GLASS MUSEUMS: EXHIBITION DESIGN AND SPACES FOR CONTEMPORARY GLASS ART IN THE 'GLASS AGE'

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES OF
ÇANKAYA UNIVERSITY

BY

SEVAL YILMAZ YATIR

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN INTERIOR ARCHITECTURE
DEPARTMENT

FEBRUARY 2020

Title of the Thesis: **Glass Museums: Exhibition Design and Spaces for Contemporary Glass Art in the 'Glass Age'**

Submitted by **Seval YILMAZ YATIR**

Approval of the Graduate School of Natural and Applied Sciences, Çankaya University.

Assoc. Prof. Dr. Ziya ESEN
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Assist. Prof. Dr. Saadet AKBAY YENİGÜL
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Fatma Gül ÖZTÜRK BÜKE
Supervisor

Examination Date: 05.02.2020

Examining Committee Members

Assoc. Prof. Dr. Fatma Gül ÖZTÜRK BÜKE	Çankaya Univ.	
Assoc. Prof. Dr. Çiğdem BERDİ GÖKHAN	Çankaya Univ.	
Assist. Prof. Dr. Feray ÜNLÜ	Atılım Univ.	

STATEMENT OF NON-PLAGIARISM PAGE

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name : Seval YILMAZ YATIR
Signature :
Date : 03.04.2020

ABSTRACT

GLASS MUSEUMS: EXHIBITION DESIGN AND SPACES FOR CONTEMPORARY GLASS ART IN THE 'GLASS AGE'

YILMAZ YATIR, Seval

M.Sc., Department of Interior Architecture

Supervisor: Assoc. Prof. Dr. Fatma Gül ÖZTÜRK BÜKE

FEBRUARY 2020, 238 pages

This thesis investigates the art of exhibition design and spaces for glass art in the so-called '*Glass Age'* with a particular focus on contemporary glass art exhibitions held in glass museums. As a phenomenon, the material of glass has both a real presence and a virtual presence, which makes it a medium of metaphor and individualises it as a versatile 'body of ambience.' By virtue of its 'phenomenal transparency,' glass is capable of exposing the structural elements of spaces and has experiential qualities, 'as a bearer of colour and multiplier of light' as the Expressionist writer Paul Scheerbart wrote in his *Glass Architecture* in 1914. Moreover, glass is also capable of manipulating 'perceptual spaces' due to its seeming immateriality. All this makes glass a versatile medium of art and design, especially that which benefits glass museums in the 'Glass Age'. This thesis likewise aims for a versatile approach while investigating contemporary glass art exhibitions in glass museums.

The so-called contemporary glass art offers an immersive artistic environment and with usually illusionist effects. Based on this, it stands somewhere between being physical art objects and dematerialized art from the 1960s onwards and it has often been (and still is) exhibited in glass museums in the 'white cube' concept, which has been applied in the context of exhibition design ever since modern museology and the Museum of Modern Art (MoMA). Since the beginning of the 21st century (in the so-called 'Glass Age'), however, a rapid transformation has been occurring in the current state of both contemporary glass art and exhibition design and spaces of glass museums, which have especially arisen under the intense influence of the New Media in our lives and thanks to the current technologies in glass. Accordingly, (1) absolute works of contemporary glass art have started to evolve into works of mixed-media art. (2) Glass art installations have started to evolve into digital and/or

interactive media installations and architecturally involved works of art. (3) The ‘black box’ concept, and other multi-sensory approaches such as the ‘total work of art’ concept, are increasingly applied in glass museum spaces in the context of exhibition design to offer an overall experience of glass. By this means, glass with its peculiar properties has enabled a holistic convergence of art, architecture and technology through interdisciplinary approaches today in exhibition spaces, which comprise both physical and virtual spaces.

In this thesis, therefore, conceptual, spatial and technical assessments of three evolved concepts of exhibition design for contemporary glass art (‘white cube,’ ‘black box’ and ‘total work of art’) and glass museums spaces in the Glass Age will be investigated comparatively between three of the world’s foremost glass museums, namely the Corning Museum of Glass (U.S.A.), the Shanghai Museum of Glass (China) and the Swarovski Kristallwelten (Austria).

Keywords: exhibition design, glass art, glass museums, perception, lighting design, colour, white cube, black box, “total work of art”

ÖZ

CAM MÜZELERİ: CAM ÇAĞI'NDA ÇAĞDAŞ CAM SANATI İÇİN SERGİLEME TASARIMI VE MEKANLARI

YILMAZ YATIR, Seval

Yüksek Lisans, İç Mimarlık Anabilim Dalı

Danışman: Doç. Dr. Fatma Gül ÖZTÜRK BÜKE

Şubat 2020, 238 sayfa

Bu tez, 'Cam Çağı' denilen çağda cam sanatı için mekanları ve sergileme tasarımı sanatını özellikle cam müzelerinde düzenlenen çağdaş cam sanatı sergilerine odaklanarak araştırmaktadır. Bir fenomen olarak, camın malzemesi hem gerçek bir mevcudiyete hem de sanal bir mevcudiyete sahiptir; bu da onu bir mecaz ortamı haline getirmekte ve çok yönlü bir 'ortam bedeni' olarak kişiselleştirmektedir. 'Olağanüstü şeffaflığı' sayesinde, cam mekanların yapısal unsurlarını ortaya çıkarabilmektedir ve Ekspresyonist yazar Paul Scheerbart'ın 1914'te Cam Mimarisi'nde yazdığı gibi, 'renk taşıyıcısı ve ışığın çarpanı olarak' deneyimsel niteliklere sahiptir. Dahası, görünüşte önemsizliği nedeniyle cam, 'algısal alanları' manipüle edebilmektedir. Bütün bunlar camı, özellikle 'Cam Çağı'nda' cam müzelerine faydası olan çok yönlü bir sanat ve tasarım ortamı haline getirmektedir. Bu tez, cam müzelerinde çağdaş cam sanatı sergilerini incelerken benzer şekilde çok yönlü bir yaklaşımı hedeflemektedir.

Çağdaş denilen cam sanatı, sürükleyici bir sanatsal ortam ve beraberinde genellikle illüzyonist etkiler sunmaktadır. Buna istinaden, 1960'lı yıllardan itibaren fiziksel sanat objeleri olma ile maddesel olmayan sanat arasında bir yerde durmaktadır ve cam müzelerinde çoğu kez modern müzecilik ve Modern Sanat Müzesi'nden (MoMA) bu yana sergileme tasarımı bağlamında uygulanmakta olan 'beyaz küp' konseptinde sergilenmiştir (ve hala da sergilenmektedir). Bununla birlikte, 21. yüzyılın başından bu yana (sözde 'Cam Çağı'nda') hem çağdaş cam sanatının hem de cam müzelerinin mekanlarının ve sergileme tasarımının mevcut durumunda, özellikle Yeni Medya'nın yaşamlarımızda ki yoğun etkisi altında ve camdaki mevcut teknolojiler sayesinde vuku bulmuş olan hızlı bir dönüşüm gerçekleşmektedir. Bu doğrultuda; (1) çağdaş cam sanatının mutlak eserleri, karışık medya sanatının eserlerine evrilmeye başlamışlardır. (2) Cam sanatı enstalasyonları, dijital ve/veya interaktif medya enstalasyonlarına ve mimari açıdan müdahil sanat eserlerine evrilmeye başlamışlardır. 3)

Bütün bir cam deneyimi sunmak amacıyla, cam müzeleri mekanlarında sergileme tasarımı bağlamında 'kara kutu' konsepti ve 'toplam sanat eseri' konsepti gibi diğer çok-duyusal yaklaşımlar giderek daha fazla uygulanmaktadır. Bu suretle, kendine has özellikleriyle cam günümüzde hem sanal hem de fiziksel mekanları içeren sergi alanlarında sanat, mimari ve teknolojinin disiplinler arası yaklaşımlarla bütünsel bir yakınsamasını sağlamıştır.

Bu tezde, bu nedenle, çağdaş cam sanatı için sergileme tasarımının zaman içinde evrimleşmiş üç konseptinin (‘beyaz küp’, ‘kara kutu’ ve ‘toplam sanat eseri’) ve Cam Çağı’nda cam müzeleri mekanlarının kavramsal, mekânsal ve teknik değerlendirmeleri, dünyanın önde gelen cam müzelerinden üçü, yani Corning Cam Müzesi (ABD), Shanghai Cam Müzesi (Çin) ve Swarovski Kristallwelten (Avusturya), arasında karşılaştırmalı olarak incelenecektir.

Anahtar Kelimeler: sergileme tasarımı, cam sanatı, cam müzeleri, algı, aydınlatma tasarımı, renk, beyaz küp, kara kutu, “toplam sanat eseri”

To my husband

ACKNOWLEDGEMENTS

This thesis has been structured as an interface between the fine arts and architecture with the invaluable help of academicians in both fields, who have illuminated my path through the field of glass although it was almost invisible at the beginning of the thesis writing process. I would like to honour all of them now by presenting my acknowledgements owing to the fact that they are the 'sparkling' influencers and 'invisible builders' of this thesis.

First of all, I would like to express my greatest gratitude to my thesis supervisor Assoc. Prof. Dr. Fatma Gül Öztürk Büke for her unique supervision, valuable advice and guidance, inexhaustible patience and continuous help in my intellectual development from the beginning to the last day of this thesis. Without her intelligent mind, this thesis certainly could not be what it is today. I will always be grateful to her and be inspired by her valuable advice and study principles in my future studies.

I also express my deep gratitude to Assoc. Prof. Dr. Çiğdem Berdi Gökhan, who is an architect and an instructor at my university and member of the thesis committee. She has always enlightened my studies in Interior Architecture with guidance and advice since starting my education at Çankaya University and she has encouraged me to continue in this thesis topic with her vast knowledge, endless support, trust and belief in my thesis. She therefore has been one of the greatest influences in the development of this thesis as it has become today and has also made great contributions to my future career in this regard.

Having agreed to be my thesis co-advisor without any hesitation while I had little to no knowledge of exhibition design, I extend my warmest and heartfelt gratitude to architect and instructor Prof. Dr. Ayşen Savaş Sargın from the METU Architecture department. Although I could not formally continue to study with her for the thesis, she was always there whenever I required any assistance, in addition to having kindly accepted me into her invaluable courses, from which I had greatly benefited. She, too, encouraged me to continue with this thesis topic. Thanks to her comprehensive knowledge of architecture, interior architecture, industrial design, art, museology and exhibitions, I felt empowered by the Professor to overcome all my dilemmas with the keyword and resource suggestions during the most difficult phase of the thesis process, especially when having been unable at times to find any written resources and information on exhibition design for glass art.

I also express my deepest gratitude and thanks to Prof. Jens Gussek, glass artist, instructor and head of the Institut für Künstlerische Keramik und Glas der Hochschule Koblenz (IKKG) in Germany. Together with his great assistance and friendly students, Lena Feldman, Verena Schatz, Jesse Magee, Masami Hirohata, Christian Schultz and Tresca Cukier, I was taught many methods and techniques of the art of glass and developed my education in the context of conceptual art. Thanks to the Professor, I found myself in the glass material, which has honest, pure, sensitive, dynamic and intellectual aspects. I integrated with the glass material by transferring my soul to the fluid structure of it as if I were talking with it while shaping it and thus, I opened my first glass art exhibition at our university in Germany after only three months under Jens Gussek's leadership. Having done so, I noticed that the design of a contemporary glass art exhibition requires a good knowledge of architecture rather than only having knowledge of art in terms of understanding the relationship between contemporary glass art works and the spaces they occupy both physically and conceptually. The topic of the thesis, and so its development, was primarily based on these premises.

Next, I express my deepest gratitude and special thanks to Assoc. Prof. Ekrem Kula and Prof. Mustafa Ağatekin, both glass artists and instructors at the glass art department of the Fine Arts Faculty of Anadolu University. They made valuable contributions in a direct or indirect manner at the beginning of this thesis and gave me their moral support throughout the thesis process. They have also taught me a number of glass art techniques very much in the same vein as Prof. Jens Gussek during my master course, which strengthened my awareness of and observations about the gaps in the contemporary glass art literature.

My thanks also go to other members of the thesis committee, namely Assist. Prof. Dr. Saadet Akbay Yenigül, interior architect and Head of the Interior Architecture Department at Çankaya University, and Assist. Prof. Dr. Feray Ünlü, interior architect and instructor at the Interior Architecture Department of Atılım University. Thanks to their valuable advice and the advice of other jury members (Assoc. Prof. Dr. Fatma Gül Öztürk Büke and Assoc. Prof. Dr. Doctor Çiğdem Berdi Gökhan), I have clearly seen and edited the structural issues and conceptual details of this thesis as indicated by them.

I would also like to extend a special thank you and express my deepest gratitude to the Honourable Governor Selçuk Haskırış and his dear wife Belgin Haskırış for their strong moral support, encouragement and assistance throughout the course of this thesis.

Gratitude also to Ömür Duruerk, glass artists and organiser of the Denizli Glass Biennale, and Serhat Özdemir, glass artist, glass photographer and movie maker on glass art, for their having kindly shared with me their knowledge, experiences and observations of glass art exhibitions held in Turkey.

It would be most remiss of me not to acknowledge the not-too-insignificant contributions of my dearest colleagues Gerit Grimm, Vecdi Cece, Mubin Inan, Özden Aslan, Senem Keser and my friends Uğur Beyza Erçakmak, Emre Koç, Elçin Telli, Melike Sayarer, Sevil Çendeoğlu and Serap İncegönül for their moral support, help and encouragement during the overall thesis process. Much gratitude to them.

Finally, I would like to thank my family and especially my husband for their unlimited love and patience, with additional thanks to my lovely cat 'Mr. Renk,' for without all their help, support and insight (including Mr. Renk's!), it would have been almost impossible for me to continue this quite compelling study. Their trust and belief in me were (and still are) always felt, even with the rare fruitless attempts to have me give up and abandon my work. Therefore, I have dedicated the thesis to my family, particularly to my husband, who has showed so much patience and love during this most difficult and gruelling phase of my education.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CMOG	The Corning Museum of Glass
Kristallwelten	Swarovski Kristallwelten / Swarovski Crystal Worlds
MoMA	The Museum of Modern Art
MORI	The Tokyo Digital Art Museum
SHMOG	The Shanghai Museum of Glass (+Park)

CHAPTER 1
INTRODUCTION

The term 'Glass Age' refers to the 21st century as regards to its relationship with the current state of glass widely used in everyday surfaces within the scope of art, design and technology. The current state of glass and the emergence of the so-called 'Glass Age' is fundamentally a result of the recent scientific studies in glass, realised particularly in the first decade of the 21st century. These studies resulted in the developments in technology of glass leading to (1) developments of new techniques and methods in glass making and the glass production process, which has enhanced the usage possibilities of glass in various fields and for a variety of aims; (2) the enabling of the manipulation of the known properties of glass (such as its flexibility, durability, information transferability at the speed of light, etc.). Following these, glass became, more so than ever before, the most versatile medium in the present century. It is used in a variety of fields as a medium of function, of metaphor and of expression. That is, glass with its seeming immateriality rapidly continues to attract the increasing interest of artists, architects, writers and thinkers today in the Glass Age.

Through art, architecture and the '*Glass Age'*, we witness a new revival of the *crystal metaphor* at the beginning of the 21st century, in the so-called Glass Age. Similarly, another revival of the age-old metaphor of crystal was experienced at the beginning of the 20th century as written in Expressionist writer Paul Scheerbart's writings and in Expressionist architect Bruno Taut's publications, in his *Glass House* and other utopian projects (Bletter, 1981; Miller, 2015).[1] The difference between them fundamentally lays in the differences in the technologies of glass in their time. The previous old-age crystalline metaphor reflects the glass technology of its time via modern architecture, whereas the current revival of the crystalline metaphor reflects the current technology in glass via contemporary approaches in today's architecture.[2]

[1] Even Paul Scheerbart has stated that "The future of civilisation lays in the hands of 'Glass Architecture'" as if he knew about these days. *By looking at the current situation in glass art, it might also be inferred now that the future of the plastic arts might lay in the hands of Glass Art.*

[2] As a result of innovative approaches, the façades of today's glass pavilions now act as three-dimensional display cases or digital displays in and of themselves. They represent reflections of their surroundings or images of the integrated digital media, such as a vitrine or light box.

The current revival of the crystal glass[3] metaphor can be best exemplified in glass museums in the Glass Age due to their being designed as complexes of glass art and glass architecture. In addition, exhibition design[4] for contemporary glass art in glass museums have gained a special importance more than ever today due to the effects of the Glass Age. In this thesis, therefore, specialised glass museums are investigated in detail with the aim of clarifying curatorial attitudes toward designing a space of contemporary glass art exhibitions (see Appendix II) of which three are investigated in terms of their conceptual, technical and spatial approaches to both the architecture of their respective buildings and in their exhibition design. The three museums examined here will be the Contemporary Art and Design Wing of the Corning Museum of Glass, the main buildings of the Shanghai Museum of Glass and the Swarovski Museum of Glass. To make the current revival of the crystal metaphor in art and architecture clearer, the following similarities can be seen in comparisons of glass museums[5] in the Glass Age with the *Glass House*[6] of Bruno Taut, designed more than a century ago in 1914.

- Glass as a material bears the notions of *movement*, *constant change* and *dissolution* as seen in kaleidoscope-like spaces such as the *Glass House* by Bruno Taut in 1914 (Bletter, 1981). These notions relating to glass are reflected in the exhibition designs and spaces of contemporary glass museums where, alongside glass, colour and light and new media are also used. New media brings to them impermanency, dissolution and reconfiguration. The same notions also affected the form, design, content and representation of exhibited glass art. Glass artists began expressing their ideas in a more intelligent, illusionist manner instead of representing ideas by creating perfectly crafted works of art. Accordingly, contemporary glass art installations started being transformed into interactive and/or digital media installations that express the inner soul of its artist/concept of the installation itself more clearly than previous mystical or spiritual intentions of glass art. Similarly, Wolfgang Pent wrote in his *Expressionist Architecture* in 1973 that "The use of crystalline imaginary is a characteristic motive of Expressionism." (Bletter, 1981)

[3] See Appendix I: Glossary

[4] See Appendix I: Glossary

[5] Glass museums in the Glass Age are here considered as the example that represents the current revival of the crystal metaphor at the beginning of the 21st century in the context of exhibition design and spaces for contemporary glass art.

[6] The *Glass House* of Bruno Taut is here considered to be the example that represents the previous revival of the crystal metaphor at the beginning of the 20th century in the context of modern architecture and modern glass art.

- In his *Glass House* in 1914, Bruno Taut had benefited from the experiential qualities of glass, glass as a material "*bearer of light*" and "*multiplier of colour*," as Paul Scheerbart expressed (Bletter, 1981). In addition to the use of coloured glass walls, Taut also used artificial coloured light in a dark room in the interior of the Glass House. He saw glass as a medium to create "sacred possessions without utility." In his utopian expressionist architecture, glass becomes a mystical instrument. Glass as a medium of metaphor still continues to create various expressions in contemporary glass museums today and the indispensable relation between glass, colour and light (water) is still used as a part of these communications.

- The permanent exhibition titled *Transparent Opacity* by Arik Levy exhibited at Swarovski Kristallwelten today (see Chapter 4) also reminds us of the utopian crystalline architecture of the post-World War I period as seen in the proposals of Bruno Taut (Fig. 1.1) and Wassili Luckhardt (Fig. 1.2).

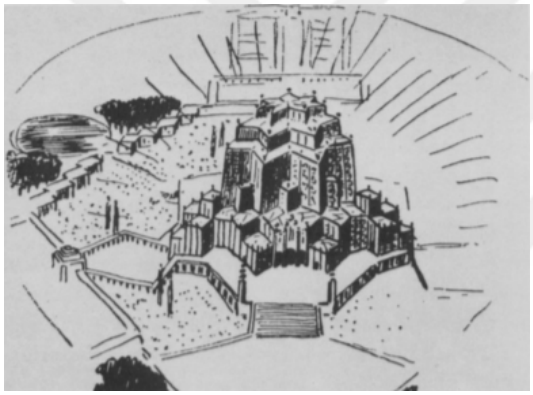


Figure 1.1: 'House of Heaven'
By Architect Bruno Taut (Stadtbaukunst-Frühlicht), 1920
(Bletter, 1981)

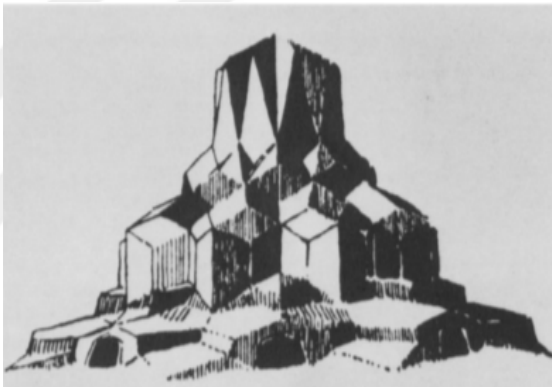


Figure 1.2: Untitled by Architect Wassili Luckharddt
(Stadtbaukunst-Frühlicht), 1920
(Bletter, 1981)

- The *multi-sensory* experience of crystal glass metaphor once achieved in Bruno Taut's *Glass House* designed in 1914 is continuing to reoccur in contemporary glass museums of today, such as at Swarovski Kristallwelten (Bletter, 1981; Miller, 2015).

