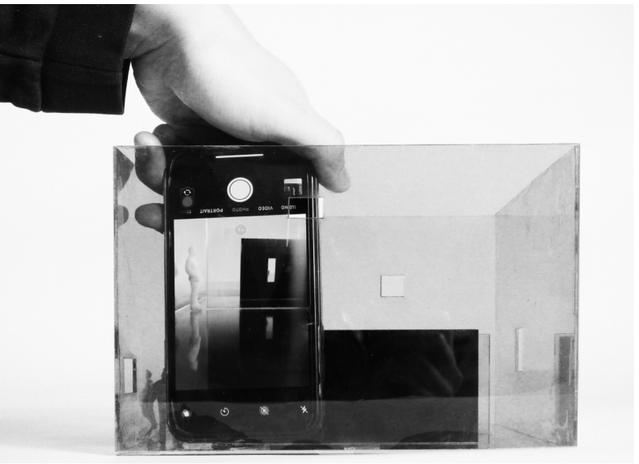


Figure 28. Physical Model of Third Floor - Moving Wall 1

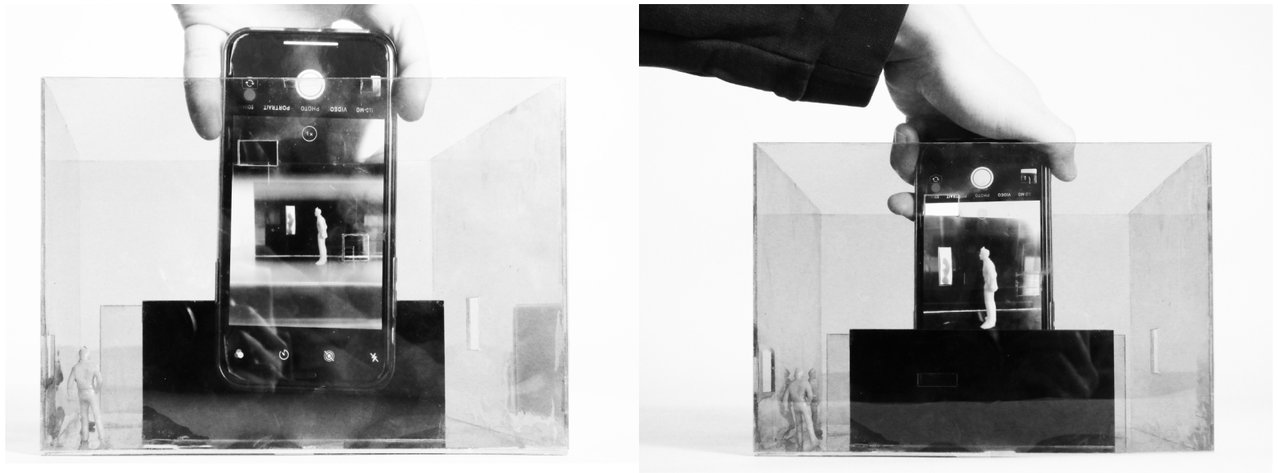
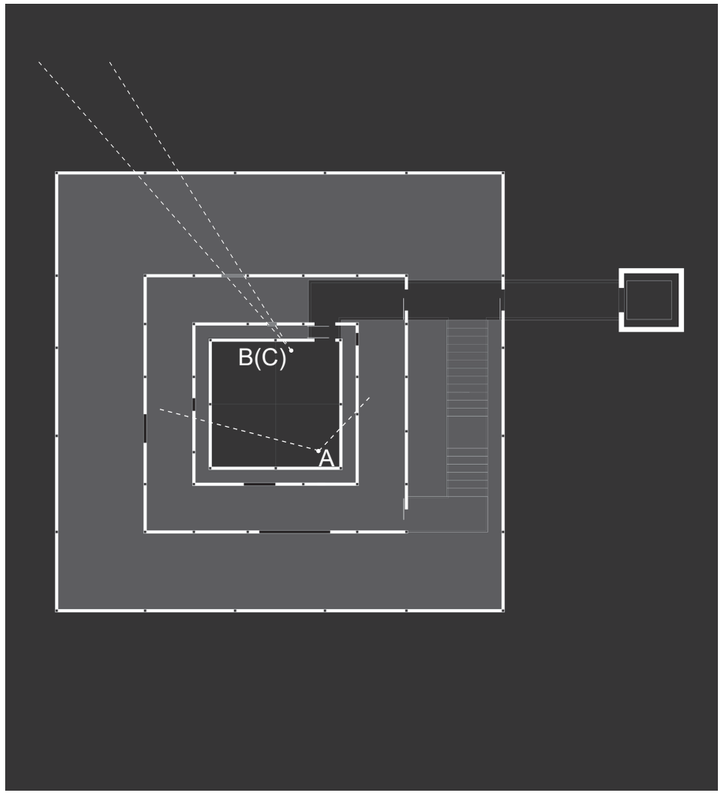


Figure 29. Physical Model Third Floor - Moving Wall 2

As Figure 28 and 29 shown, the “walls” with openings in them are moving as people are moving. So each layer has totally a different perception of space. The perception of space is determined by the location of the visitors, so that the interaction relationship between people becomes unpredictable.



4F Plan

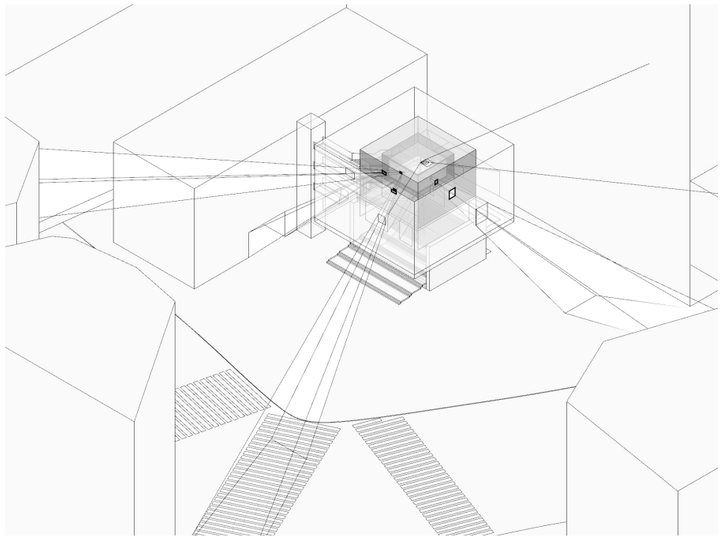
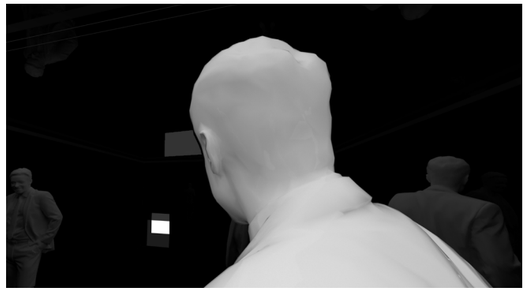


Figure 30. Plan and Diagram of Fourth Floor

A - Is this totally an infinite black room?



B - What is this person looking at?

C - I was one of them just 10 minutes ago.

Figure 31. Perspectives of Fourth Floor

The fourth floor is to explore the relation in time. As Figure 30 and 31 shown, this level is a room with black and reflective walls, roof and floor. Although there are no opendings on the walls of the fourth floor, when people walk around, they can find several unexpected “windows” to see the surrounding context of the site, because of the opengings on the second and third layers and the same orientation of walls in the first and forth floor. The visual connection reminds and relects the existence and time of the real world.