- Based on the *holistic* and *interdisciplinary approaches* in curatorial attitudes of the museums today, the concept of the 'total work of art' has evolved as a concept of exhibition design in the spaces of contemporary glass museums today, which was once achieved in the design of Bruno Taut's Glass House. Accordingly, the concept of the 'total work of art' has taken its own place together with the two other dominant concepts of contemporary glass art exhibitions held in glass museums: the 'white cube' and the 'black box' concepts. Walter Gropius, renowned architect and founder of the Bauhaus School, appears to have had the foresight for this current transformation of the total work of art in exhibition design one hundred years prior when he stated:

> *"Together, let us desire, conceive, and create the new structure of the future, which will embrace architecture and sculpture and painting in one unity and which one day rise toward heaven from the hands of a million workers like the crystal symbol of a new faith."*
>
> Walter Gropius, opening manifesto for the Bauhaus in 1919 (Wingler, 1969)

- The new concepts of art and exhibition design have brought together more freedom in spatial organization of the works of art in exhibition spaces.[7]

Except for the details above, a current conceptual transformation is seen in glass museums in a general sense today during the overall study of glass museums in the scope of this thesis (see Appendix II), which may be explained with the following reasons:

- Rising interest in contemporary glass art since the 1960s and the widespread use of contemporary glass art installations, particularly between the 1970s and 1990s;
- An increased number of openings of glass art departments at fine arts faculties particularly since the 1970s;
- An increased number of openings of glass museums just prior to the Glass Age (1990s);
- A rapid interest in design in glass in relation to the properties of glass in smart technology, particularly since the 1990s;
- Early traces of the integration of glass art and glass architecture through 'contemporary glass art installations' particularly in the 1990s; and
- Rapid developments in glass technology at the beginning of the 21st century.

[7] For this reason, the thesis will not examine traditional spatial design concepts in the scope of exhibition design nor other known topics such as types of exhibit, etc., which can easily be found in most reference books of architecture and are simply summarized in Appendix V.

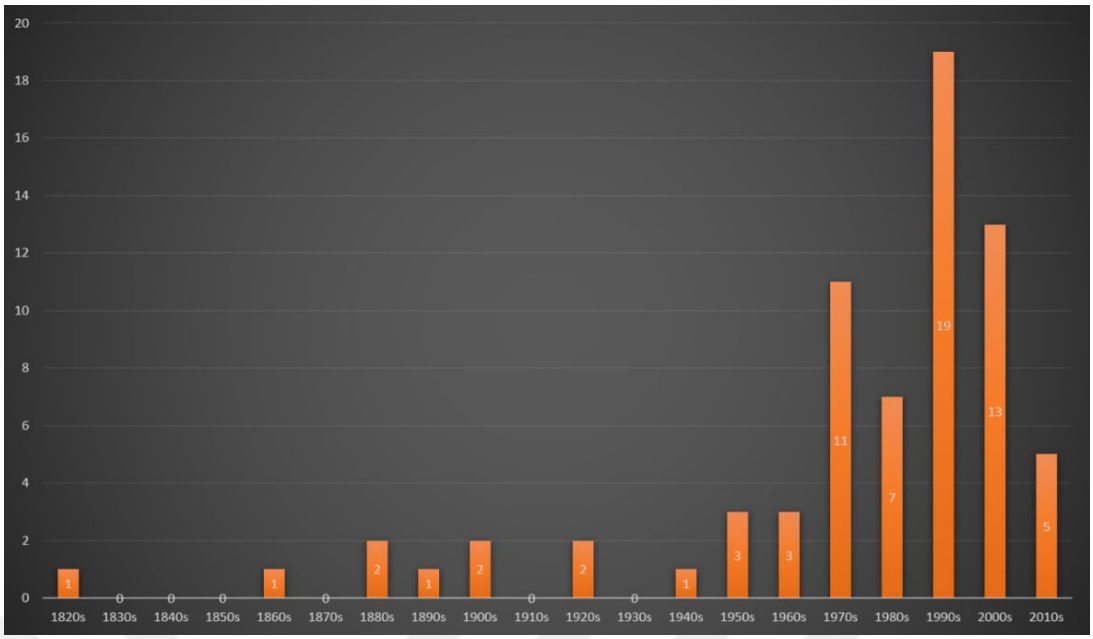


Figure 1.3: Establishment of Specialised Glass Museums around the World according to Opening Dates

As seen in the Fig. 1.1, specialised glass museums began opening from the 1820s. The figure above covers the periods of modern glass art and contemporary glass art and many of the foremost transformations of glass in the fields of art, architecture and technology. The chart in Fig. 1.3 also visually indicates that the largest number of glass museums opened worldwide in the 1990s. This period corresponds to the rising interest in glass art, particularly in art academies as well as early traces of the integration of glass art and glass architecture in contemporary glass art installations.

1.1. Aim of the Study and Research Questions

This thesis aims to investigate exhibition design and spaces for the exhibition of glass art in the Glass Age with a particular focus on contemporary glass art exhibitions exhibited in specialised glass museums. In this respect, the thesis aims to make conceptual, spatial and technical assessments of three of the foremost glass museums in the world as regards to exhibition design and the respective architectural design of each of the buildings themselves, these museums being the Corning Museum of Glass, the Shanghai Museum of Glass and the Swarovski Kristallwelten.

To achieve proper qualitative and quantitative results to create a framework for exhibition design for the future of contemporary glass art exhibitions, the following questions will be answered in this thesis:

- What should the relationship between a displayed contemporary glass work art and its surrounding space and among displayed exhibits themselves as regards to the interactive ability of glass be?

- What is the role of perception in the overall experience of an exhibition, in the perception of displayed works of art and in the indispensable interplay between light, colour and material glass that emerges on and in displayed glass works of art?

- How should a glass work of art be modelled on display with respect to its design and material properties?

- What is the role of colour preference for the space in the design of a contemporary glass art exhibition?

- Are there any defined concepts applied in exhibition spaces for glass art exhibitions in the so-called Glass Age?

- How do glass museums handle glass material in the so-called Glass Age with respect to the current technology in glass in terms of the architectural design of a building, the exhibition design of its spaces and the design of display cases?

- How do glass museums organize contemporary glass art exhibitions in the so-called Glass Age in terms of the representation techniques and the methods in exhibition design for contemporary glass art?

By answering the above questions, this thesis aims to suggest applicable advice, especially for interior designers wishing for a career in exhibition design with a special interest in the material of glass. The thesis also aims to be a comprehensive resource for anyone who works in fields relating to light, colour, glass and space in their designs without being limited to exhibition design.

1.2. Scope of the Study and Structure of the Thesis

This thesis will reveal the relationship between a displayed glass made object and the exhibition space with respect to concepts of exhibition design. In particular, the thesis aims to investigate the effects of the colour of the space and lighting design in the perception of displayed glass art pieces. Since glass can be a transparent, translucent or reflecting material and have a wide range of colours, it allows the interaction between the space and itself as no other material is able to do. Accordingly, the topics of visual and spatial perception, colour, lighting design as well as concepts of exhibition design for contemporary glass art will be selected for inquiry in the scope of the thesis.

The thesis will cover research on the material aspects of glass, on the history of glass in art and design, contemporary approaches in glass museums and in the exhibition design (including lighting design) of contemporary glass art in addition to research on the visual and

spatial perception of glass works of art and installations on displays. Since concept-based flexible spatial design, display design and lighting design are prominent today in the so-called Glass Age, the topics of spatial organisation, types of exhibition and exhibition design techniques, which can be found easily in conventional and reference books, are excluded from the scope of this thesis (see Appendix V). With regard to its scope, the thesis is structured in five chapters:

- Chapter 1 (this chapter) presents an introduction of the thesis and the research questions, and it clarifies the aim, scope and structure of the thesis in relation to the research questions as well as the methods, objectives and the hypothesis to be achieved.

- Chapter 2, titled 'Historical Evolution of Glass, Glass Art and Exhibitions,' explores the historical and conceptual journey of glass in art and design since the first discovery of glass around 5000 BC and touches upon the effects of technological developments in glass and the effects of known techniques and methods in glass making in art and architecture. This chapter also investigates the conceptual, perceptual and technological role of the three concepts of the 'white cube,' 'black box' and 'total work of art' in exhibition design of contemporary glass art. Detailed research will be presented of the history of glass art and its curation starting from the 1851 Great Exhibition of the Crystal Palace in London to the recent contemporary glass art installation in the concept of the *total work of art* at Chihuly Garden and Glass in Seattle in 2012.

- Chapter 3, titled 'Exhibiting Glass Art: Perceptual and Technical Assessment,' explores the visual and spatial perception of glass art with respect to its relationship to space, colour preferences in space and lighting design. It also explores how lighting design can be arranged accurately on displays of glass art works in order to reveal their forms and surface structure details properly in addition to highlighting them in a space in order to attract attention. In this respect, Chapter 3 begins with a theoretical framework that includes studies in colour, light and material glass and their respective properties.

- Chapter 4, titled ‘Case Studies: A Comparative Analysis of Glass Museums in the Glass Age,’ explores conceptual, technical and spatial assessments in exhibition design as well as the architectural designs of the selected buildings of the three foremost glass museums previously mentioned. The Contemporary Art and Design Wing of the Corning Museum of Glass will be investigated as an example of the ‘white cube’ concept in exhibition design. The Main Building of the Shanghai Museum of Glass will be investigated as an example of the ‘black box’ concept and the Main Building of the Swarovski Kristallwelten, the so-called ‘Giant,’ will be examined as an example of the ‘total work of art’ concept. The chapter will conclude with a comparative analysis of the three case studies with regard to the three aforementioned concepts of exhibition design.

Following the conclusion chapter, the thesis will end with a glossary, appendices and references.

1.3. Literature Review and the Gap in the Literature

Over the course of working on the thesis, a comprehensive investigation into exhibition design and spaces for exhibiting contemporary glass art was made in national and international databases. As a result of the extensive research on theses written in fine arts and architecture faculties from the 1950s onwards and from other academic studies such as articles etc. with regard to the available thesis topics, formal academic studies can be gathered into general groups under the following headings[8]:

a. historical development and transformation of glass in a certain period and in a certain region;

b. developments in glass-making and glass production techniques;

c. the use of special types of glass as in art;

d. pioneering glass masters and investigation of their artworks and techniques;

e. pioneering glass manufacturers, factories and their pioneering initiatives in glass history;

f. an examination of glass as an expressive art medium in conceptual contexts;

g. an examination of glass in terms of transparency in physical and conceptual contexts;

[8] See Appendix III

h. the current status of glass: different ways to use it in combination with other materials in various artistic fields;

i. an examination of the glass collections around the world;

j. education programmes around the world for glass art schools; and

k. the application of glass as an architectural material in interior decoration and architecture.

Regarding contemporary glass art, only a few theses appear in the literature which were written after 2000.[9] However, none of these theses explores exhibition design and spaces for the exhibition of contemporary glass art (see Appendix III), which makes obvious the presence of a gap in the literature.[10]

In addition, the related special topic of the thesis: *lighting design for glass art exhibitions* has hitherto not been investigated in a thesis. The relationship between displayed glass works of art and the space with regard to the perception of each displayed glass work of art as well as the perception of the exhibition itself as a 'whole' has also hitherto not been investigated in a thesis despite there having been studies on the semantics of contemporary glass art in a few theses (see Appendix III).

For this reason, the thesis will discuss the concepts of exhibition design for contemporary glass art applied in spaces of glass museums in the Glass Age in order to close some of the lacunae in the literature.

As interpretations, the causes of these lacunae in the literature may be explained as follows:

- Contemporary glass art being a relatively new study area in fine arts faculties;

- Recent emergence of related professions in the fields of museology, such as those of exhibition designer and curator;

[9] Between them, the master's thesis of Hong (2006) is the closest to the thesis titled *A Research on Exhibition and Installing Form of Contemporary Glass Art* written at the Institute of Art Education at the National Changhua University of Education, Changhua, Taiwan in 2006 and published in the Chinese language. His thesis, written at an art faculty, even explores the formation of contemporary glass art installations in the context of contemporary glass art by benefiting from semiology. His thesis also suggests a further study to explore the relationship between displayed objects and the space itself. This can be mentioned as proof that the thesis topic (titled *Glass museums: Exhibition Design and Spaces for Contemporary Glass Art in the Glass Age*) is a necessity of the Glass Age and it is required to be written in the scope of architecture to fill the gap in the literature Source: (Hong, 2006)

[10] The relationship between the three evolved concepts of exhibition design (white cube, black box and total work of art) and displayed glass works of art has hitherto not been investigated in any thesis.

- The relative rarity of glass art museums around the world in comparison to general art museums;

- The handling of innovative, contemporary and interdisciplinary approaches to exhibition design in glass museums being new;

- Studies on glass in architecture faculties mostly focusing on handling glass as a material of function and a material of metaphor with regard to transparency rather than handling its versatility in all forms of design.

1.4. Objectives and Methods

By focusing on the exhibition assessment of exhibition design for glass artworks on display in glass museums in the Glass Age, the thesis expects to address a gap in the literature by realising the following statements:

- Drawing artists' attention to the perceptual relationship between the glass works of art and exhibition space(s);

- To make this relationship and interaction more visible for responsible persons of the exhibition (artists, curators, interior architects, architects, exhibition designers, lighting designers, owners of institutions, etc.);

- It is expected that current artists will be encouraged to create contemporary glass art installations with respect to the space instead of continuing to create conventional glass art that often neglects conceptualisation and its interaction with the exhibition space.

- Alongside recent technical and conceptual exhibitions, installations, space-art events created with glass by varied professions such as mechanical engineers, graphic designers, computer programmers, film-makers, etc., it is hoped that glass artists will be motivated to create meaningful, interactive, contemporary art installations made with multi-media, including glass.

- In addition, it is expected to motivate glass museums to hold more frequent contemporary glass art exhibitions that cultivate the interaction of glass art pieces and the space by considering the role of lighting design and the perception of glass exhibits by observers and the conceptual approach(es) of the artist(s).

- It is expected that contemporary interior architects and architects will be encouraged by exhibition design for a contemporary glass art exhibition, architectural design of glass museums and even the design of contemporary glass art pieces.

In the thesis, to fulfil the objectives, the following methods were followed:

- A comprehensive literature review was made in order to determine how to fill the gap in the literature.

- Literary research into national and international theses, dissertations, articles and other visual, audio and written documents (such as books, journals, papers, conference papers, lecture notes, brochures, museum catalogues, opening speeches, sound recordings, curatorial interviews, photographs and interviews with national and international experts, artists, architects and curators).

- Theoretical studies based on studies of the literature to seek for an understanding of the relationship in between displayed glass art pieces and the space itself.

- Case studies to demonstrate the effects of each of the three concepts of exhibition design in terms of the illumination and perception of displayed artworks. For this purpose, cases are selected from the world's foremost glass museums that handle one of the three concepts in the Glass Age: the 'white cube,' 'black box' and the 'total work of art' concepts.

CHAPTER 2
HISTORICAL EVOLUTION OF GLASS, GLASS ART AND EXHIBITIONS

2.1. A Concise History of Glass: An Art and Design Medium

Glass is one of the earliest craft (art) and design media in the history of mankind whether natural or man-made (Kula, 2018). In both usages, it has undergone various transformations accompanied by technological developments.[11] This has actually made glass a versatile medium of art and design due to its manipulable physical properties particularly in the present age, the so-called "Glass Age."[12] The end-products of this evolution under the effect of technological and scientific developments are seen in three main concepts today: artistic glass, architectural glass and technological glass.

In history, natural glass (such as obsidian) was first discovered in the Palaeolithic era as a result of the interaction between man and the environment around 3000 BC. Its use actually started with design requirements and due to crafting. Because of war and the need for protection, Palaeolithic people made use of the fragile and cutting features of glass in order to *craft functional tools* such as knives, arrow heads, and so on. Concurrent with this, ancient people started using natural glass, particularly obsidian, to *craft aesthetic tools* such as mirrors and ornaments.[13] In a short time, before 2000 BC,[14] people learned how to produce glass[15] artificially and they started using this artificial glass to craft objects such as vases, cups, etc.

[11] See Appendix IV

[12] The term "Glass Age" will be explained in the following pages of Chapter 2.

[13] In fact, based on this information, it is argued that aesthetic pleasure, which has a close relationship with art, was a need as old as human history.

[14] In fact, it is not known clearly when the first glass composition has made consciously using raw materials. Archaeological findings indicate that the first glass-making probably occurred in the Bronze Age in Mesopotamia around 3000 BC. Based on this information, some researchers consider the glazing technique in ceramics as the first stage of glass-making, hence the use of glass on beads, ceramic utensils, tiles, etc. is considered to be the earliest glass-making examples. In some other resources, it is mentioned that the glass beads dating back to the Bronze Age were shaped by cold-glass shaping methods from the natural glasses before the discovery of making man-made glass. Nevertheless, it is certain that the man-made glass is produced before 2000 BC.

[15] Man-made refers to artificial glass. Glass is produced by mixing raw materials (glass components) and applying a heating and cooling process in special conditions and with special temperatures. Today, the most used man-made glass is produced in factories; it is rarely produced by artists or engineers for experimental aims.

with methods such moulding, shaping with tools and even blowing(Ağatekin, 1998, pp. 1-2; Bayazıt, 2008, pp. 175-185; Cummings, 2011, pp. 6-11; Olcay, 1998, p. 146).[16]

From that time to the present day, mostly man-made glass has been widely used by craftsmen, artists, designers and architects for functional, aesthetic and artistic aims. Today, particularly in the 21st century, mostly man-made glass is used as a versatile medium in nearly all fields owing to its wide range of useful properties. In terms of art and design, glass has been transformed to be a material of metaphor and a tool of inspiration and it has almost shifted from being merely a material of function. The present century can therefore readily be mentioned as a milestone in the history of glass, which is why this thesis is structured to examine glass in art and design (as regards to architecture).

2.1.2. From Craft to Mass-Production; From Mass-Production to Art and Design

Generally, the transformation from craft to art as well as architecture and technology is a process that occurs spontaneously with the effects of various art movements, scientific and technological developments, exhibitions, industrial revolutions and the other factors ever since the 15th century. The original sense of the artist was a skilled practitioner in art, science or other disciplines, while in modern usage, an artist would refer to genius, originality, the ability to transform ideas into objects and images, or the production of attractive and interesting items that simply have no usage value (Bird, 2016, p. 114; Kula, 2014). On the other hand, the term craft is defined as talent and does not include elements such as originality, genius or creativity, nor processes related to science or other disciplines.

With regard to the comparison of the two terms ‘art’ and ‘craft,’ the differences between ‘glass craft’ and ‘art glass,’ and ‘architecture glass’ and ‘technology glass’ can be explained much more clearly. All these derived terms are actually a result of the rapid development in technology and in the science of glass because before the Industrial Age and factories, glass could only be produced in small amounts and be shaped by craftsmen and there were technological deficiencies and difficulties in production. Accordingly, the development of glass in art and design had taken some time until the new techniques and methods in glass production were discovered and the scientific knowledge about glass increased (Benli, 2008, pp. 43-44).

In the literature of the glass arts and even from the references in this thesis, much information can easily be found about detailed historical processes exploring the change from glass craft

[16] The historical evolution of glass is explained in a Table A.2 in Appendix IV and is adopted and extended with interpretations from the information given on the Corning Museum of Glass web page.

to the mass production of glass and then from mass production to separate academic fields of glass art and industrial design and architectural design in glass. In this thesis, therefore, this topic will be briefly examined by summarising effects which were thought to have played a role in these transformation processes.

a. Effects have a role in the transformation of glass from a craft to mass-production as follows:

- Increased and developed industrialisation in glass in 18th and 19th centuries to supply the increased demand in glass caused by the Industrial Revolution, particularly in Europe and America (Kocabağ, 2002, p. 6).

- Significant developments occured in glass furnace technology. The (annealing*)* furnace was developed by Beivs in 1870 and the tank glass furnace was developed by Siemens in 1873. Primarily, a semi-automatic and then an automatic serial production of glass was started in glass factories as well as the invention of the machine producing textured glass in 1890. At the end of the 19th century, textured moulds were produced in America and glass was shaped in decorated moulds which made textured glasses easier, cheaper and faster in mass production (Aydın & Ağatekin, 2010, pp. 52-53).

- Increased demand in plate glass walls was caused by the development of industrial architecture and the development of pre-fabricated buildings constructed with steel frames and glass plates (Wilkinson, 2010, p. 74).

- Increased demand for glass bottles occurred due to an increase in mineral water production in Europe in the late 18th century (Kocabağ, 2002, p. 6).

- Fast, rapid and cheap production of glass-made objects (e.g., glass walls, objects, bottles, etc.) resulted in a rapid increase in sales of mass-produced glass products and in turn to the growth of glass manufacturers (Benli, 2008, pp. 43-44).

Craftsmen, artists and designers started working in glass manufacturing for a few reasons. Firstly, people became bored with seeing uniform, soulless, emotionless, cheap and simply designed mass-produced glass products in their homes and consumers began to desire unique glass objects crafted by craftsmen. Thus, demand had increased for glass manufactories to produce crafted, elegant, high quality consumer goods made of glass (e.g., glassware, decorative objects, furniture, etc.). Secondly, special designs were needed in glass factories for the image of the factory and for promotions to attract the attention of those connected to fairs and exhibitions with their glass made products. Finally, factory owners had invited artists and architects, who had academic educations, to work in their

factories in order to achieve unique designs in mass-production in return for good working conditions and good salaries (Benli, 2008, pp. 43-44; Cummings, 2011). [17]

- Rapid increases in the number of glass factories opened by glass artists and architect designers. One of them was William Morris, who was a stained-glass artist, an industrial designer, a craftsman, a writer and a manufacturer. He founded Marshall, Faulkner & Co. in 1861 and produced hand-made glass, furniture and decorations. In his company, he was both designing and creating his designs. He also employed artists and designers in addition to himself to create artist manufactured products (Bridge, 2017, p. 167; Wilkinson, 2010, p. 80)

- A new 'industrial glass' typology was born in the triad of craftsman-artist-architect owing to the possibility of bringing 'soul' or artistic content to lifeless and characterless products of industrialisation. This led to a new synthesis between physical objects and thought (Fig. 2.1) (Melvin, 2006, pp. 90-91). This new situation in mass-production would later lead to the emergence of a new discipline under the name of 'industrial designer.' Industrial glass such as glassware, lighting, perfume bottles, stained glasses, etc. now began to be produced in factories under the leadership of artists and designers such as Frenchman René Lalique (1860-1945) and American Louis C. Tiffany (1848-1933) (Fig. 2.2, Fig. 2.3).

Figure 2.1: Untitled Vase

by Manufacturer Boston & Sandwich Glass Company (active 1825-1888); Overall H: 24.9 cm; Base Diam: 11.1 cm; designed in 1835-1845 (Url 2.1)

Figure 2.2: 'Automobile Mascot' Vitesse (Speed)

by Artist and Designer René Lalique; mould-pressed glass; H. 21 cm, W. 11. cm, 7 cm, D. 8 cm; designed in 1929 (Url 2.2)

Figure 2.3: 'Vase with Peacock Feather Plique-a-Jour Mount'

by Designer and Manufacturer Louis C. Tiffany; designed in 1897-1899 (Url 2.3)

- The craft was no longer a Profession and most small workplaces of craftsmen were closed as a result of craftsmen working in factories as glass engravers, glass painters,

[17] For example, Orrefors, a glass factory in Sweden, in 1916 employed Simon Gate, who studied at the Stockholm Academy, and in 1917 employed Edward Hald, who was a student of Matisse. Simon Gate and Edward Hald's windows attracted great attention at the Paris Fair in 1925, which enabled the Orrefors factory to be recognised internationally in the field of glass.

glass cutters, glass blowers, decorators, etc. or they started to work in factories as workers due to an increased demand for labor (Url 2.4).

b. The effects have a role in the transformation of glass from mass-production to art and design as follows:

- Scientific and technological developments in glass led to new developed production techniques and methods in artistic glass-making (Cummings, 2011, p. 13).

- Glass became a material readily available in in many varieties and alternatives thanks to the rapid industrialisation of glass, such as the development of the famous 'cristallo' glass by the British. This new version of crystal glass[18] was very suitable for engraving, leading to the rise of mass produced engraved glass (Aydın & Ağatekin, 2010, pp. 52-53).

- A significant increase in the respectability and effectiveness of the handicraft, including glass craft. Longing for the former products, life and craftsmen-based architecture, which were not extravagantly decorated. Thus, the singularity, individuality and importance of handicrafts began to be expressed more than ever (Cummings, 2011, p. 13).

- A group of artists and thinkers were disturbed by the monotony and soulless mass-production and industrial architecture as well as the results of industrialisation in human life and in urban aesthetics (e.g., difficult working conditions for workers, constant changes in urban aesthetics due to migrations of the worker class, etc.). These artists and thinkers argued that all these issues were pushing art standards back, affecting the quality of life and causing oral corruption and the dehumanisation of society (Bridge, 2017, p. 166).

- The efforts of artist and architects to unite industry and art having become almost universal; these artists and architects included William Lethaby from England and Henri van de Velde from the Weimar School of Applied Arts (later to become Bauhaus) (Melvin, 2006, p. 91).

- In the 19th century, European artists became progressive, social commentators and activists and their intellectual identity was strengthened, leading to their exploration of art movements (Bird, 2016, p. 114).

[18] See Appendix I: Glossary

- Start of the use of glass in academies, particularly in the Bauhaus School in Germany in the 19th century. Under the influences of seeking new trends in art academies during the 17th and 18th centuries, architect Walter Gropius, one of the proponents of the Deutscher Werkbund and head of the Art and Crafts school in Weimar, reorganised the school and changed its name to Bauhaus in 1919. Bauhaus advocated a utopic vision that was based on combining the fine arts and crafts. This new design philosophy positioned both art and craft equally and aimed to unite their unique skills in an effort to achieve a final form of art. Bauhaus aimed to combine good design with the use of machinery in manufacturing and the acceptance of modern materials such as glass in architecture (Bird, 2016, pp. 108-114; Bridge, 2017, pp. 203-206; Grzymkowski, 2017, pp. 13-17; Wilkinson, 2010, pp. 120-121).

- An increase in schooling on glass art. In the middle of the 19th century, specialised glass schools were established in Czechoslovakia because of the rising interest in glass materials and an increasing value of the other glass masters such as glassblowers, most of whom were at high school level. In addition, the Leerdam Glass Factory established the Leerdam Glass School due to the increasing interest in glass factories and artistic glass production as well as teaching students various glass art techniques. In a short time, many glass schools were established around the world (Ağatekin, 1998, pp. 1-2).

- The rise of some art movements, particularly Arts & Crafts[19] (Wilkinson, 2010, pp. 80-84) and Art Nouveau,[20] (Bridge, 2017, pp. 171-175; Wilkinson, 2010, pp. 92-94) highlighted the importance of handicrafts and affected the ideas of factory owners and producers. These movements were both a decoration and an architectural movement

[19] Under the leadership of a versatile designer, artist William Morris, a group of architects and designers, including art and society commentator John Ruskin, designer and founder of the Craftsman magazine Gustav Stickley, Morris' architect friends Philip Webb and R. Norman Shaw, developed the Arts and Crafts movement in England between 1880 and the1920s. It spread throughout Europe and especially America; therefore, it is known as an international trend in decorative and fine arts. One of the main ideas of the Arts and Craft movement, which can be considered as a movement that integrates art and design, was care and respect for the material. At this point, glass gained importance and was influenced by this movement. The carefully processed stone, wood, glass, etc. materials and their constructions were never concealed with the idea that they should remain faithful to the materials. Thus, an 'honest structure' would be desired. The other and most important role of the Arts and Crafts movement in the transition of glass craft to glass art is the opening of craftsmen's lodges, the emergence of discussion groups and unions in order to argue the relationships between art, craft and architecture. Thus, art was revived and a special style emerged both in design and architecture, with handmade and artistically created products as well as architecture focusing 'personal design' by using a variety of local materials and creation with craftsmanship. Nevertheless, this proved to be expensive.

[20] Art Nouveau movement emerged under the influence of the 1878World's Fair in Paris. It means 'new art' and was the result of the effort to merge all kinds of art equally. Therefore, artists, architects, craftsmen, glassmakers, etc. who applied Art Nouveau embraced an open-minded philosophy that embraced all branches of art as a 'total work of art' or *Gesamtkunstwerk*. Previously, only paintings and sculptors were taken seriously in the art scene, but now all forms of art, including glass art, began to be valued. This also meant that applications for buildings, furniture, decorative products, etc. all had to function together in perfect harmony in order to ensure compliance with the principles of the vision. This vision of Art Nouveau might be compared with the formation process of the developed museum complexes of today such as the Swarovski Glass Museum, which has been designed as a 'total work of art' with its multi-sensory approach. The Swarovski Museum of Glass was formed by adopting the principles of open-mindedness, a common working system and giving an equivalent attitude to glass materials in the hands of different disciplines (artists, designers, architects, etc.) and interpreting glass materials as a metaphor in all different approaches.

bringing craftsmen, artists and architects together. Both movements were born in opposition to industrial products and architecture, which was believed to be lacking individual style with its soulless, straight lines. Two of the differences is the fact that most Art Nouveau artists had embraced modern industry and Art Nouveau is a distinctive style, inspired by nature, characterised by organic and curved lines and with the help of industry, they were reaching out to a wider audience and nurturing the movement with advertisements, posters, labels and magazines (Grzymkowski, 2017, pp. 24-25). As a result, the use of glass that occurred in the Arts and Crafts movement as an artistic and design material has gained a formal identity in artistic use with the Art Nouveau movement. One of the most famous Art Nouveau glass artists and designers is Louis Comfort Tiffany, who followed the principles of Morris, the leader of the Arts and Crafts movement and a founder of the glass company Tiffany Glass Furnaces founded in 1893 and located in New York, U.S.A. (Fig. 2.3) (Url 2.5).

- The rise of associations, organisations, artists' lodges, discussion groups, etc. to share ideas in art, craft and architecture, particularly the Deutscher Werkbund. The Werkbund is a German Association of Craftsmen founded in Munich in 1907, after Art Nouveau under the leadership of intellectual architects Hermann Muthesius and Henry van de Velde, who were influenced by William Morris, the leader of the Arts and Crafts movement. With the aim of inspiring good design and craftsmanship of manufactured goods and architecture, the organisation brought together a group of artists, craftsmen and architects ahead of their time who designed commercial, industrial and household products and also practising architecture. In a short time, the Werkbund divided into two groups, one of which was advocating the greatest possible use of standardised design and mass-production under the leadership Muthesius and the other advocating the value of individual artistic expression under the leadership of van de Velde. In 1914, the Werkbund adopted the vision of Muthesius and the influence of this movement in the field of art and architecture lasted for many years. Similar organisations were established in a short time (Österreichischer Werkbund, 1912, in Austria; Schweizerischer Werkbund, 1913 in Switzerland and England's Design and Industries Association, 1915, all of which modelled Werkbund). Its principles were adopted and applied by renowned architects and artists such as Ludwig Mies van der Rohe (Fig. 2.4.), Le Corbuser, Bruno Taut, László Moholy-Nagy (Fig. 2.5), Marcel Breuer, Herbert Bayer and Walter Groppius, the founder of the Bauhaus school (Url 2.6; Wilkinson, 2010, p. 120).

Figure 2.4: 'Illinois Institute of Technology'

by Architect Mies van der Rohe;
Modern Architecture
(Url 2.7)

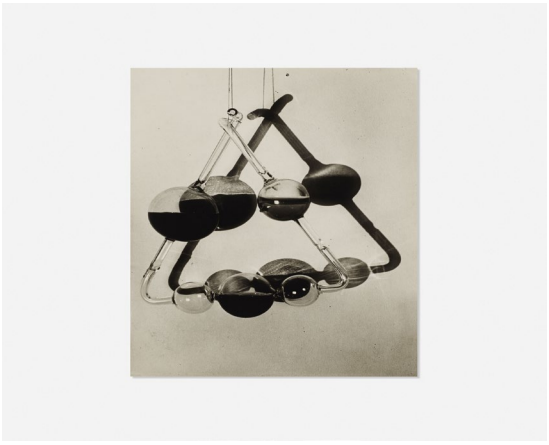


Figure 2.5: Light and Glass Abstraction

by Artist and Designer László Moholy-Nagy;
designed in 1930
(Moholy-Nagy, 1930)

- The mass-production of glass products were exhibited at international fairs, expositions, exhibitions, biennials, triennials, etc. for the purpose of promotion and advertising. For example, for industrial art and architecture, the exhibition of The Werkbund's held in Cologne in 1914, and the International Exposition of Modern Industrial and Decorative Arts held in Paris in 1925. In this process, where product design became an important part of the competitive dynamics of industrial capitalism, the 'handmade' aesthetics of artistic production gained a place in the industrial process (Bird, 2016, p. 128).

- The symposiums, conferences, etc. were organized and magazines, lectures, etc. were published about glass. For example, the Paris Conference in 1956 and the Liege Conference in 1958 had brought together glass scholars and designers from all over the world (Morse & Evenson, 2016).

- Increases in openings of glass museums and galleries that spread uniformly across Europe.

- Increases in the number of artists and designers who were trained in academies.

- The rise of 'new glass' in Europe between the late 1950s and early 1960s as a reaction to the functionalism movement, which was prominent by these times (Url 2.8).

- The rise of the Studio Glass Movement and the experimental workshops of Harvey K. Littleton and Dominick Labino in 1962. Harvey K. Littleton and Dominick had built a small glass furnace and organised workshops to demonstrate to artists the possibility of making glass art pieces in their studios thanks to their small furnace with the use of

industrial artificial glass (Url 2.4). This caused a large artistic movement in the development of glass art, known as the Studio Glass Movement. Later, Littleton introduced this new development by arranging temporary, mobile exhibitions called 'Vrij Glass.' (Url 2.9) As a result, artists started working in their studios with the, easily-forming material 'glass' in their own studio type furnaces and glass art pieces started to become widespread among the artists who received art education in various art branches (ceramics, painting, design, etc.). In the 1970s, the studio glass movement also affected the art academies with glass art programmes starting to be opened in fine arts faculties.

In summary, the following three statements can be inferred:

- The Industrial Revolution can be considered a milestone in the transformation of the glass craft into mass-production.
- The Arts and Crafts Movement, which arose towards the end of the 19th century, can be considered a milestone in the transformation of mass-production to be the material of art and design, particularly in the faculties of art and design.
- The Studio Glass Movement, which began in 1962, can be considered a milestone in the transformation of glass from being a material in art faculties to being accepted as an individual high-art, also called 'glass art.'

2.1.3. The "Glass Age": Glass as a Metaphorical Medium of Contemporary Art and Design in the 21st Century

In the 21st century, material glass stands somewhere between art, architecture and technology and it plays the role of being a medium of metaphor through contemporary art and design. This actual situation of glass is actually caused by the fact that glass is the most transformative od all materials. Due to its versatility and technical capabilities, glass has transformed culture and society for a long time. L. David Pye, editor of the International Journal of Applied Glass Science Journal, states that:

> *"Clearly glass has played major a role in advancing civilisation and mankind throughout recorded history be it in the arts, architecture, transportation, medicine, communication, and especially important, other branches of science."*
>
> (David Pye, 2016)

Today, in the 21st century, glass has reached its peak in its overall transformation with the totality of scientific knowledge in glass as well as with further development of the technologies of glass. This age, the 21st century, is therefore declared as the 'Glass Age.' Particularly

Corning Incorporated,[21] together with its foundation Corning Museum of Glass, has played a role in promoting this century as the Glass Age by making movie series and encouraging engineers to write and talk about it. On its website, Corning strikingly announces that this century is the Glass Age as much as the other transformative ages, such as the Stone Age, the Bronze Age and the Iron Age (Url 2.10). Moreover, with announcements by Corning as well as a few articles and books (e.g., the book *The Age of Glass* written by Stephen Eskilson in 2018), have been contributing to the literature on this topic since 2016. Nevertheless, the term "Glass Age" is a fresh term in the academic world (Eskilson, 2018; Morse & Evenson, 2016).

By looking at the articles, the following two reasons make it clear as to why this century has been announced as the Glass Age according to Morse and Evenson:

- ***The ubiquity of glass:*** Glass has the central role in day-to-day lives (e.g., glass screens of smart phones, computers, etc.; glass lenses in cameras; glass fibers in communication technologies; glass light sources in lighting technologies; protective materials in glass enclosure cases or containers; decorative and functional elements in homes).

- ***The accelerating speed of glass innovation:*** Particularly in the first decade of the 21st century, glass scientists have developed various types of glass with different properties (e.g., chemically strengthened glass, thin optical fibre strands, flexible glass, hybrid glasses made from organic-metallic frameworks and bioactive glasses). Scientists Adam Ellison, John Mauro and David Pye describe glass today as a "quintessential nanotech material." However, scientists have also made crucial scientific studies on glass about its unique atomic state in order to understand the transition and relaxation of glass as well as studies to develop innovative vitrification techniques. Thanks to the understanding of the chemistry of glass and glass physics, the atomic state and structure of a glass can be determined today with different fabrications and formulations to control its thermal, mechanical and optical properties and the related attributes (e.g., refractory compatibility) (Morse & Evenson, 2016).

As a result of rapid scientific and technological advances in glass, Professions from a variety of fields have started to push the boundaries of glass in order to invent innovative glass enabled designs and technologies for everyday surfaces and for day-to-day objects. Engineers who work in the glass industry have moved away from time-consuming experimentations into the

[21] Corning Incorporated is the company known for advanced glasses (such as gorilla glass) and it is at the same time the founder of the Corning Museum of Glass.

sophisticated techniques of modelling in glass manufacture as have designers in the glass industry.

These factors have affected the fields of art and architecture due to the wide range of the properties of glass. Glass artisans started to seek new possibilities of glass in their work, but they also started to organise and participate in co-working programs (e.g., workshops, symposiums, etc.) together with engineers and designers in order to share their ideas in exploring 'the new in glass.' Accordingly, glass art, glass architecture and glass technology started to be used in the context of art and design. In fact, the fields of art, architecture and technology have started to merge in spaces thanks to the material that is glass. This situation is more obviously visualised through the architectural design of specialised glass art museums and in the design of exhibited contemporary art in specialised glass art museums.

In terms of only architecture and since especially the beginning of the 20th century, glass has almost shifted from being a material of function and has transformed into being a medium of metaphor that expresses the concept of the building itself or the idea behind its design (Altıparmakoğlu Sakarya & Mutlu Tunca; Miller, 2015). This new approach in architecture, the handling of glass as a medium of metaphor, had actually arisen from the knowledge of the optical properties of glass, particularly as a bearer of light and a multiplier of colour as explained in the writings of expressionist writer Paul Scheerbart on glass architecture (Ballato & Dragic, 2016). Accordingly, the concepts of transparency and opacity and the concepts of openness, honesty and privacy are interwoven with one another (Balik, 2017). Glass has become the carrier of […] political metamorphosis rather than being the carrier of personal or spiritual transformations (Bletter, 1981, pp. 8-17). More recently, in the Glass Age, glass has the roles of being a temporal and ephemeral reflective screen of representation, a condensed opaque veil of a building, a communicative medium of Expressionist architecture and an inspirational source for all observers. In the so-called 'Glass Age,' a revival of the age old metaphor of "crystalline glass" of the post-World War I period has emerged through art and architecture at the beginning of the 21st century; hence, it is best exemplified in glass museums. Similarly, the revival of utopian crystalline architecture had been experienced at the beginning of the 20th century. However, the difference is that the glass architecture of the beginning of the 20th century represented the known scientific knowledge and technology of its time and the glass used in the architecture of the current Glass Age represents the current technology and scientific knowledge of glass. In fact, the glass of architecture and the glass of smart technology have begun to be integrated with each other in the scope of design in a contemporary style. Accordingly, glass used in architecture seems today to be a technologically well-developed evolution of previous materials and it tells more than ever it expressed (Bletter, 1981; Butterfield et al., 1993, pp. 8-17).

In terms of only art, contemporary glass art stands somewhere between being physical objects and being dematerialised art in the Glass Age and it handles glass as a medium of metaphor as in the architecture (Aalto-Setälä, 2018, p. 41; Butterfield et al., 1993, pp. 8-17). As a metaphoric medium and as an inspirational source, the inner soul and voices of the creators come to life with the material of the age: glass. Studies cited throughout this thesis make clear that today glass is not only the medium of glass artists educated in the glass art field of the fine art faculties, it is also simultaneously a medium of other artists and designers from a variety of fields (Butterfield et al., 1993, pp. 8-17; Coirier, 2013). This means that works of art and installations made with glass are actually an intellectual product of such art movements (e.g., light art, space-art, video art, digital art, projection art, installation, performance, conceptualism, minimalism) that might be created as interdisciplinary work by a team of co-creators that can include artists, architects, multi-media designers, engineers, etc., or it might be created as a single work of art or installation made by glass artists. It can be inferred that this current complexity in glass art pieces and glass made installations is generally based on the following statements:

- Under the concept of the new materialism notion of contemporary art, glass media started to be used integrated with other media (such as digital media, light, neon gas, ceramics, paper, metals, etc.). Thus, some new styles have emerged in contemporary, single glass art pieces as mixed media works of art (Fig. 2.6), light art or neon art and kinetic plasma glass sculptures, etc.