3.3 Inspiring Site

Figure 32. Site Diagram 1

Figure 33. Site Diagram 2

The need for a large number and diversity of people drives the selection of the site - Shibuya Crossing in Tokto. It is the buiest pedestrian crossing in the world. Approximately 2500 people cross it at a time and an average of 2.4 million passengers each day. (Figure 32)

The proposed building sits above the original metro station infrastructure. It is like a 3D billboard which blends into the site context and contrasts with its surrounding environment at the same time. (Figure 33)

Figure 34. Site Photo 1

The site is surrounded by commercial buildings and skyscrapers with lights, advertisements and television screens. The surrounding business and commercial area is a popular destination for shopping and entertainment, but there is a constant sense of being lost while walking through the crossing among the crowds of people. (Figure 34)

Figure 35. Site Photo 2

The constant mechanical movement is a reflection of the everday life of the Japanese people. Most of them live in such an fast-paced and stressful environment without a chance to meet and communicate with other people. (Figure 35) The design proposal provide them an opportunity to slow down, socialize and meditate.

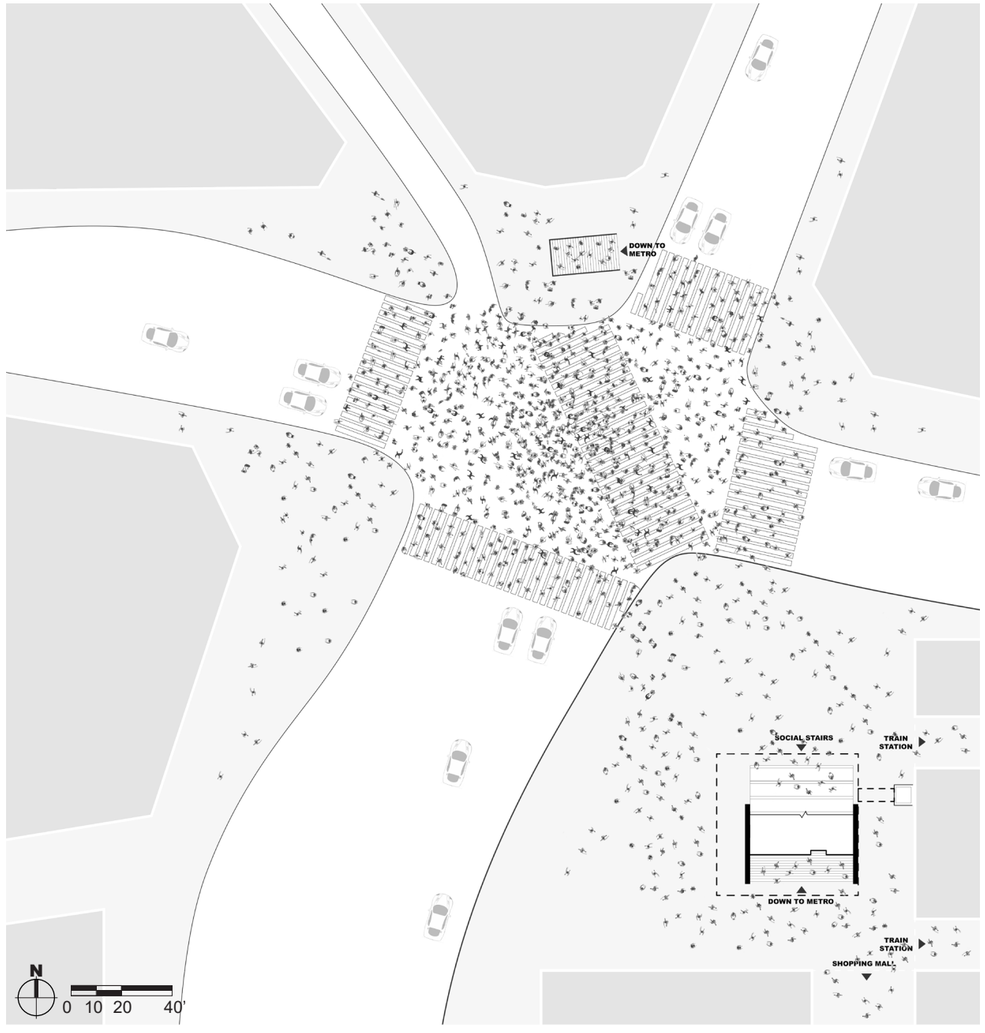
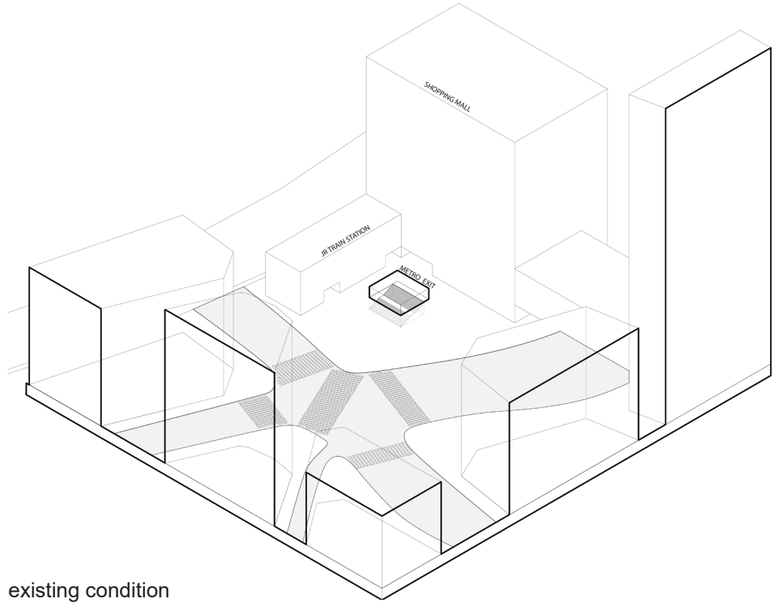
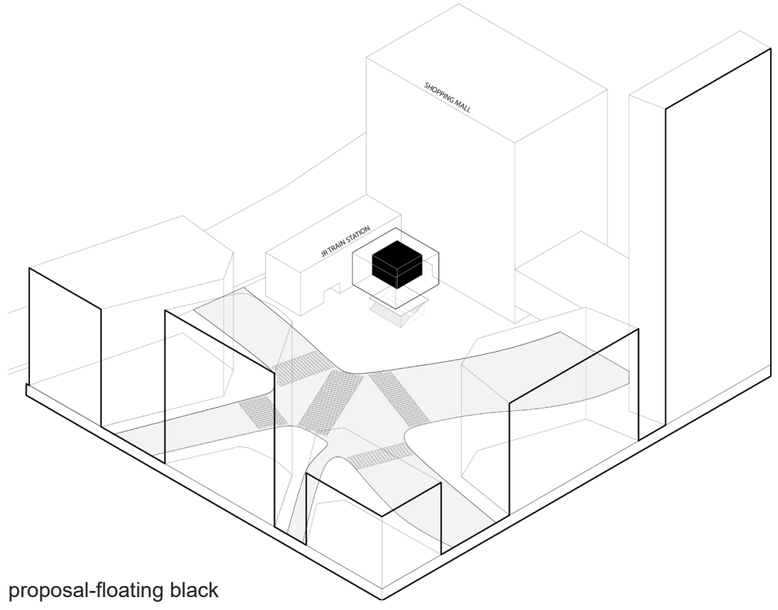


Figure 36. Site Plan

The thesis project takes advanges of the existing structure for the metro station and reforms the existing roof to create a “social stair” to serve both the roof for the metro station and the entry for design proposal. (Figure 36) As Figures 37 and 38 shown, the proposed building floats above the ground with another black and reflective box inside, which is not only a reflction but also a strong contrast to the surrounding environment. The building provides an opportunity for people to transform from the mechanical movement to an emotional movement through the different layers of exploration. (Figure 39)