Figure 2.6: Work of Art: 'Angles II'

by Artist Mustafa Ağatekin;
two glass panels, a thin layer of ceramics; 2005
(Url 2.11)

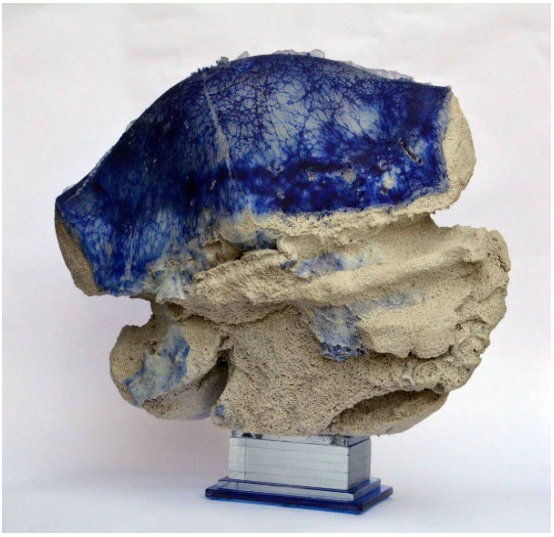


Figure 2.7: Works of Art: 'Offbeat'

by Artist Ekrem Kula;
foam glass; 2014
(Url 2.12)

- Thanks to the discoveries of new possibilities in glass making methods, contemporary glass artists sought new appearances achieved in glass works of art such as foam glass (Fig. 2.7), geometric portrayals in glass (Fig. 2.8) or fine grain glass (Fig. 2.9).

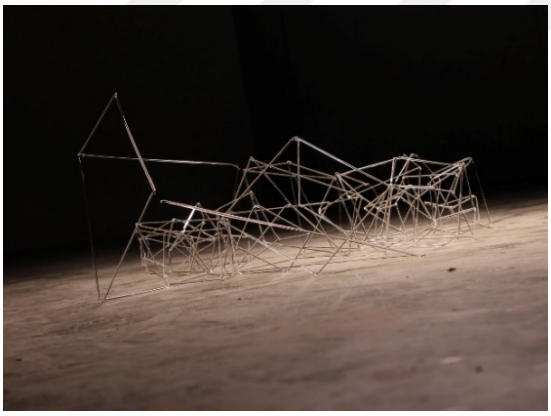


Figure 2.8: Glass Art Installation: 'Towards Freedom'

by Artist and Designer Seval Yılmaz Yatır (the Author);
borosilicate glass, lamp working technique, 2015
(Yılmaz Yatır, 2015)

Figure 2.9: Glass Art Installation: 'Hide and Seek'

by Artist Fatma Çiftçi;
glass, pate de verre technique, 2019
(Url 2.13)

- Thanks to the wide range of properties and easily shapable aspects of glass, glass started to be used as a medium of communication by other artists and designers under the concepts of some art movements such as conceptualism, minimalism, light and space art, performance art, media art, etc. Thus, glass is used as a medium for the creation of site-specific architecturally involved installations (Fig. 2.10), space-experience installations, light and space art installations (Fig. 2.11), multi-media

installations (Fig. 2.12). Moreover, hot glass demonstrations might be considered a performance art made with glass.

Figure 2.10: Installation: 'White Cube Gallery'

by Artist Larry Bell;
clear glass, grey-coloured glass and partially coated glass panels; 2014
(Url 2.14)

Figure 2.11: Installation: 'Elliptical Glass'

by Artist James Turrel;
LED, curved glass, corian, steel; 2017
(Url 2.15)

Figure 2.12: Installation: 'Vulkaneifel'

by Artist Judith Röder

a) experimental film, 16 mm transferred to HD Video, 40:45 min. loop, b/w, silent; and

b) Vessels made with cast glass
(Url 2.16)

- In the concept of contemporary glass art, traditional techniques of glass art have started to be altered with new techniques provided by current technology (such as laser engraving, laser printing, water jet cutting, and projection).

- Due to the difficulties of traditional techniques of glass art, glass artists started to seek new forms in contemporary glass art and thus, glass art installations, made with single media glass or mixed media including glass, has emerged in contemporary glass art in the late 20th century (Fig. 2.13). Today, in this Glass Age, contemporary glass art installations have also begun to evolve as interactive glass art installations (Fig. 2.14) and digital media installations made with multi-media included with glass (Fig. 2.15).

Figure 2.13: Installation: 'KURSK III'

by Artist Jens Gussek; glass, iron, latex; 2012 (Url 2.17)

Figure 2.14: Installation: 'A Part of You'

by Artist Verena Schatz; glass, stainless steel, camera; 2012 (Url 2.18)

Figure 2.15: Installation: 'Presence'

by Artist Verena Schatz; glass, wood, video camera, projector; 2013 (Url 2.19)

Based on all the above explanations, it can readily be interpreted that the 21st century, the so-called 'Glass Age,' is the milestone in glass art that seems to be transforming contemporary glass art into installation art and mixed media art. Similarly, the Studio Glass Movement was the milestone in glass art that transformed modern glass art supported by industry into the contemporary glass art taught in fine arts faculties. In the near future, contemporary glass art will seem to be at the centre of all other departments in fine arts faculties and material glass will seem be the most used material in all departments of art and design thanks to its technical possibilities and extensive properties.

2.2. Conceptual and Contextual Evolution of Glass in Exhibitions

Research shows that special glass art exhibitions started to be organised after the modern art period and in the contemporary art period. In the literature, an exhibition named *Glass 1959*, which was organised by the Corning Museum of Glass, is stated to have been the first international glass art exhibition and there is no other information about any other national glass art exhibition before this time. Previously, glass art pieces were exhibited together with other works of art and industrial glass works in hybrid exhibitions, fairs and biennials. Therefore, one could infer that the term 'glass art exhibitions' corresponds to 'exhibitions of contemporary glass art.'

Starting from 1959, an increased interest in glass art has seen and so, an increase in the number of openings of special glass art exhibitions has been seen. In the development of special glass art exhibitions, workshops by the Studio Glass Movement arranged in 1962 and the acceptance

of glass art in the so-called 'high arts' in fine arts faculties in 1964 played the most crucial roles in the history of glass exhibitions (Aydın & Ağatekin, 2010). From that time to the present day, the opening of the Chihuly Garden and Glass permanent glass exhibition in Seattle, U.S.A. in 2012 created a new beginning in the history of glass art exhibitions. It is presented as a site-specific glass installation in and of itself, but it is actually a permanent exhibition that houses contemporary glass works of art and installations (Url 4.70; Url 4.71; Url 4.72). Accordingly, it can clearly be interpreted that the international glass art exhibition Glass 1959 was the first milestone in the history of glass art exhibitions and the Chihuly Garden and Glass permanent glass art exhibition is the second milestone in the history of glass art exhibitions opened in the Glass Age.

2.2.1. A Concise Journey of Glass in Exhibitions

In this thesis, the most important exhibitions, which have played special roles in the conceptual and contextual evolution of glass in exhibitions, will be discussed.

2.2.1.1. The Great Exhibition of the Works of Industry of All Nations, London, 1851

Industrial exhibitions and world fairs began at the end of the 18th century. The Great Exhibition, also known as *The Great Exhibition of the Works of Industry of All Nations* or the *Crystal Palace Exhibition*, ran from 1 May 1851 to 15 October 1851 and was the first of the World's Fair exhibitions of culture and industry, displaying more than 14,000 exhibitors' products made in the industrial period in addition to artists' works from around the world (Fig. 2.16, Fig. 2.17). In its 990,000-square-foot (92,000 m^2) exhibition space, this international exhibition was categorised to display in four main groups: raw materials, machinery, manufacturers and fine arts. The exhibition also housed a 27-foot tall Crystal Fountain installation. The Great Exhibition displayed modern art glass works, industrial glass products and architectural glass panels in the Crystal Palace building. In relation to fine art, this exhibition is regarded as the first indicator of modern glass art. However, it is much more (Ağatekin, 1998).

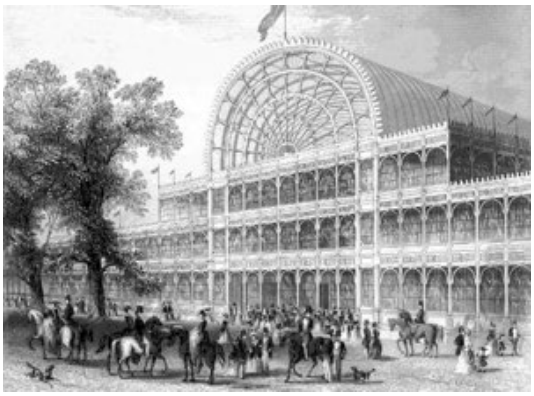


Figure 2.16: Outdoor View of the Crystal Palace

by Architect Joseph Paxton, in Hyde Park, London 1851
(Url 2.23)

Figure 2.17: Indoor View of the Crystal Palace

by Architect Joseph Paxton, in Hyde Park, London 1851
(Url 2.23)

The Crystal Palace was especially designed as a temporary construction with prefabricated elements of steel, glass and wood by Joseph Paxton 'to house the Great Exhibition.' (Url 2.24) The Crystal Palace was mentioned as 'a showcase for the best of everything.' (Url 2.24) Today, in terms of exhibition spaces, there are so-called glass pavilions built in specialised glass museums such as the Glass Pavilion of the Toledo Museum of Arts. These new ones may have been influenced by the Crystal Palace, but developed with the technology of the period resulting in a 'light box'[22] illuminating cities as iconic glass exhibitions to exhibit glass on facades and exhibit glass works of art in its gallery spaces.

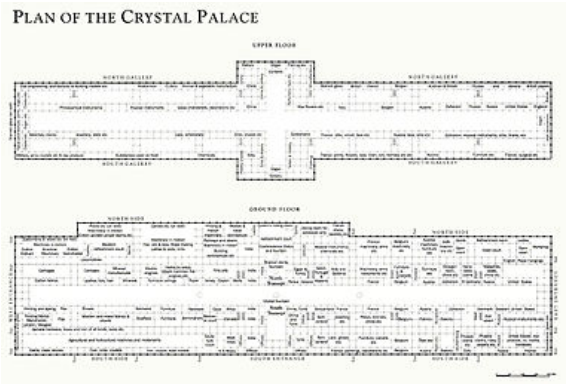


Figure 2.18: Architectural Plan of the Crystal Palace

by Architect Joseph Paxton, in Hyde Park, London
(Url 2.23)

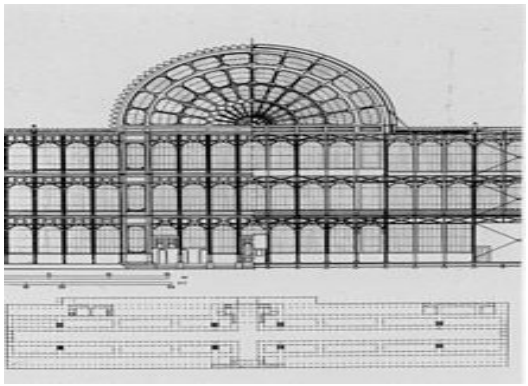


Figure 2.19: Partial Front and Rear Elevations of the Crystal Palace

by Architect Joseph Paxton, in Hyde Park, London
(Url 2.23)

The pre-fabricated construction idea used in the construction of the Crystal Palace is based on the use of labour and time-saving machines of the Industrial Revolution that can accelerate

[22] The term 'light box' refers to an illuminated box and it is usually used to display graphic or digital media. In this thesis, the term 'light box' is used to refer to galleries and museums made with transparent glass to display glass artworks based on the similarity between building architecture and the light box.

and standardise building construction. Paxon visualised this idea with the design of the Crystal Palace. It was the largest glass structure at that time (Url 2.25). Since the exhibition committee left little time for the Crystal Palace, it was necessary to use pre-fabricated components of repeating standard elements such as arches, beams cast in iron, profiles, gutters and glass panels (Url 2.23).

The Crystal Place was 1,851 feet (564 m) long with an interior height of 128 feet (39 m). The glass was manufactured by the Chance Brothers Company from Birmingham, which introduced the sheet glass method in Britain in 1832 and made possible the production of large-scale sheets of strong and cheap glass. Thus, a structure with the greatest area of glass which had never been seen before in a building was created in the Crystal Palace and exhibited both commercially and culturally in the scope of industrial glass. Visitors were surprised when they encountered the building's transparent walls and ceilings which did not require artificial interior lighting. It has been mentioned that the name of the building comes from a piece penned by the playwright Douglas Jerrold in 1850 about the forthcoming Great Exhibition referring to it as a "place of very crystal" (Url 2.23; Url 2.25; Wilkinson, pp. 72-75). In short, modern glass architecture and modern glass art were simultaneously exhibited at the Crystal Palace with the construction of glass façades of the building and installation of glass fountains in the exhibition spaces.

2.2.1.2. Deutscher Werkbund's Industrial Art and Architecture Exhibition, Cologne, 1914

Another important early glass exhibition was the Deutscher Werkbund's exhibition of industrial art and architecture organised in Cologne in 1914. The exhibition included some of the most notable modern examples of glass, steel and concrete architecture (Url 2.6). One of these was the Glass Pavilion, also called the Glass House, designed by the expressionist architect and urban planner Bruno Taut. The Glass Pavilion was a brightly coloured landmark of the exhibition, constructed with concrete and glass (Figures 2.20 and 2.21) (Url 2.26; Url 2.27; Url 2.28).

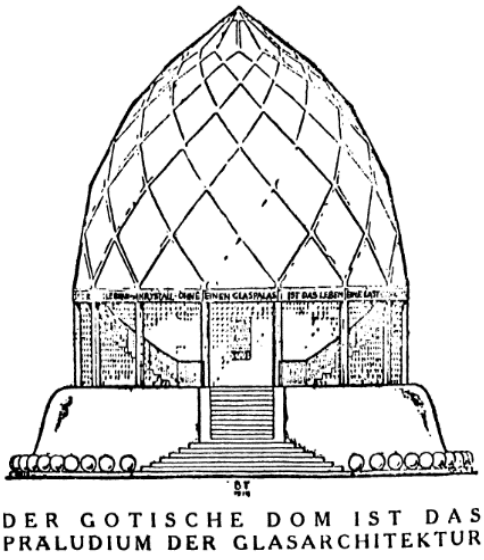


Figure 2.20: Drawing of the 'Glass House'
by Architect Bruno Taut
for the Werkbund Exhibition in Cologne in 1914
(Bletter, 1981, pp. 20-43)

Figure 2.21: 'Glass House (Glass Pavilion)'
by Architect Bruno Taut
for the Werkbund Exhibition in Cologne in 1914
(Url 2.28)

The architectural design of the building was a pineapple-shaped, multi-faceted, polygonal designed rhombic structure (Fig. 2.21). The dome was designed with double glass outer layers which was inlaid on a concrete frame. Coloured glass prisms were exhibited on the inside and the reflective glass used on the outer facade acted as mirrors. This has been mentioned as 'a little temple of beauty' and described by Taut as "...reflections of light whose colours began at the base with a dark blue and rose up through moss green and golden yellow to culminate at the top in a luminous pale yellow." (Url 2.26)

Additionally, Taut's pavilion was the first building where glass bricks were used in large numbers. On the exterior walls, between the dome and the base, it had a fourteen-sided base devoid of rectangles, created with thick glass bricks. In the interior space, there was a glass treaded metal staircase which led to the upper projection room that showed a kaleidoscope of colours in what can be considered the cantered part of the exhibition space. There was a seven-tiered cascading waterfall with underwater lighting between the staircases. The interior space had prisms which produced coloured rays from the outside sunlight. The coloured glass floor-to-ceiling walls were a mosaic. With all these components, the Glass Pavilion gave one the experience of being inside a large crystal producing a large variety of colours from natural sunlight (Bletter, 1981, pp. 20-43).

This building, the Glass Pavilion or Glass House, was specially designed for the 1914 Werkbund exhibition and was considered 'a house of art' for the association of the German

glass industry, which financed it. In fact, it was designed only as an exhibition building as being one of the first exhibition buildings not for any other practical use. Therefore, the Glass Pavilion of Bruno Taut can be accepted as the first holistic approach in exhibiting glass as both an art and architectural material. With the same aim as today's multi-sensory museum vision, Taut's Pavilion was designed as a mechanism for creating vivid experiences where visitors would be able to feel, touch and primarily see (Url 2.26). Thus, glass was used as an inspirational source, as a metaphor, as a medium of expression and provocation in the context of art, architecture and the glass industry.

Conceptually, Taut's vision behind this design was the search for a new artistic spirit in architecture by following the contemporary expressionist painters and creating a different structured building similar to Gothic cathedrals. During these times, expressionism stood at the highest level in Germany and sought to create new dramatic forms and shapes in modern architecture (Wilkinson, 2010, p. 108). With the design of the Glass Pavilion, his goal was to create a functionless building where architecture would include other arts such as painting and sculpture in order to achieve a new and unified expression. In this way, glass house would provoke something in someone more so than a practical building would. Therefore, it can be said that Taut actually did the same single-handedly what is still trying to be done in art museum designs by a collaborative work of architects, artists and designers today. In fact, in time the Glass Pavilion of Bruno Taut was made into a symbol, a mystical sign, an installation in and of itself, a start for a new world view and future architecture. The anarcho-socialist writer Paul Scheerbart wrote the frieze of the Glass Pavilion with aphoristic poems of glass and who wrote on modern glass architecture and explored it in relation to *transparency* (Bletter, 1981, pp. 20-43; Miller, 2015). Moreover, it influenced magazines, philosophers. One famous art historian and architecture writer Adolf Behne wrote about the Glass House in his Kunstgewerbeblatt in 1915:

> *"The longing for purity and clarity, for glowing lightness and crystalline exactness, for immaterial lightness and infinite liveliness found a means of its fulfilment in glass—the most ineffable, most elementary, most flexible and most changeable of materials, richest in meaning and inspiration, fusing with the world like no other. This least fixed of materials transforms itself with every change of atmosphere. It is infinitely rich in elations, mirroring what is above, below, and what is below, above. It is animated, full of spirit and alive... It is an example of a transcendent passion to build, functionless, free, satisfying no practical demands—and yet a functional building, soulful, awakening spiritual inspirations—an ethical functional building."* (Stacher, 2018, p. 60)
>
> Adolf Behne

2.2.1.3. International Exposition of Modern Industrial and Decorative Arts, Paris, 1925

Another effective exhibition in relation to exhibitions of modern glass was the International Exposition of Modern Industrial and Decorative Arts held in Paris from April to October 1925, visited by 16 million people. It was a world fair which presented for the first time many international avant-garde ideas in the fields of architecture and applied arts. This exhibition was designed by the French government to highlight (for its time) the new *style modern* of architecture, interior decoration, furniture, glass, jewellery and other decorative arts in Europe and throughout the world (Url 2.29). As explained previously, the design style which was presented as 'the style modern' at the Exposition was later to become known as 'Art Deco' after the name of the exposition. Art Deco, a new movement after Art Nouveau, widely used glass. 15,000 exhibitors from twenty different countries participated in this exhibition, including one of the most famous glass artists Rene Lalique (Figures 2.22 and 2.23) (Url 2.29). Rene Lalique was a famous jewellery designer and glass artists who had worked primarily in the Art Nouveau style and then the Art Deco style. The 1925 Exposition set his career as a glass master similarly to how his career as a jeweller was set previously at the 1900 Exposition. Lalique had written an essay as the preface for the exposition's catalogue and guide, "Glassware," in which he extolled the virtues and possibilities of glass as a decorative and architectural material and praised the exposition's organisers for its inclusion of so much glass (Fig. 2.24) (Url 2.30)

Figure 2.22: Untitled Table Lamp
by Artist and Designer René Lalique;
mould-pressed glass,
acid-etched, applied patina;
H: 39.8 cm,
D: 21.9 cm,
designed 1910
(Url 2.30)

Figure 2.23: 'Vase (Martin-pêcheurs sur fond de roseaux)'
by Artist and Designer René Lalique;
mold -blown glass a cire perdue (lost wax);
H: 26.3 cm,
D: 32.1 cm,
designed in 1930
(Url 2.30)

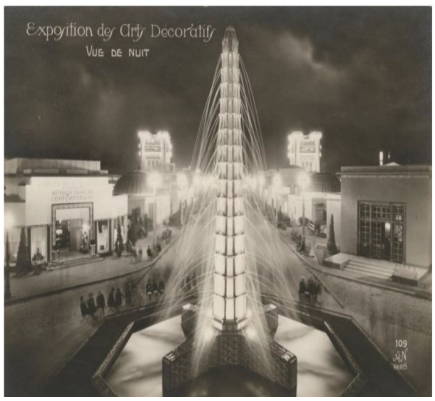


Figure 2.24: Night View of the Illuminated Glass Foundation called 'Les Sources de France' (Springs of France)
by Artist and Designer René Lalique and Architect March Ducluzaud;
exhibited at the Exposition Internationale des Arts Decoratif et Industrials Modernes in Paris, 1925
(Url 2.30)

In addition to the International Exposition of Modern Industrial and Decorative Arts, a number of other international exhibitions also exhibited glass art pieces from many different nations

such as the Brussels World's Fair and the Trienniale in Milan (Corning Museum of Glass, 1959).

2.2.1.4. Glass 1959 Exhibition of CMOG, New York

Glass 1959 was the first international exhibition of contemporary glass art, organised by the Corning Museum of Glass (CMOG), which exhibited 1,814 glass made objects from all over the world. In terms of design, technique and glass materials used, every type of exhibited object was made, including unique, handmade pieces (Fig. 2.25), as well as mass produced decorative objects and table glass from 173 glass manufacturers from 23 countries made since 1955 (Figures 2.26, 2.27 and 2.28) (Corning Museum of Glass, 1959).

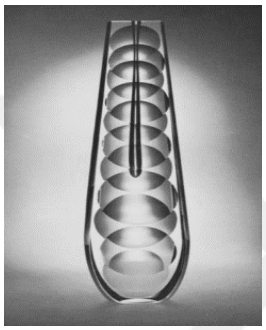


Figure 2.25: Untitled Vase, designed and cut by Pavel Hlava

Czechoslovakia Art Centre
(Corning Museum of Glass, 1959, p. 51)

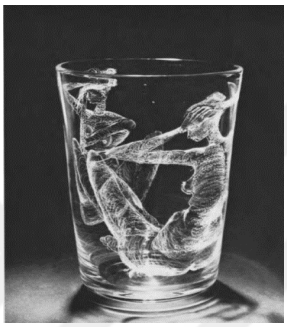


Figure 2.26: Untitled Vase, designed and engraved by John Hutton

Th. Webb & Sons, England
(Corning Museum of Glass, 1959, p. 98)

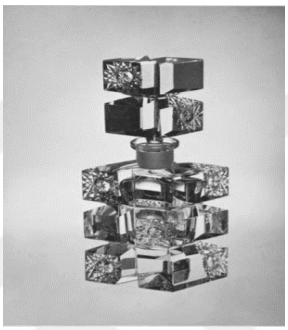


Figure 2.27: Untitled Perfume Bottle, designed and cut by Franz Burkert

Kristallglass GmbH, Oberursel/Taunus
(Corning Museum of Glass, 1959, p. 59)

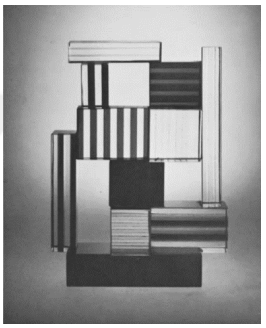


Figure 2.28: Untitled Glass Sculpture, designed by Anthony D'Attilio

Horriton Carved Gloss, Inc.,
New York City;
laminated clear, amethyst,
blue and green glass
(Corning Museum of Glass, 1959, p. 313)

The Corning Museum of Glass also publishes a book titled *Glass 1959*. Through this book, all the information can be found regarding decoration styles as well as developments in technology, techniques and methods of glass making reflecting the period (Corning Museum of Glass, 1959).

2.2.1.5. The Chihuly Garden and Glass Exhibition, Seattle, 2012

Chihuly Garden and Glass is a long-term exhibition of contemporary glass art that first opened in 2012 (Fig. 2.29) at the Seattle Centre, U.S.A., which also housed the 1962 World's Fair. Today it is still the house of the iconic Space Needle (Url 2.31).

The exhibition was designed as an 'adaptive reuse project'[23] by renowned glass artist Dale Chihuly, who has given interior design and glass art education and was invited to this exhibition by the Wright family, owner and manager of the Seattle Center. The Chihuly Garden and Glass Exhibition presents a comprehensive collection of glass art pieces as well as glass art installations created by Chihuly. Although this exhibition is mentioned basically as a permanent exhibition of Chihuly, it has special importance in the world of glass art exhibitions designed in the Glass Age as this permanent exhibition appears to follow the 'total work of art' approach by itself due to its overall concept for exhibition design, which was designed holistically and provides an overall experience of glass via multi-sensory perception (Url 2.31; Url 2.32; Url 2.33).

Figure 2.29: Chihuly Garden and Glass Exhibition

Seattle, 2012
(Url 2.32)

Figure 2.30: View from Glass Garden installation

Chihuly Garden and Glass Exhibition
Seattle, 2012
(Url 2.34)

In terms of exhibition design and architecture of the building, the exhibition, the so-called Chihuly Garden and Glass, was specially designed as a whole in 6,070 m^2 areas in a collaboration between Chihuly and the manager of the Wright family. In the project, the existing building was first redesigned to be the house of the Exhibition Hall that included eight galleries (Figures 2.31, 2.32 and 2.33) and three drawing walls. A glass house was designed to be a centrepiece of this project (Fig. 2.29) Then, a garden space was added to be the glass garden installation of Chihuly (Fig. 30) and finally, a theatre was designed for the presentation of short videos of interviews and the working process of glass artist Dale Chihuly (Url 2.35). In addition to the building itself, the glass house installation also appears as a total work of art as it is the centrepiece of the exhibition and houses the glass art pieces of Dale Chihuly in the shape of the installations. Moreover, the Glass House building itself acts as if it were a light box at night due to its transparent glass façades presenting the illuminated glass installations to the city (Fig. 2.29).

[23] See Appendix I: Glossary

Figure 2.31: Interior view of Chihuly Garden and Glass Exhibition, 2012

(Url 2.32)

Figure 2.32: Northwest Room, Exhibition Gallery, Chihuly Garden and Glass Exhibition, 2012

(Url 2.35)

Figure 2.33: Exhibition Gallery, Chihuly Garden and Glass Exhibition, 2012

(Url 2.36)

The Chihuly Garden and Glass Exhibition acts as if it were a glass museum in and of itself in the so-called 'Glass Age,' which brings it to a special position among all other special glass art exhibitions since the first ever exhibition to the present day.

2.2.2. Most Frequently Used Concepts of Exhibition Design for Contemporary Glass Art

> *"The role of an exhibition designer is to create a three-dimensional environment which explains the story."*
>
> (Locker, 2017, p. 38)

Exhibition design can occur though an interface that integrates art and architecture in a holistic approach as it requires knowledge in both fields and merges them into one design. The communication between artists and visitors is actualised via exhibitions of artwork in a space with the help of exhibition designers. As in any event or situation with which we interact, the context of an exhibition is also acquired in our minds as sensory experiences.

This thesis is based on the idea that an exhibition should be designed as a cooperative work of architects and artists due to an exhibition being a 'three-dimensional essay' that requires education in both the field of architecture and in the field of art. Even other professions can participate if required, including stage designers, multi-media designers, and so on. Michael Berchler approached exhibition design in a similar context in his 1991 book Exhibitions in Museums stating:

> *"Exhibition design is almost unique in combining two- and three-dimensional design elements."*
>
> (Belcher, 1991, p. 32)

With this aim, the exhibition design of specialised glass art museums is investigated comprehensively. Focusing on the term 'specialised glass museums,' it can be seen that three distinct kinds of exhibition design approaches are mainly used in the scope of exhibiting contemporary glass art. The three approaches used in the exhibition design of contemporary glass art are the 'white cube,' 'black box' and 'total work of art' approaches. Therefore, these three concepts will be examined.

2.2.2.1. The 'White Cube'

In history, museology as it is known today, started in the 17th century with the opening of the first public museum named *Ashmolean* in Oxford, England in 1683 (Url 2.37). It was designed taking a classical museum approach for the exhibition of collections. The 18th century saw an increasing number of new museums opening and this continued in the 19th century. In the years following, museum architecture was influenced by the art and architecture movements of the time and new requirements for exhibition events were born. Most museum design is based on the approaches of modern architecture and its newer tendencies. In the 1930s, modern museums emerged leading to a new way of looking at exhibition design in response to increasing abstraction of modern art in the early 20th century. These new museum architectures created the design of 'white box' galleries as a symbol of modernism in modern art museums (Lorente, 2016, pp. 9-53; O'doherty, 2010, pp. 11-23).

The term 'white box' refers to a certain gallery aesthetic which is characterised by oblong or square shape, with white walls and with a light source, placed usually on the ceiling (Url 2.39). It emphasises the lightness and colour of displayed works of art and it minimises visual distraction between exhibits and visitors. Within this context, the Museum of Modern Art (MoMA) is a great breaking point in the field of museology because modern art had gained a new expression with this museum.[24]

MoMA is known as the first *modern art* museum in many ways and was also designed in a modern style. The director of MoMA, Alfred H. Barr, exhibited only modern works of art, which was the art of the early 20th century and avoided exhibiting any of the formal and academic art of the period. The new building of the museum also strengthened the idea of MoMA being the pioneer of modern art (Fig. 2.34). It can therefore be accepted as the pioneer of the 'white cube' concept in the exhibition design of art museums (Fig. 2.35) (Lorente, 2016).

[24] Although it was the first attempt by modern art museums to exhibit the work of living artists, the Musée des Artistes Vivants, was founded by King Louis XVIII in 1818 in Luxemburg Palace in France, but it was not defined specifically as a modern art museum. In fact, the first specialised institution of modern art was Gallatin's Gallery of Living Artists, founded in 1927 in New York and renamed the Museum of Living Art in 1936 (Url 2.39). However, it had also not come to the forefront in art history as a modern art museum as much as MoMA had.

Figure 2.34: Exterior View of the Museum of Modern Art (MoMA)

New York
(Url 2.40)

Figure 2.35: Interior View of the David Geffen Wing Gallery at the Museum of Modern Art (MoMA)

New York
(Url 2.41)

The new MoMA building has been designed in the international style introduced by the museum's curators Henry Russell Hitchcock and Philip Johnson during 'Modern Architecture: International Exhibition' in 1932 (Lorente, 2016, pp. 144-171). Lean and homogeneous surfaces were designed in such a way as to give a sense of volume and the galleries were designed in such a way as to focus on the works being exhibited. When the audience enters the gallery, they can focus on artefacts instead of ornamented, glazed walls, doors and windows, and they can continue their journeys in a simple, quiet space surrounding them. The galleries are surrounded by white walls, which had come up for discussion later by Irish artist and critic Brian O'Doherty in the 1970s regarding the 'white box' metaphor (O'doherty, 2010, pp. 9-53). Such a space design emphasised the uniqueness of works of art contained therein by strengthening the communication between the viewer and the work. Daniel Buren defines the role of museums as regards to the concept of 'white cube' while exemplifying the perception of a *bread exhibition* in the gallery space:

> *"Putting a slice of bread in a museum or exhibiting it does not change the function of the museum, but the museum, at least during the exhibition, it turns a slice of bread into a work of art."*
>
> (O'doherty, 2010, p. 12)

The widespread influences of MoMA with regard to the concept of the 'white cube' are still continued in today's museum architecture, including contemporary glass museums.[25] In the Glass Age, after 90 years of the existence of MoMA, the exhibition design concept of modernism, the 'white cube' phenomenon, is still used in the most comprehensive and leading glass art museum in the world, the Corning Museum of Glass (Figures 2.36 and 2.37).

[25]One of its reasons lays in the fact that modernism had spread over a very long period of time in architectural history and in exhibition design.

Figure 2.36: Exterior View of the Contemporary Art and Design Wing of the Corning Museum of Glass New York designed by Architecture Firm Thomas Phifer and Partners (Url 2.43)

Figure 2.37: Interior View of the Contemporary Art and Design Wing of the Corning Museum of Glass New York designed by Architecture Firm Thomas Phifer and Partners (Url 2.43)

The Contemporary Art and Design Wing project was started in 2012 and completed in 2015 by the renowned architecture firm Thomas Phifer and Partners (Fig. 2.36). The fact that it was specially designed to exhibit only contemporary glass works of art makes this design quite interesting. Therefore, the Corning Museum of Glass will be examined in detail in the cases in its 'white cube' context in the scope of exhibition design in the Glass Age (Url 2.43).

In a general sense, the concept of the 'white cube' can be applied in glass museums in order to display modern glass artworks, historical and industrial glassware and hybrid exhibitions composed of colourful contemporary glass works of art, even in the future.

2.2.2.2. The 'Black Box'

In the 1960s, due to the intense cultural transformation from the development of technology and contemporary attempts in art, a variety of new art movements emerged in new forms. New forms of art such as conceptualism, landscape art, assemblage, happening, performance art, installation art, light art, video art, media art, etc. had brought new approaches to exhibition spaces and led in turn to a closer, more interactive, bilateral relationship by transforming it to a 'black box.'

The 'black box' refers to a square room painted black where artists present and/or perform their experimental works (Url 2.42). This concept has the ability to focus the attention of observers onto the artists/performers due to the lack of a backdrop or set in space. It is therefore related to performance art. In the plastic arts scene, the concept of the 'black box' initially become popular when artists started using warehouses as workplaces in the late 1960s. However, in a short time the 'black box' took its own place as a concept of exhibition design for galleries and museums.

The evolution of the ‘black box’ approach in exhibition spaces was actually based on the following situations, having emerged consecutively with the effects of these art movements in exhibition spaces:

- Three-dimensional works of art and paintings lost their value due to new art movements coming to the forefront (e.g., installation art, media art, etc.)
- Art galleries turned into exhibition spaces for architects, engineers and performance artists rather than for artists or sculptors.
- Architects and interior architects began to design exhibition spaces spatially as exhibition designers and they became the designers and installers of their own art installations.
- Museums started to be considered ‘makers of art’ in and of themselves.
- New modes of expression were examined for better representations of works of art by curators who mostly concentrated on designing exhibitions for the current tendencies in art.

Based on all these, the art of the 1960s (e.g., performance art, light art, etc.) brought to the forefront the need for a dark gallery space in museums to focus visitors’ attention on displayed action and/or motion free from distraction. Due to the modern design of museum buildings until that not having had these kinds of dark room, museum architects sought new concepts in the design process. By these initiatives, it ultimately led to the birth of the ‘black box’ concept in gallery and museum designs, affected by the display aspects of computers that display everything from inside a black box and by ‘black box’ theatre halls.[26] By doing so, exhibition spaces of museums were transformed into a type of stage being the critical point of that query process.

In an exact manner, the first emergence of the ‘black box’ approach in exhibition spaces occurred in contemporary art institutions, which are dedicated for new forms in art and digital culture such as ZKM (Centre for Art and Media Karlsruhe), Germany established in 1987, HEK (House of Electronic Arts Basel), Switzerland established in 2011 and ARS Electronica Centre, Austria, established in 1996. However, the Tokyo Digital Art Museum (MORI), the first digital museum in the world, can be considered as the best example of the ‘black box’ in art museums. As a digital art museum, it was specially designed as an exact ‘black box’ and opened in 2003 (Url 2.44).

[26] The black box theatre in architecture first found its roots in the early 20th century in Europe in a square room with black walls and a flat floor with a flexible stage. It specialised only in theatres and emerged in these spaces to provide a direct interaction with the audience.

Figure 2.38: Exterior View of the Tokyo Digital Art Museum

Japan
(Url 2.44)

Figure 2.39: Interior View of the Tokyo Digital Art Museum

Japan
(Url 2.44)

The Tokyo Digital Art Museum offers visitors a three-dimensional journey of exhibitions in a real exhibition space, but in real time and with movement. By doing so, the museum presents visitors a living experiment of the interplay of light and colour in a black space through multi-sensory perception (Figures 2.38 and 2.39). It gives them the feeling of walking inside a virtual museum on computers because the computers represent all the colours through light and allow them to be perceived as forms and compositions as a display case inside a black box.[27]

With respect to the relationship of computers, digital media and evolution of the 'black box' concept in exhibition spaces, material glass undoubtedly plays quite an important role. The best effective interplay of light and colour harmony can only be presented by using the colourless, transparent glass material 'ultra-clear,' optic glass or crystal glass[28]. Therefore, the glass material is the most important component in the development of computers, television monitors as well as display cases and vitrines. Therefore, the interior designs of digital art museums are based on the most proper spatial organisation of the glass forms such as digital screens or objects made with glass in the concept of 'black box' exhibition design. Considering all these relations, it would be inevitable that the 'black box' concept would be reflected in the exhibition design of specialised glass art museums and this has been realised effectively in the Glass Age. The Shanghai Museum of Glass is one good example that presents the 'black box' approach in exhibition design and which will be examined in the detail in the cases (Fig. 2.40). However, other glass museums such as the Toyama Museum of Glass (Fig. 3.41), the Museum of Glass, Washington, and even the Corning Museum of Glass have also started using this contemporary exhibition design concept in recent years for some of their exhibitions.

[27] The computers offer visitors (observers) a two-dimensional journey of virtual exhibitions in a virtual space inside the computer, perceived only visually and spatially by looking at glass screens. By doing so, the computers would present visitors with a visual experience of the interplay of light and colour through glass screens in a black box.

[28] See Appendix I: Glossary

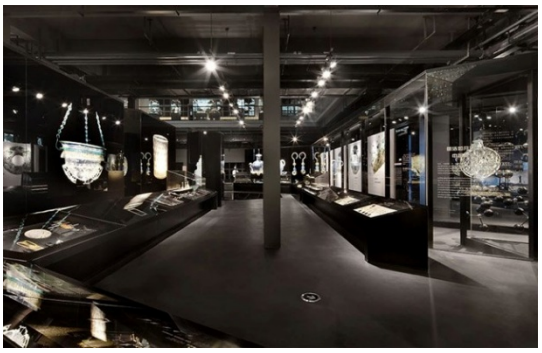


Figure 2.40: Interior View of the Shanghai Museum Of Glass

China
(Url 2.45)

Figure 2.41: Interior View of the Toyama Museum Of Glass

Japan
(Url 2.46)

As seen in Figures 2.40 and 2.41, the Shanghai Museum of Glass can be viewed very closely as a digital museum due to the 'black box' approach in exhibition design. Therefore, it has been selected to be examined in the cases in the context of this thesis. However, it is well worth mentioning the reasons for the necessity of the 'black box' approach to the exhibition of contemporary glass artistic works as follows:

- The development of contemporary glass art installations via interactions with other art fields in exhibitions. One of the reasons for glass artists being influenced by this idea is based on the technical and production-based difficulties of glass materials.
- The development of conceptualism in contemporary glass art. This led to the development of light and space art, produced with light and glass/Plexiglas, etc.
- The development of *mixed-media art.*[29] This led to the use of fluorescent coloured gases, such as phosphorus, neon, etc., inside glass art sculptures, referred to as neon art or light art. Moreover, it led to the development of plasma glass works as kinetic sculptures of contemporary glass art. All these kinds of works of art present an accurate interplay of light, colour and material glass when presented in a dark place.
- The emergence of new tendencies in presentation methods and techniques by art museums (e.g., projection, digital displays etc.) in order to offer visitors multi-sensory perceptions of exhibits.
- Providing hot glass workshops or demonstrations in glass museums, which requires dark rooms to perceive fluid and solid states of glass via visual and thermal perception.

[29] It is based on the idea of a search for new materials and combining them in the context of art among all artists, not only glass artists.

- Providing proper representation of glass works of art made with crystal glass or super clear glass[30] or opaque glass in glass museums as this kind of glass work/installation cannot properly be perceived in the 'white cube' space.
- The requirement of a dark gallery space for an accurate presentation of stained-glass windows, printed and other painted glass works of art, just as it is required for the display of video artwork or others presented digital displays.

As a result, all the above factors were led to the development of the 'black box' concept in specialised glass museums, and thus, some works of contemporary glass art (e.g. plasma glass works etc.) were presented to visitors in a more appropriate context. However, the concept of 'black box' has also two significant effects in exhibition design, which are;

- All the above mentioned effects in relation to light and perception bring more freedom in the spatial organisation of a space[31] as exhibits (illuminated in the dark to be seen) should be positioned at a proper distance depending on the design of the exhibits.
- Lighting design has become more flexible than ever in specialised glass art museums with the 'black box' concept because the specular properties of glass (e.g., transparency, translucency, light penetration, insensitivity to light damage, etc.) allows the illumination of displayed glass works with various light sources.[32]

2.2.2.3. The 'Total Work of Art'

The term 'total work of art' is a modern term in the same vein as 'white cube' and it refers to 'expressionist architecture.' However, it first used by the German composer Richard Wagner in the early 19th century. He defined his operas as 'total works of art' due to their being a synthesis of theatre, set design, drama, poetry, music and costume.[33] In German, it is referred to as 'Gesamtkunstwerk,' which translates to 'total work of art' in English. The concept of Gesamtkunstwerk was expanded later beyond opera into other art forms in the 19th and 20th centuries (Url 2.47).

Over the past two centuries, the concept of the 'total work of art' had a powerful influence on artistic practices and discourse, encouraged architects, designers and artists for searching the 'new forms' and for seeking political issues by using expressionist approach in art.

[30] See Appendix I: Glossary

[31] See Appendix V

[32] Glass is also used in exhibition spaces as a material for display cases, display screens and with developed lighting technologies due to its properties.

[33] According to him, all these elements contributed to creating a unified, coherent 'entire performance' (opera), which explains the reasons for his attempts to control each element and resultant product that could be mentioned as a 'total work of art.'