existing condition



proposal-floating black

Figure 37. Site Response

Figure 38. Perspective from Crossroads

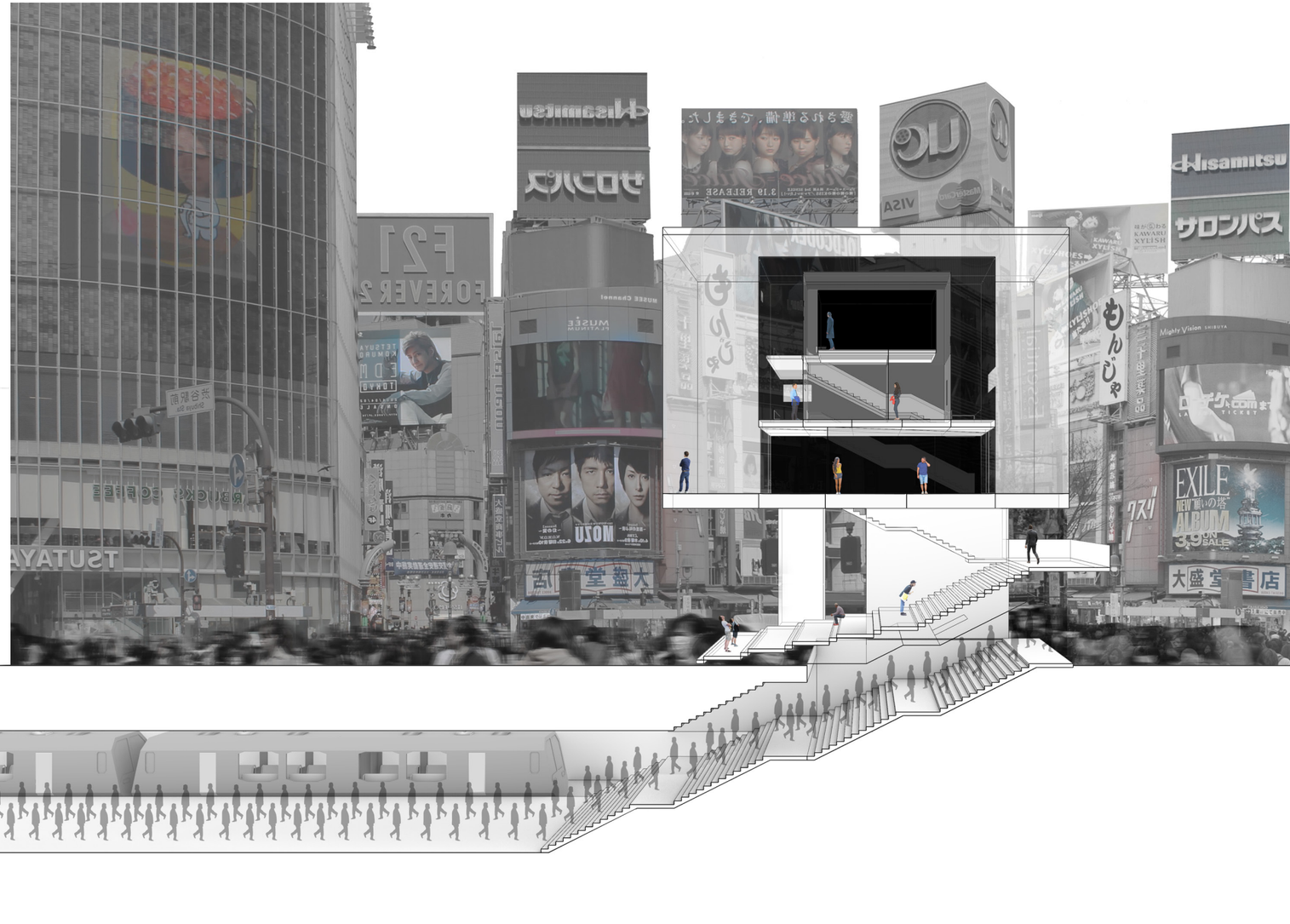


Figure 39. Longitudinal Section

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Figure List

All images are created by author otherwise other noted