In terms of art and architecture, this concept was once noticeably achieved in design of the *Glass House* of Bruno Taut (in Germany in 1914) and now, it continues to reoccur in contemporary Glass Museums today, in the so-called 'Glass Age', such as in Swarovski Kristallwelten. Just as Taut's *Glass Haus* had been specially designed according to the concept of 'total work of art' in 1914, Kristallwelten had been specially designed according to a holistic approach to offer a multi-sensory experience of exhibitions, referring to the 'total work of art' concept. Hence, the most recent 'total work of art' concept was realised in Austria at the Swarovski Kristallwelten, which opened in 1995.

The Kristallwelten is also called the Swarovski Museum of Glass because it has been established as a house of crystal glass [34] works of art and installations. However, the Kristallwelten is in fact a mixture of an art centre and entertainment centre rather than solely being a glass museum. Therefore, the architecture of the building itself and its exhibition galleries were designed accordingly.

The architecture of the building itself was designed in the shape of a Giant as if from a theme park similar to Universal Studios Hollywood in Los Angeles, U.S.A. or Disneyland in Anaheim, U.S.A. (Fig. 2.42). The exhibition spaces of the Kristallwelten, the so called 'Chambers of Wonder,' were designed separately in the 'total work of art' concept taking a holistic approach with the aim of providing visitors an overall multi-sensory experience of crystal glass. The term 'Chambers of Wonder' makes a statement about all exhibition galleries of the Kristallwelten and it refers to term 'cabinets of curiosities,' which was used for ancestors of modern museums shaped in a gallery space.

Figure 2.42: Exterior View of the Swarovski Kristallwelten

Austria
(Url 2.49)

Figure 2.43: Interior View of the Swarovski Kristallwelten

showing one of the Chambers of Wonder, here 'Transparent Opacity'
(Url 2.50)

Figure 2.44: Interior View of the Swarovski Kristallwelten

showing one of the Chambers of Wonder, here 'Chandelier of Grief'
(Url 2.51)

The Kristallwelten consists of several isolated galleries organised as if they were underground spaces. All these exhibition spaces are architecturally flexible in character and supported with highly developed lighting equipment to transform them into uniquely designed total works of

[34] See Appendix I: Glossary

art. As a result, it houses seventeen total works of art today, which are completely different from each other in terms of concept and therefore context. They were simultaneously created taking an interdisciplinary approach in the hands of artists, designers and architects under a defined concept. Accordingly, each total work of art may be designed with different colours and illuminated differently. To create a total work of art, an exhibition designer might benefit from the approach of either the 'white cube' or the 'black box' owing to the fact that both approaches consider the relationship between displayed work of arts and the exhibition space itself in terms of the *figure-ground relationship*. For example, one of the Chambers of Wonder, 'Transparent Opacity,' has been designed holistically as a 'total work of art' in and of itself such that it benefits from the 'white cube' approach in terms of exhibition design (Fig. 2.43), while another of the Chambers of Wonder, the 'Chandelier of Grief,' has been designed holistically taking the 'total work of art' approach such that it benefits from the 'black box' approach in terms of exhibition design (Fig. 2.44).

It seems that the concept of the 'total work of art' might lead to exhibition design of other glass museums in the near future of the so-called 'Glass Age.'

CHAPTER 3
EXHIBITING GLASS ART: PERCEPTUAL AND TECHNICAL ASSESSMENT

3.1. Theoretical Background

In the scope of interior design, exhibition design can be subtitled in two main headings: spatial design and lighting design. The two of these should be designed by considering perceptual processes. As for glass art exhibitions, the same is valid. Based on these and with the exception of spatial organisation in space[35], the topics of perception, lighting design and colour preference in space are selected to be examined in the scope of this thesis. To clarify the scope, it is well worth mentioning briefly the current situation of glass art exhibitions in Glass Age glass museums.

In the Glass Age, glass art exhibitions started to be transformed into site-specific installations in glass museums influenced by current developments in glass technology and architectural glass. By doing so, exhibitions in glass museums started to present an integration of art, design and technology of glass as a whole body instead of presenting only individual glass works of art. In terms of spatial design, art, architecture and technology are handled in equal importance and integrated into an interdisciplinary approach with holistic approaches. This new type of evolved exhibition design concept aims to provide an overall glass experience to be perceived mostly with multi-senses as much as possible.[36] Exhibited glass works of art or installations made with glass are emphasised and highlighted in the space in a manner that simplifies or eliminates the space from visual field in order to allow perception of only the exhibits themselves through visual and spatial perception.[37] Based on the common approach in design of glass art exhibitions, this thesis focuses on an examination of only the visual and spatial perception of glass art exhibitions in Glass Age glass museums. Moreover, the new type of exhibition design concept (total work of art) and in the common exhibition design concepts (white cube, black box), traditional spatial arrangement concepts almost disappeared in glass museums and the space is designed depending on the exhibition concept and the physical properties of the exhibition space. The spatial design, which is mostly related to spatial

[35] See Appendix I and Appendix V

[36] This type of exhibition design concept will be examined under the concept of the 'total work of art' in this thesis.

[37] In this thesis, the two exhibition design concepts in relation to hybrid glass art exhibitions are referred to as the 'white cube' and 'black box' concepts.

arrangement, has been excluded from this thesis, but only its subtitle of colour preference in space is examined due to its importance in the perception of exhibitions.

On the other hand, lighting design gains more importance in Glass Age glass art exhibitions than most other exhibition types. The light insensitivity of glass brings glass art to a special position among other types of exhibits in museums. In the Glass Age, glass museums are aware of this special feature of glass; hence, they benefit from current technologies in lighting products and technology to illuminate glass works of art. Even some artistic glass installations have even started to be designed with glass-made lighting products in glass museums.

With regard to perception, the physical properties of an exhibition space should be considered in an exhibition design because perceptions of the exhibited works of art will be affected by the aspects of the space. In literature sources, a schema was illustrated to visualise space perception and its relationship between the fundamental space elements of colour, form and texture (Fig. 3.1). The same mechanism can be adopted to illustrate the perception of glass works of art.

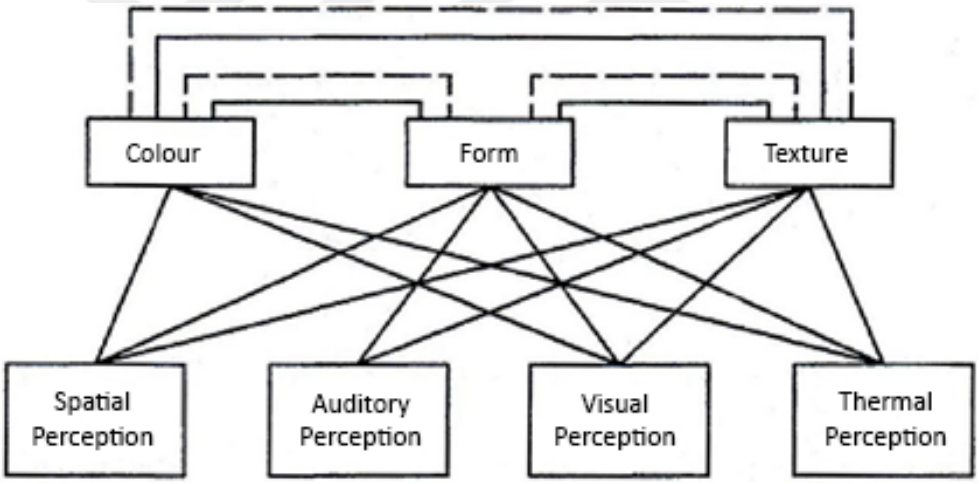


Figure 3.1: Perceptual Interaction System of Spatial Design Elements.
(Aydınlı, 1986)

Between the four types of categorisation in the schema, the visual and spatial perceptions have the fundamental role in both space perception and in the perception of exhibits because the bedrock of perception is provided visually and visual perception constitutes 80% of sensory information. These establish the structural skeleton and relate the parts to the whole so that the brain merges these visual stimuli into a perceivable three-dimensional image through the application of its own principles of order (Ching & Binggeli, 2012, p. 84; Ganslandt & Hofmann, 1992, pp. 28-29; Karcher et al., 2010, p. 12; Wördenweber et al., 2007, p. 23). Accordingly, it can be said that the spatial perception is contingent upon the visual perception, namely all the volumetric dimensions, sizes, relative distances or proximities and the three-

dimensional depth in relation to shapes and forms (Aydınlı, 1986; Ganslandt & Hofmann, 1992, pp. 28-30; Wördenweber et al., 2007, pp. 9-10). The brain tends to perceive the objects or spaces as a whole with their parts (Karcher et al., 2010, p. 12). In a similar manner, glass exhibitions are perceived as a whole body comprising flat images and three-dimensional relations among the exhibits and between exhibits and the space. In this context, the two perceptual classifications, visual and spatial, will be examined together in relation to light, colour and glass within the scope of the thesis.

By looking at the illustration in Fig. 3.1, it can also be clearly interpreted that the perception of a space can be realised with the total data coming from the physical properties of the space so that the perception of a work of art will be realised with the total data coming from the physical properties of an exhibit. As a result, the overall perception of an exhibition will be affected both by the physical properties of the space and by the physical properties of each exhibit. Exhibition designers should be aware of this situation.

In the literature, the three main physical factors are stated as being manipulable and playful factors in interior design, namely light sources, nearby colours, surface features of the used materials (absorbing, glossy, reflective, etc.) (Spankle, 2012, pp. 128-131) By altering light and colour, interior architects alter visual and spatial perceptions of a space (Spankle, 2012, pp. 129-131). It can be observed that the same can be applied as a general rule to the exhibition design of glass art for the following three reasons:

- Firstly, the main components of exhibition design seem to be lighting design and colour preference of a space for contemporary glass art exhibitions in glass museums in the Glass Age.[38] In terms of lighting design, glass artworks have a special position in exhibitions. They can be exhibited with various light sources (e.g., UV light) due to glass not being sensitive to light damage. In terms of colour preferences in space, glass artworks have a special position in exhibitions such that the nearby colours of the surroundings might alter perception of glass exhibits of art through interaction due to transparency. Additionally, the presence of coloured light rays might alter the perception of glass exhibits as a result of interactions of a transparent, colourless glass form with light.

[38] Based on the flexibility in exhibition spaces, which has rapidly increased in the last quarter of the 20th century, various spaces of different functions have started to be used as exhibition spaces for temporary exhibitions, including spaces such as warehouses, houses, forums, concert halls, gardens, cafés and bars, restaurants or even entrances to hotels or shopping centres, etc. This situation has brought flexibility to spatial organisation; works of art have started to be placed in the space by choosing the appropriate position according to the features of the space. As a result, traditional spatial organisational concepts are not applied in most hybrid glass art exhibitions today, so it can not affect the perception of exhibitions (See Appendix V).

- Secondly, glass is widely used as a space element in the design of glass museums and so in the design of their exhibition spaces in the 'Glass Age.' It is at the same time used as the material of exhibited works of art or installations in the same exhibition spaces.
- Thirdly, interactions of light and glass materials in space result in an inevitable interplay between light, colour and glass materials through perception.

Based on these three important factors in the exhibition design of glass art, it becomes important to examine light, colour and glass materials in detail within the scope of the thesis. With the help of this knowledge, artists/designers can manipulate any perception of their work and exhibition designers can manipulate the perception of a glass art exhibition.

3.1.1. Light and Colour Duality

> *"Colour is mysterious, eluding definition; it is a subjective experience, a cerebral sensation depending on three related and essential factors: light, an object and an observer." (Edwards, 2004, p. 15)*
>
> Enid Verity, Colour Observed, 1980

Light is a lively, dynamic, vibrant and apparently colourless physical property. In physics, it has an absolute state that is defined as 'radiant energy' which travels at different wavelengths and the differences between them are calculated in nanometres (nm). The wavelengths of electromagnetic radiation on the electromagnetic spectrum range from the longest waves to the shortest waves (Fig. 3.2). However, the human eye can only perceive a small part of the spectrum, namely visible light rays between 380 nm and 720 nm (Fig. 3.2). This range lying within the broader spectrum is referred to as the visible spectrum. Accordingly, information is gathered from the outer world due to the amount and distribution of light within the visible spectrum which is radiated or reflected to and from objects.

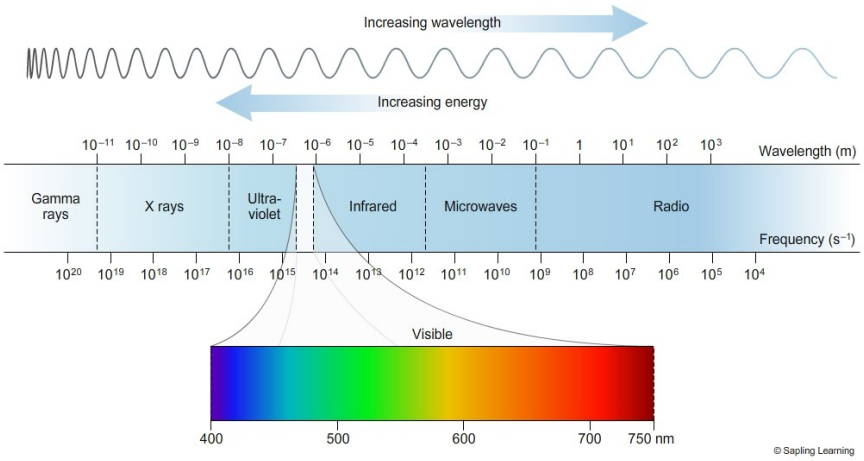


Figure 3.2: Wavelengths of Visible Light in Nanometres on the Electromagnetic Spectrum (Url 3.1)

The differences in the wavelengths of visible light are perceived as colours depending on the ability of the eyes**.** Colour is also often defined as a property of light by the science of physics (Abu Dhabi City Municipality, 2014, p. 28; Fielder & Jones, 2001, p. 2; Grey, 2004, p. 9; Holtzschue, 2009, pp. 11-13; Ocvirk et al., 2015, p. 184). In fact, colour exists with light and is carried with it (Singh, 2012, p. 49). Therefore, in most definitions, colour is defined as the visual correspondence of different wavelengths. However, in definitions of some pioneering colour theorists, the physical characteristics of the observer also have to be included since the sensitivity of the eyes for each wavelength is not equal for all wavelengths (Abu Dhabi City Municipality, 2014, p. 28; Dodsworth & Anderson, 2018, p. 146; Fielder & Jones, 2001, p. 2; Ocvirk et al., 2015, p. 183). In this respect: "Goethe proclaimed as contribution of the physical media and surfaces encountered by the light as it travels from its source to the eyes of the viewer; and Schopenhauer foresaw in a fanciful though uncannily prophetic theory the function of retinal responses in the eyes." (Amheim, 1974, pp. 337-338)

In fact, colour is a much more complex phenomenon than light. It is provocative, calming, expressionist, impressionist, cultural, vibrant, emotional and symbolic. Hence, it is studied as an individual field in psychology, sociology, aesthetics and semantic sciences in addition to physics (Holtzschue, 2009, p. 203). A more comprehensive explanation has been made by Manlio Brusatin in the book titled *A History of Colours*, written in 1991:

> *"In fact, the field of colours is a territory with ragged borders located somewhere between the sciences and the arts, between physics and psychology, a land whose configuration constitutes a border between these two diverse cultures."* (Brusatin, 1992; Edwards, 2004, p. 7)

Although colour is a complex phenomenon that is examined in most fields today, its relationship to light was first defined by observations in nature. It was noticed by the Impressionist painters who were studying the alterations of intrinsic colours with sunlight and its reflections. They were convinced that local colours are dissolved in a total atmosphere of sunlight (Itten, 1970, p. 80). Sir Isaac Newton demonstrated the same relationship for the first time using a glass prism in the 1660s.[39] He revealed that sunlight acts as a white light at noon on a sunny day, but it is distributed as colours in a linear order as a rainbow after passing through a glass prism (Fig. 3.3). This study has been accepted as the first scientific study of the nature of colours and it can be assumed to be an indication of the similarities between the colours of light and hues of colours and a scientific proof that reveals the interplay between

[39] For the first time, Newton examined the nature of colours by revealing the components of white rays of sunlight through a glass prism and thus, he formed the first colour wheel with the help of this information around the 1660s that was published in his book, a theoretical study of colour called *Optics* in 1704. The white rays of sunlight were distributed as colours in a linear order like a rainbow that he named the "spectrum," derived from a Latin Word meaning "apparition." Then he combined the free edges of the linear spectrum, red and violet, and created the first colour circle including seven of the radiant, spectral colours: violet, indigo, blue, green, yellow, orange and red.

light, colour and glass materials (Dodsworth & Anderson, 2018, p. 146; Edwards, 2004, p. 15; Grzymkowski, 2017, p. 10; Ocvirk et al., 2015, pp. 215-216; Per, 2012).

Figure 3.3: Transition of Light rays through a Glass Prism

Light strips in the rainbow are referred to as a 'spectrum of colour extracts' comprised of red, yellow, green, blue, indigo and violet. Red has the longest wavelength, so it bends the least, whereas violet has the shortest wavelength and bends the most (Ocvirk et al., 2015, p. 185).

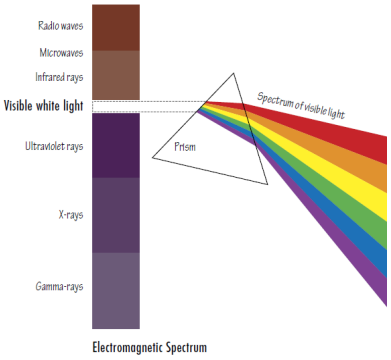


Figure 3.4: Electromagnetic Spectrum and the Visible Spectrum of Colours

(Ching & Binggeli, 2012, p. 107)

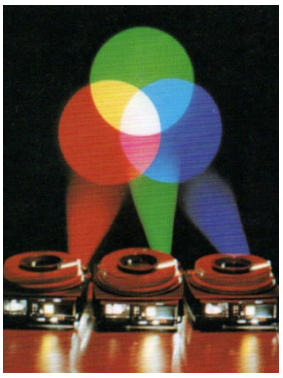


Figure 3.5: Primary Colours of Light (red, blue and green)

When two overlap, they produce one of the secondary colours (cyan, yellow or magenta). When the all three primary colours overlap, white is produced (Ocvirk et al., 2015, p. 185).

As seen in Fig. 3.3, sunlight appears white before interacting with the glass prism. After transition, it spreads as a rainbow of colours at an angle of refraction. Based on this, sunlight is accepted as visible white light defined as the entire spectrum of light rays. In other words, it is the presence of all colours (Fig. 3.4).[40] The light bands in the rainbow are referred to as the spectrum of colour extracts, which appear in electromagnetic spectrum as red, orange, yellow, green, blue and violet. As seen in Fig. 3.5, the same situation was realised by artists by overlapping colours of artificial light. Accordingly, the indispensable relationship between light and colour was proved once again (Ocvirk et al., 2015, p. 185).

Due to all these factors, the two main topics of interior architecture, light and colour, should be examined together in terms of interior design and in turn exhibition design since exhibits being modelled on displays can benefit from the knowledge of the materials of which they are composed, particularly in glass art exhibitions.

3.1.1.1. Properties of Light

In the scope of exhibition design, it is necessary to be aware of the properties of light. One of the well-known theatrical and architectural lighting designers Stanley McCandless emphasised that: "The primary characteristics of light – intensity, colour, form and movement – had a direct effect on sensual perception" (Petty, 2007, p. 196). He implies that manipulations and

[40] Later, artists demonstrated the same situation by using artificial light. They produced artificial white light in air by overlapping reflections of the three primary light colours (red, blue, green) in equal amounts. The three primary colours can produce the entire spectrum of colour hues.

combinations of these aspects allows for the determination of the emotional and psychological experience of any visitor in the environment.

In some other sources, intensity, colour and texture are defined as the three main properties of light. Although in some glass art works, the form of light is shaped according to the form of the work, such as plasma glass works, neon glass sculptures, etc. The two aspects, form and movement, are excluded from the scope of this thesis (Russell, 2012, p. 22).

Intensity of Light (Bright vs. Dark, Bright vs. Dim)

Intensity is the most obvious aspect of light. The intensity of light refers to perceived brightness, and it is related to two poles, namely light and dark.

In terms of architectural space, lighting designers arrange the most appropriate lighting levels according to the function of a space. The subjective perception of a space can be manipulated by creating intensity contrasts in spaces. This influences the working performance and behaviours of any people in the space, including their feelings and emotions. The same manipulation can be applied for artistic spaces (with works of art) (Gordon, 2003, p. 14). Generally, higher light levels stimulate activity and movement, whereas lower light levels give the feeling of relaxation and lingering (Fig. 3.6). Therefore, higher light levels are usually preferred in more active, kinetic and public spaces and lower light levels are usually preferred in more relaxed, personal environments (Gordon, 2003, p. 12; Russell, 2012, p. 22).

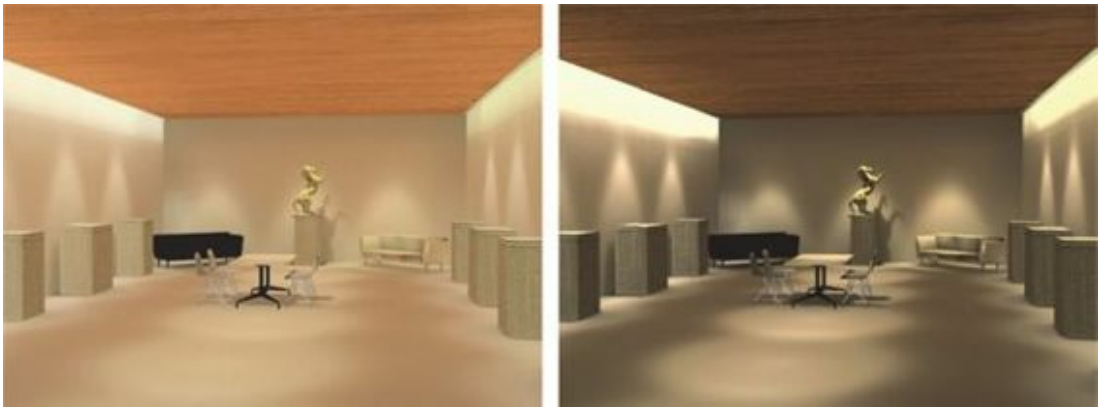


Figure 3.6: High and Low Levels of Light

Higher light levels (left) translate an exposed, public feeling, whereas low light levels (right) translate calm and privacy. (Russel, Sage, p. 22)

The subjective perception of a space can be manipulated by creating intensity contrasts which can influence the emotions of visitors. One wall can inevitably be distinguished from another and where they meet can be seen with the help of the contrast between two different surfaces. However, if the two intersecting walls are exhibited with the same brightness, they will be perceived as one continuous surface. Similarly, objects cannot be visible simply when illuminated with the same brilliance as their surroundings. Generally, equal contrast of the

lights causes one to feel depressed and listless as such a feeling on an overcast or cloudy day. The equal emphasises of the objects and space established with no hierarchy between foreground and background are behaviourally neutral and low in stimulation (Gordon, 2003, p. 12). On the other hand, brightness contrasts produced by bright highlights and crispy shadows increase stimulation and evoke emotions create the feeling of alertness, energy, positivity as how a sunny day would create (Gordon, 2003, p. 11). Thus, brightness contrasts affect the performance of the tasks and behaviours of people working in such spaces and influence the contentment and pleasure of visitor experiences. The high contrast (which can be produced by a small proportion of diffuse light and a large amount of focused light) renders patterns of light and shade and these establish a hierarchy between the foreground and background (Gordon, 2003, p. 14). The brightness contrast produces a visual direction to focusing, so it directs visitors' interest and attention in an exhibition. To emphasise exhibited or accented objects, the contrast of intensity is preferred and created by providing higher light levels on art objects as well as contrast of colours in museums and galleries. The differentiation between objects and surroundings makes objects more visible to recognise detail as they reflect light differently from their surroundings (Russell, 2012, p. 32). The light effects the plastic corporeality of exhibited objects. The contrast of illumination makes objects more visible and distinct by making them more conspicuous (Wördenweber et al., 2007, pp. 69-70). The brightness contrast in space is established by developing patterns of light and shadow. This is realised by emphasising selected objects and surfaces with light as a foreground or focal point while allowing other objects to stay in comparative darkness as a background (Gordon, 2003, p. 12). Thus, the relationship between the foreground and background is emphasised and the shining focal point is drawn attention to it (such as accent lighting creating stark contrasts). In a spatial perspective, "[t]he intensity of contrast between bright and dark regions dictates the atmosphere within the exhibition space" (Sylvania, 2015, pp. 9-10). Traditionally, the contrast ratio usually suggested for museums is 6 to 1 between the brightest and the dimmest objects in the field of vision and 2 to 1 for galleries (Sylvania, 2015, pp. 9-10). The brightness contrast is also useful for guiding circulation in different galleries at a museum. The brightness contrast and colour contrasts help to establish an initial response. High-contrast environments are useful for guiding the circulation of people entering an unfamiliar room (Gordon, 2003, p. 14).

By considering light intensity in relation to exhibited works of art, the intensity of light can be categorised in three steps: full light, medium light and shadows produced by intensity contrasts. Medium light represents the local colour of the objects in the most effective fashion in addition to the details of the surface and texture are seen as mostly clearly visible. However, the use of full light whitens the intrinsic colour of objects and shadows darken it, so full light may not be proper for the perception of form and colour as a whole. Low intensities may lead

to objects not being seen well in details of texture and pattern. Thus, the proper balance in lighting intensity must be configured according to the physical properties of exhibited works in an exhibition (Itten, 1970, p. 80). Moreover, the amount of illumination affects the perceived colour of the objects. The apparent value of a colour can be altered in such a fashion. The decreasing amount of illumination makes a colour's value darker and it neutralises the hue of the colour. The increasing amount of lighting makes a colour's value lighter and enhances the intensity of the colour. In addition, high levels of illumination tend to make colours less saturated or washed out (Ching & Binggeli, 2012, p. 113).

Colour of Light (Warm-Cold)

Both artificial light and the natural light can be varied in colour and the light source might not be well balanced in colour. Even daylight varies depending on the time of day, its direction, season and weather conditions. Similarly, incandescent bulbs glimmer a warm light, whereas some fluorescent lights glimmer a cool light. It is possible to alter the colour of light in various ways both overtly and subtly. By such modifications, lighting sources may exhibit different variations of colour temperatures, slight variations of neutral and very saturated, vivid colours.

In terms of architectural space, a particular colour hue is rarely used for general illumination. They are mostly used in high-design in order to create visual interest and unique emotional experiences where themed environments are required; e.g., galleries or museums as the colour of the light source also affects the moods and emotions of people in the space. However, it simultaneously affects the perceived colour of objects in the space and the perceived colour of the space itself. As a general rule, warm colours of light (e.g., red, yellow) tend to stimulate elicit relaxation, calm and a slower pace of attention, whereas cold colours of light (e.g., blue, green) tend to elicit activity and alertness (see Fig. 3.7).(Ching & Binggeli, 2012, p. 113; Russell, 2012, pp. 23-24)

Figure 3.7: Warm and Cool Light

Warm light on the left and cool light on the right should be chosen depending on whether they reveal the colours and materials in the space and create the desired mood
(Russell, 2012, p. 23).

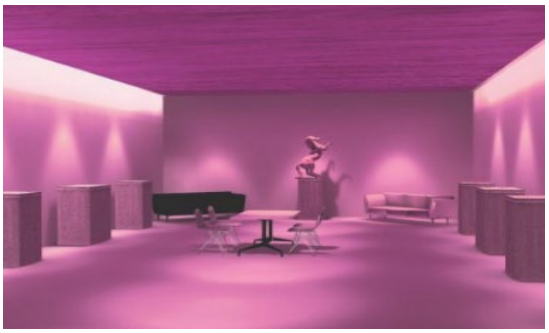


Figure 3.8: Strongly Coloured Lights in Space

that grabs the attention of observers and transports them away from the neutral and ordinary environments to which they may be accustomed
(Russell, 2012, p. 24)

The colour of light influences the perceiving colouration of the objects and surroundings (Fig. 3.8) and the natural fluctuations of light in an interior setting can alter colours in subtle ways (Ching & Binggeli, 2012, p. 113) In the same manner, the colour of objects may be altered by a large reflecting surface within a space (Ching & Binggeli, 2012, p. 113). The colour of the incident light has primacy in colour perception. However, coloured lights have mutual effects on each other. Warm light tends to accentuate warm colours and neutralise cool hues, while cool light intensifies cool colours and weakens warm hues. If light is altered with a particular hue, it will raise the intensity of the colours of that hue and neutralise colours of complementary hues (Ching & Binggeli, 2012, p. 113). For instance, a blue object illuminated with orange light will appear to be black because orange light does not have blue light inside it to reflect on that object. Therefore, the intrinsic colours of objects may be altered in perception by using coloured lighting. The resulting colour will occur depending on the chromatic aspects of the light. The more chromatic the lighting, the more the intrinsic colours can be modified (Itten, 1970, p. 80). It is known that light in a space emerges either from a light source or as reflected light from surrounding spaces. In this context, the reflected coloured light from coloured surfaces variously alters the colours of other objects. Each object will reflect its own colour into its surrounding space. For instance, a red object in space reflects red lights around it. If its red light falls upon a white object, the latter would appear as a reddish reflection. If its red light falls upon a green object, the latter will appear to be grey. If its red light falls upon a black surface, the latter will have a black-brown appearance. The situation is examined as the simultaneous contrast phenomenon in the literature. Moreover, the appearance of reflected light depends on the visual properties of the surfaces. The glossier the surface, the more conspicuous these reflections will be (Itten, 1970, p. 80). Therefore, colour perception could be considered in terms of four main aspects, namely intrinsic colour, the colour of light, reflection and shadow (Itten, 1970, p. 80).

Texture of Light (Diffuse/Direct)

The texture of light may refer to the physical manner of the light, which is delivered from a lighting source. It has a dramatic effect on overall feeling and function.

In an architectural space, both a soft and diffuse light and/or a harsh and directional light can be achieved according to the design of luminaries (Figures 3.9 and 3.10). Depending on the design, diffuse or direct luminaries can distribute light in different directions (such as upward or downward). Luminaries might also be designed to deliver light multidirectionally (see Fig. 3.11) (Gordon, 2003, pp. 23-30).

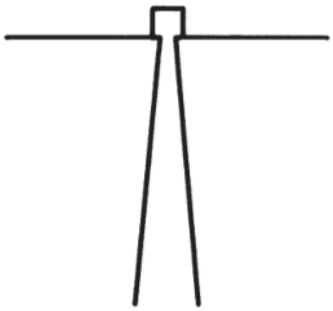


Figure 3.9: Concentrated and Downward

provide direct distribution
(Gordon, 2003, p. 27)

Figure 3.10: Diffuse and Upward

provide indirect distribution
(Gordon, 2003, p. 29)

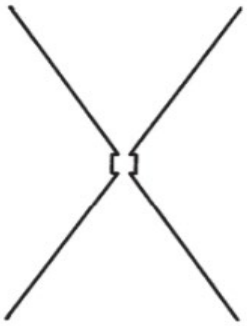


Figure 3.11: Mixed Direction

provides direct/indirect distribution

(Gordon, 2003, p. 30)

Diffuse luminaries (e.g., a glowing globe) are comprised of diffusing materials and deliver light diffusely, while direct luminaries (e.g., a spot light) deliver light directly in a specific direction. Accordingly, a diffuse light source and a direct light source create different shadows and shapes in light. This means that each manifests significant differences in the texture of light. Therefore, an ideal lighting design mostly includes a combination of direct and indirect light sources and direct light would act as sunlight in interiors to produce and cast shadows modelled on the shapes of the objects. On the other hand, indirect light acts as a blue sky or a photographer's fill light that softens shadows in order to balance the visual comfort of a space (Gordon, 2003, p. 31; Russell, 2012, pp. 23-24).

Diffuse light fills in shadows by overlapping lights and therefore creates indefinite borders in light. It is mostly used in galleries and museums to make a space indefinite to distinguish the art objects inside it. Diffuse light can also be produced by extensive areas that emit light, such as luminous ceilings in the field of artificial lights or flat surfaces under the sky. In interior spaces, architectural elements may include also secondary light sources that can reflect diffuse light in space, such as illuminated walls, ceilings, floors, etc. In this case, a very uniform, soft lighting will be produced that illuminates the entire space and makes objects visible; however, diffuse light produces reduced shadows or reflections (Gordon, 2003, p. 31; Russell, 2012, pp. 23-24).

On the other hand, direct light sources create distinct shapes of light with exact borders, so they produce sharp contrasts and shadows on objects and structured surfaces as well as reflections on specular objects such as glass. The light can be delivered or blocked altogether by object surfaces and textures. When there is only a small amount of diffuse light that is present in space, these effects will be particularly noticeable. For this reason, spaces must be arranged very carefully with items being placed in proper positions and distances in lighting designs for exhibitions. For instance, daylight has a more or less fixed ratio of sunlight to sky

light of 5:1 to 10:1 in comparison with directed light to diffuse light. Direct light is emitted from point light sources, such as the sun; therefore, it can also open new horizons for the lighting designer by means of determining beam angles and lighting directions. In some specific representational situations, such as shadow art, etc., directional light is also preferred in museums (Ganslandt & Hofmann, 1992, pp. 76-77; Russell, 2012, pp. 23-24).

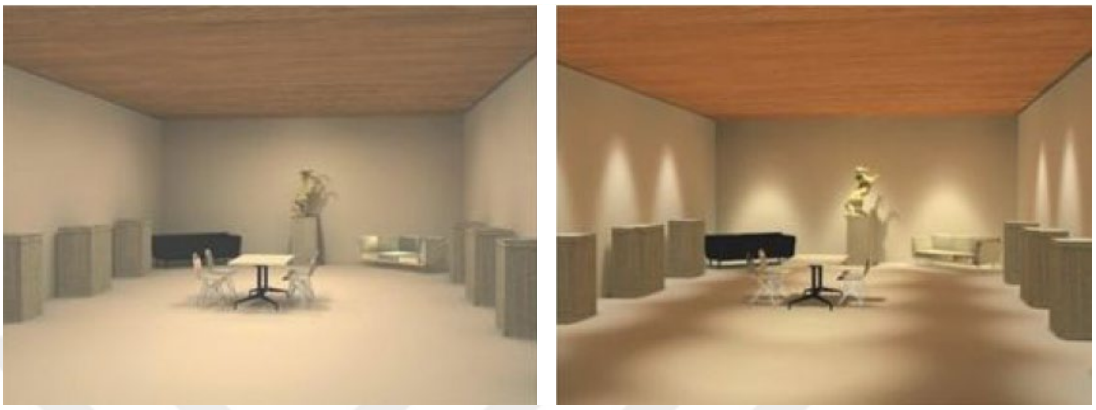


Figure 3.12: Diffuse and Directional Light

(1) Diffuse light (left) reduces shadows and encourages long-term visual comfort. (2) Directional light (right) creates visual interest due to the creation of contrast in the space.
(Russell, 2012, p. 24).

Lighting preferences influence different emotions and so, each of the aspects of light may be useful for the different functions of a space (see Fig. 3.12). When relaxed, calm, soothing environments are desired, lower light levels, warmer light colours and more diffuse sources may be implemented. When designing more kinetic, active, productive spaces, higher light levels, cooler light, and more directional sources may be applied (Russell, 2012, p. 25).

In lighting design, the lighting designer can determine the ratio of directed and diffuse light required or preferred depending on the task for the types of exhibited art objects. For example, in a darkly coloured space that receives very little light or in an environment with low reflectance surfaces, a portion of diffuse light can be decreased. In such cases, dramatic effects can be produced in the space via accent lighting. This technique is usually applied in galleries and museums for the presentation of art objects or other places when a concept intends to create a dramatic spatial effect. However, it is only used in architectural lighting. The light always affects the overall perception of a space. In the case of tightly controlled light, the position of the light source is directly related to the resultant effect. We can configure illumination at specific levels for exactly defined regions in a space, so a purposeful illumination can be arranged in space. In this way, the focus of attention in a space can be adjusted to suit the significance of a particular part by means of relative illumination levels so that information can be perceived as directed to be perceived (Ganslandt & Hofmann, 1992, pp. 76-77).

3.1.1.2. Properties of Colour

> *"Every hue throughout your work is altered by every touch that you add in other places."* (Edwards, 2004, p. 129)
>
> John Ruskin

The topic of colour is quite broad and innumerable colours with shades and tones can be experimentally found. Nevertheless, all the colours qualitatively have three distinct properties: hue, value and saturation. Each of these properties has a dynamic, three-dimensional relationship between the other. Therefore, they are able to easily interact with each other and be harmonious in architectural and artistic spaces (Albers, 2013, p. 3; Dodsworth & Anderson, 2018, pp. 148-149).

Due to the complexity of colours, artists and designers have worked for centuries to create a common, logical system in order to organise colours schematically. In this context, the most comprehensive and applicable colour systems are three-dimensional colour systems that handle colours in terms of hue, value and saturation. Among them, the Munsell Colour System is one of the earliest and best-known examples. The example below and most others are adopted from it (see Fig. 3.13) (Dodsworth & Anderson, 2018, p. 146; Holtzschue, 2009, p. 47; Ocvirk et al., 2015, pp. 190-216).

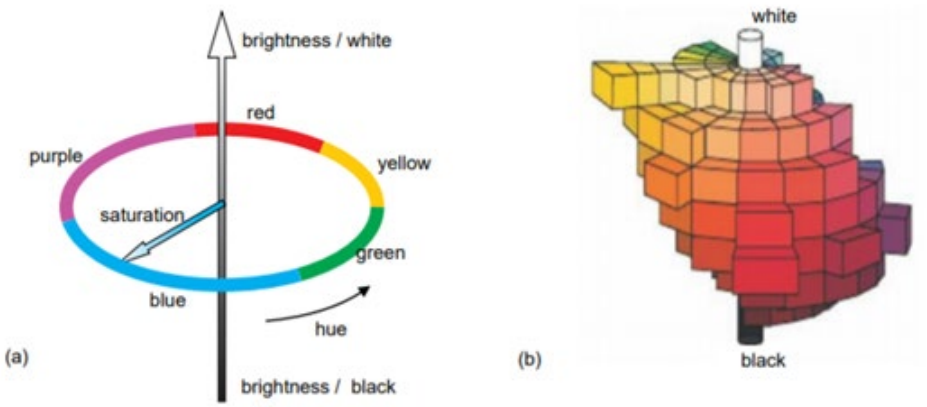


Figure 3.13: The Cylindrical Colour Space and Three-Dimensional Colour Cylinder

(a) The Cylindrical Colour Space presenting colours in the HSB colour model in which hues are given on a planar disc, values given by the vertical axis and saturation given by the distance from the centre of the disc along the radius. (b) The Three-Dimensional Colour Cylinder is formed by the colour representation of solids (Tilley, 2011, p. 29).

By benefiting from such a three-dimensional colour wheel, Ching was able to illustrate the properties of colours separately, as in Fig. 3.14. In a similar manner, the properties of colours will be examined.

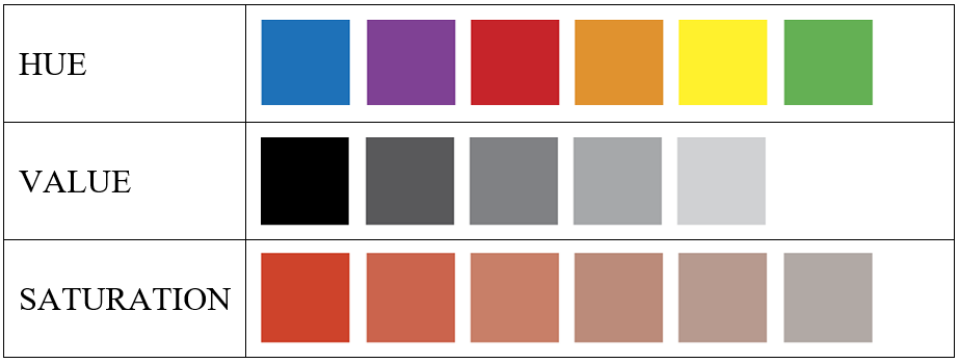


Figure 3.14: Properties of Colour: Hue, Value and Saturation

(Ching & Binggeli, 2012, p. 109)

Hue (essence)

This is the general attribute or common description of a colour. The hue of a colour is determined according to its specific wavelength in a beam of light. Due to small differences in wavelengths being visually insignificant, colours are fundamentally characterised under six general names: blue, violet, red, orange, yellow and green (Fig. 3.14). Each of the hues have various tones and shades in a colour spectrum, so it is difficult to describe the relations of hues adequately without considering the values and saturations of colours (Ching & Binggeli, 2012, pp. 109-115).

On the other hand, as a result of experimental studies, colour hues have led to the derivation of new colours, including white, grey and black, and new terms have been coined in relation to colours. Artists arrange the relations of colours in colour wheels, which in turn has led to the definitions and use of terms such as 'colour temperature,' 'colour contrast phenomenologies' and 'colours in harmony' in architectural or artistic spaces. Therefore, it is necessary to briefly mention the relation of colours on the colour wheel. In this context, colours can be defined under three main headings: primary, secondary and tertiary colours.

- *Primary hues* refer to the three hues – red, yellow and blue – which cannot be separated into any components or be transformed into other hues.
- *Secondary hues* refer to the other three hues – green, orange and violet – which can be produced by an equal combination of two primary hues.[41]

[41] Green can be produced by an equal mixture of blue and yellow; orange can be produced by an equal mixture of red and yellow and violet can be produced by an equal mixture of red and blue. They are placed between the produced two colours in the artist's colour wheels.

- *Tertiary hues* refer to six intermediate colours – red-orange, red-violet, yellow-green, yellow-orange, blue-violet and blue-green – which can be produced by an equal combination of a primary hue and a nearby secondary hue (Holtzschue, 2009, p. 48).

In artists' colour wheels, which include 12 colours, secondary hues are placed between primary hues and the tertiary hues are placed between secondary hues, as in Fig. 3.15. Based on this placement on the colour wheel, the closest colours are termed *analogue colours* and the opposite colours are termed *complementary colours*.

Figure 3.15: The Colour Wheel
as illustrated by Ching is comprised of primary, secondary and tertiary colours (Ching & Binggeli, 2012, p. 109)

In this context:

- *Harmonious colours* are produced by an equal mixture of two adjacent or analogue colours.

- *Neutral colours* are produced by an equal mixture of complementary colours or by an equal mixture of the three primary hues since two complementary colours include the three primary colours. Due to the primary colours being the fundamental colour components and having intrinsic characters, an equal mixture or combination of them neutralises each other and thus, the neutral colours black, grey and white emerge. In theory, the combination of the three primary hues results in the appearance of white. However, in practice the pigmentary mixture of the three pigmentary hues results in the appearance of grey-black. The greyness may change depending on the amount of pigment in the material composition object being made and the roughness or inability of the surfaces to absorb all wavelengths (Amheim, 1974, p. 364; Ching & Binggeli, 2012, pp. 109-112; Edwards, 2004, p. 25; Holtzschue, 2009, pp. 45-54; Itten, 1970, p. 20; Ocvirk et al., 2015, p. 190).

In addition to all these, colour temperature is expressed with regard to colour hues. In terms of colour temperature, the two contrasting hues of red and blue are defined as the two poles of

warm and cold. The colours close to red (e.g., oranges, yellows and the colours between these) are defined as *warm colours* because they evoke sun and flames. In contrast, the colours close to blue (e.g., greens, purples, blue-greens and the colour tones between these) are defined as cold colours because they evoke air, sky, sea, ocean and plants. However, colour temperature is a subjective phenomenon (Itten, 1970, pp. 45-46). Although the terms warm and cold refer to the perceived temperature of an object or space with respect to haptic perception, the warmness or coldness of colours are the visual realms of colours perceived through visual and spatial perception (Coles & House, 2012, p. 136; Holtzschue, 2009, p. 51; Itten, 1970, pp. 45-46; Ocvirk et al., 2015, pp. 190-199).

Value (brightness)

Value is the relative degree of colours in terms of perceived brightness or darkness. It is therefore somewhat related to the amount of reflected light to the eyes. In this respect, yellow and violet are the two poles since pure yellow reflects light abundantly and so it is lighter in value than violet, red, blue, green and orange. Moreover, violet reflects less light than all the other hues and it is therefore darker than yellow, orange, red, blue and green. In other words, light colours are high in value and dark colours are low in value (Ching & Binggeli, 2012, pp. 109-112; Ocvirk et al., 2015, pp. 190-192).

In addition, some colour hues are closest to each other in value, while others are farther. For example, a greater number of colours can be noticed between yellow and red and between yellow and blue, but fewer colours can be noticed between red and blue because of the large value difference between yellow and two other colours. However, blue and red are closed in value, so the range of perceptual units between them is smaller than between yellow and blue or between yellow and red (Holtzschue, 2009, p. 50).

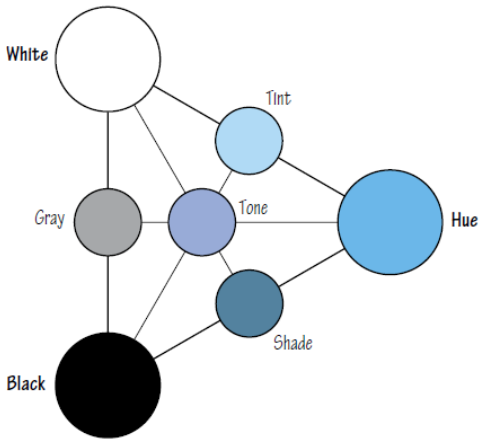


Figure 3.16: Value Leads Production of the Tints, Tones and Shades of the Hues
(Ching & Binggeli, 2012, p. 112)

In practice, the value of colours is described with respect to the closeness to the two poles of white and black (see Fig. 3.14). In this context, the value of a colour can be changed only with the neutral pigments of white, grey and black without altering its hue (see Fig. 3.16). In this manner, tints, shades and tones of hues are produced as follows:

- A mixture of different amounts of white with a hue of a colour produces lighter colours of that hue, known as the *tints of that hue;*
- A mixture of different amounts of black with a hue of a colour produces darker colours of that hue, known as the s*hades of that hue;* and
- A mixture of white and black in equal quantity with a hue of a colour produces greyish colours of that hue, known as the *tones of that hue* (Ching & Binggeli, 2012, pp. 109-116; Holtzschue, 2009, p. 45; Ocvirk et al., 2015, pp. 190-192).

Saturation (Chroma)

Saturation is the amount of white light that mixed with a colour hue (Tilley, 2011, p. 22). This allows colours to be described as 'pale' (see Fig. 3.14). Therefore, it is also known as the brightness or dullness of a colour hue. Alternatively, saturation may be known as the chroma of a colour hue that depends on the amount of hue or intensity of hue in a colour (Holtzschue, 2009). In this context, the perceived saturation of a colour can be altered in a variety of ways as follows:

- The saturation of a colour can be changed by adding a pigmentary neutral white, grey or black or by addition of its pigmentary complement colour. In contrast, the intensity of a colour can be increased with the addition of a more dominant pigmentary hue of that colour.
- If the same amount of two complementary colours are reflected to the same area at the same time (e.g., red and green), the brightness of each of the two colours dims due to a loss of their intensity. As a result, they produce a neutral grey effect (Ching & Binggeli, 2012, pp. 109-112; Holtzschue, 2009, p. 45; Ocvirk et al., 2015, pp. 192-193).

In summary, the following two prominent results can be inferred after extensive research into the properties of colour:

- The properties of colours are interrelated. It is difficult to alter one of the three attributes without altering the other two attributes.

- The relationship between light and colour seems more obvious relying on the information given in the properties of colours.

3.1.2. Material Glass

Materials or substances are the visible and touchable essence of the real world because they are the building blocks of every physical objects both in natural environments and in built environments (Holtzschue, 2009, p. 19). Glass is one of these material substances, a rigid, brittle and inorganic substance that may naturally occur or be artificially produced. It has mostly a transparent and reflective character. However, in some cases, it may also reveal a translucent or opaque character (Url 3.2). All these factors make glass a versatile medium which is suitable for man-made and natural environments.

3.1.2.1. Properties of Glass

a. ***Chemical properties:*** glass is a durable material that resists chemical corrosion when interacting with most chemicals. It is a better heat at absorption than metals and it retains heat.

b. ***Electrical properties:*** Glass is a strong electrical insulator similar to ceramics.

c. ***Thermal properties:*** Glass becomes a thermal shock resistant material through some additional processes in production. Thus, it can withstand immediate temperature changes as well as intense cold and heat, which makes it a useful architectural element.

d. ***Mechanical properties:*** Glass is a strong, hard material that resists absorptions and scratches. It is at the same time an elastic material that behaves flexibly under stress until failing.

e. ***Optical properties:*** Glass transmits, scatters, reflects and absorbs light at the same time (see Fig. 3.17).[42] In addition, some absorption centres are able to re-emit light as radiation that appears as luminescence or fluorescence within the glass (see Fig. 3.17) (Holtzschue, 2009, pp. 19-23; Tilley, 2011, p. 34). All these processes are dependent on the wavelength of light and can lead to colour production. In this context, glass may be a bearer and multiplier of coloured light rays on or in it (such as crystal glass, optic glass, iridescent glass, etc.). As a result, a dynamic interplay occurs between light, colour and glass which varies depending on the surface texture in relation to transparency, translucency, opacity, reflectivity, colour and the form of the glass.

[42] Due to its optical features, glass is widely used in the lighting industry. Moreover, the light insensitivity of glass and any aesthetic concerns might be regarded as secondary advantages of the use of glass in lighting products.

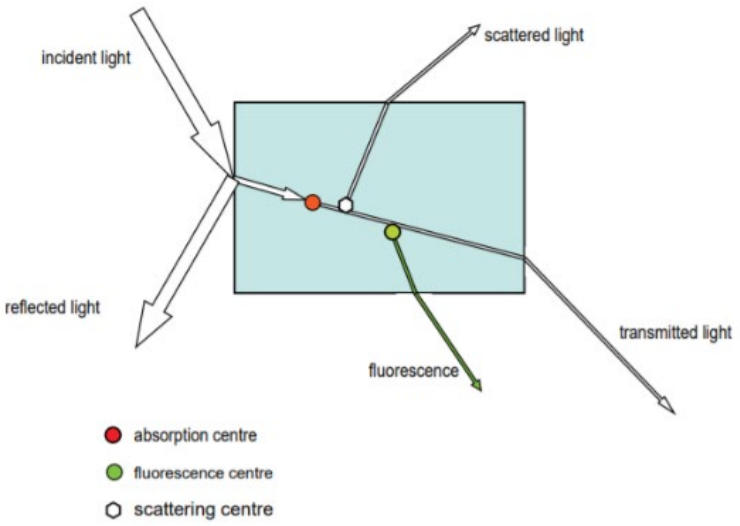


Figure 3.17: Optical Properties of Glass

showing interaction of light with glass
(Tilley, 2011, p. 34)

The dynamic relationship makes it an intriguing material in terms of visual and spatial perception, thereby making it an important topic in the scope of this thesis.

f. ***Physical properties:*** Glass can be transparent, translucent, opaque and/or reflective depending on its chemical structure, material components in a glass batch, and its production technique. Each of these factors will present different optical properties. Glass can also be colourless or coloured depending on the presence or absence of colorant oxides in the glass batch or on the surface (Url 3.2; Url 3.3; Url 3.4). Moreover, each type of glass might have differences in size, dimension, texture, pattern, and shape, which depend on differences in form structure and surface structure. These all depend on the design.

Physically, glass resembles two other natural substances, namely air and water, but it is absolutely different from all other materials found in nature. Although glass is one of the best-known transparent solids, it is described mostly as a super cooled liquid. In actuality, glass is neither a liquid nor a solid and shares quality of both a liquid and a solid. It has its own state of matter.[43] On the one hand, glass possesses the atomic structure of a liquid of which molecules are held closely and randomly due to molecular forces, but not rigidly as in solids (see Fig. 3.18 left). However, glass is actually a viscous liquid and hence different from other liquids which are fluid. On the other hand, glass possesses the physical properties of a solid. Its molecules rigidly inhabit a definite position due to the stronger attractive forces and they are ordered in a three-dimensional lattice of a crystalline state (see Fig. 3.18 right). However,

[43] It makes glass an easily-shaped material and allows it to be processed consecutively a few times. With the benefit of its liquid state, artists can shape glass into desired forms with varied techniques such as mould-shaping, hot-blowing, lamp work, etc. With the benefit of its solid state, the shapes and forms of the resulting products can be changed with cold glass techniques.

glass does not have a ‘melting point’ like other solids; it has a so-called ‘softening point’ instead (Aydın, 2008, p. 29; Küçükerman, 1985, p. 20; Richard, 2004, p. 68; Tilley, 2011, p. 43; Url 3.4).

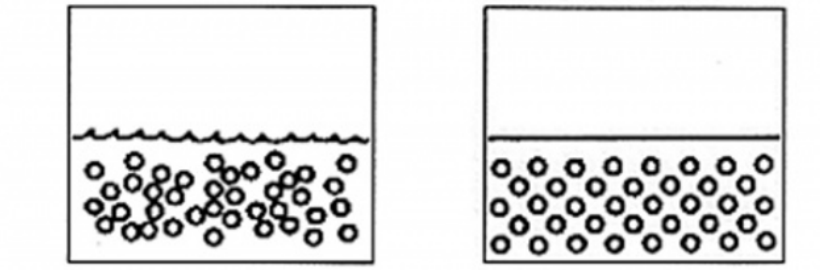


Figure 3.18: Two States of Glass

liquid state of glass (left) and crystalline state of glass (right)
(Url 3.4)

The unique atomic structure of glass is directly related to its physical properties in relation to the components inside the glass batch. Prof. Önder Küçükermen likewise links its transparency to its state of being a super cooled liquid (Küçükerman, 1985, p. 21). Accordingly, the translucent and light absorbing characteristics of glass can also be surprisingly increased or altered with various additives, such as phosphorus, uranium, etc. into the glass batch (referred to as phosphorescent glasses) (Aalto-Setälä, 2018, p. 42; Küçükerman, 1985, p. 21). Moreover, translucent glass can be made by means of having a glass crystallise (such as sand-blasted glass). As a result, the tiny crystallites act as scattering centres that result in the emergence of diffuse and specular components by scattering. In a similar fashion, opaque glasses such as opal can be made with large numbers of scattering centres made present deliberately. The more the scattering, the whiter it becomes in terms of perception because every wavelength of light is affected equally by the scattering. Therefore, opaque glasses appear to be whiter in comparison to colourless transparent or translucent glasses (Tilley, 2011, p. 42).

In addition to all these, glass can be colourless or it can be coloured in material structure or on its surface in a few ways:

- A coloured material structure can be achieved by adding metal oxides into a glass batch. Thus, the addition of cobalt oxide (Co_3O_4) results in a vibrant blue glass. The addition of copper oxide (Cu_2O) results in blue-green. The addition of manganese oxide ($Mn0_2$) or nickel oxide (NiO) results in purple. The addition of lead oxide (PbO) results in yellow and the addition of gold (Au) results in red (Bugler et al., 2017, pp. 80-82).
- A coloured form structure can be achieved by fusing or fixing coloured glass pieces.
- A coloured surface can be achieved by colouring the surface with glass decoration techniques; e.g., painting, print-making or coating with a thin, coloured film.

In a similar manner, by adding other substances (e.g., uranium, phosphors or metal oxides), different glass compositions can be produced.

3.1.2.2. Comparative Study of the Properties of Light and Colour in relation to Colour Transparency

In the research process, it was noticed that the properties of light and colour have some similarities based on the fact that, in theory, colour is a property of light. Even if there are many studies that examine the relationship between light and colour, there has been no comparative study in the literature yet about their properties inasmuch as it could be researched during the thesis period. In the thesis, this comparative study is realised in relation to the phenomenon of colour transparency in order to support the fact of the interplay between light, colour and glass.

The phenomenon of colour transparency was first described by the well-known colour theorist Josef Albers, who performed experiments with his students to create space illusions by means of different spatial organisations of coloured transparent papers. Colour transparency refers to the volume of colours or the ratios of colour saturation. It is therefore related to the amount of pigment in colours (Albers, 2013, pp. 29-31; Holtzschue, 2009, p. 73).

With regard to the saturation or chroma of colours:

- the purest saturation of a colour is determined by the refracted wavelengths of the pure light beam that passes over a transparent glass prism;
- an intense colour, such as red, is perceived by the reflection of the red rays of a light beam from red pigments because red pigments are able to reflect only red rays of light; (Ching & Binggeli, 2012, pp. 109-112)

Colour transparency emerges in relation to and between the two factors above. For example, if coffee pours out on a white coffee plate, the colour of the plate is seen behind the coffee. This situation is explained as colour transparency (Holtzschue, 2009, p. 73). This is due to the amount of coffee pigment in visual field decreases and its perceived colour saturation decreases. Here, colour transparency is seen to be related to the amount of reflected light from each pigment of the poured coffee. Due to the amount of pigment decreasing when the coffee is poured, the intensity of light also decreases. This means that:

The lower the amount of pigment in coffee, the less saturated colour and the lower the intensity of the light (reflected). This situation makes coffee to be seen as 'transparent brown' in terms of colour.

Another prominent example is that of the emergence of rainbows in nature. However, this time the cause is achromaticity in transparency and the demonstrated relationship between the hue of a colour and the colour of the light. It is known that rainbows spontaneously appear after rainy days as the light rays of the sun are refracted and reflected while passing through water droplets in the air and thus, the refracted light rays appear as a rainbow of colours. This case is exactly the same as reflected coloured light rays after refraction through a transparent, colourless glass prism. In fact, the following two conclusions are inferred in both cases:

- *In contrast to the coffee example, all the colours of the light rays seen in and on a glass prism appear saturated in terms of colour and appear as being high intensity;*

- *When no colour pigments are present in a visual field, the rays of sunlight are seen with their intrinsic colours. This means that the colour of the light corresponds to the hue of colours.*

As a result of the coffee, rainbow and glass prism examples, the following statements can be briefly inferred:

- *The more hue in the visual field, the more saturated are the colours and the greater the intensity of the light (reflected);*
- *The less hue in the visual field, the less saturated the colour of that hue and the lower the intensity of light (reflected).*

These two statements demonstrate the interrelationship between the properties of the colours and therefore the interrelationship between the properties of colours and the properties of light once again.

It can be said that the saturation of a colour corresponds to the intensity of light, the value of a colour corresponds to the texture of light and the hue of a colour corresponds to the colour of the light.

In the following study, the properties of colour and the properties of light will be compared without taking into account the amount of colour pigment on matte surfaces; colours will be accepted as transparent colours as found in most glass artworks.

Relationship between the Properties of Light and Properties of Colour

a. Comparison of the 'saturation of a colour' and the 'intensity of light': The saturation of a colour refers to the quality of light in a colour and it is determined by the refracted wavelengths of pure light (Dodsworth & Anderson, 2018, p. 146). On the other hand, the intensity of light refers to the quality of the light and is related to perceived brightness and

darkness on surfaces. For example, light scattering by the sun at noon on a summer's day is defined as intense light because it includes all coloured rays of light. Moreover, a well-balanced artificial white light is accepted as being intense such that allows one to see the intrinsic colour of an object. For the same reason, exhibited objects are displayed with intense accent lighting in order to allow visitors to perceive the intrinsic colours of the objects.

With all these factors, it can be said that saturation of a colour corresponds to the intensity of light. In this context, the saturation of a colour depends on the perceived brightness or darkness on the surface of objects and/or spaces as in the following cases:

- *Under the pure, intense light, the colour of objects will be seen saturated; and*
- *Under low intensity of light, the colour of objects will be seen darker and pale. As a result, an object's colour will be perceived as less saturated and a little bit greyish.*

b. Comparison of the 'value of a colour' and the 'texture of light': Value describes the intensity of colours and positions colours in range between the two poles of darkness and lightness (Amheim, 1974, p. 331; Dodsworth & Anderson, 2018, p. 146; Edwards, 2004, p. 4). It refers to the number of photons reaching the eyes, so a normal value for colour is indicated by the reflected light at maximum intensity (Tilley, 2011, p. 22). In fact, the texture of light does the same. The texture of light basically examined as diffuse and direct light. Between the two, the amount of light scattering onto a unit area is different. Therefore, the number of photons reaching the eyes will differ, which refers to value. In another words,

- *When the same amount of light is scattered on each pixel area of a surface from a diffuse light source and from a direct light source, the reflected light on the surface will be higher in the second situation (which is illuminated with a direct light source). Thus, the intensity of surface colours will be higher when it is illuminated with the same amount of direct light. For the same reason, direct light is mostly preferred for accent lighting on exhibits instead of diffuse light. This means it can also provide energy savings.*

In light of this, it was stated that value is more effective than hue in the distinction of colours (Amheim, 1974, p. 364; Ching & Binggeli, 2012, pp. 109-112; Holtzschue, 2009, pp. 45-46; Ocvirk et al., 2015, p. 190). In fact, texture of light also takes first place in the configuration of light for exhibited works of art. It can be said that the value of a colour corresponds to texture of light.

c. ***Comparison of the 'hue of a colour' and the 'colour of light':*** Hue is the true colour of something and it corresponds to the wavelength or frequency of the radiation (Dodsworth & Anderson, 2018, p. 146; Tilley, 2011, p. 22). In fact, the hue of a colour is determined according to its specific wavelength in a light beam. It therefore obviously corresponds to the colour of the light as the colours of light are the specific wavelengths of light.

In summary, each property of a colour appears to correspond to each property of light. Similar to the relationship between colour and light, the hue of a colour, value of a colour and saturation of a colour are closely related to the colour of light, texture of light and intensity of light.

3.1.2.3. Colour Transparency in Displayed Glass Exhibits

As previously mentioned, colour transparency is a subcategory of the saturation of colours and it is actually related to the amount of colour pigment in a transparent environment located in the visual field. However, the interrelationships between value, saturation and hue are also effective in colour transparency. As explained in the coffee example:

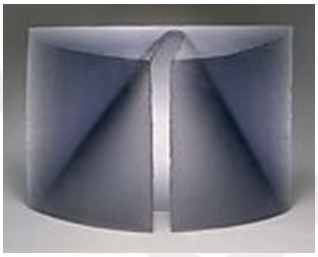
- A thin area of a transparent environment in the visual field includes fewer colour pigments inside it, which is the reason for its lower saturation and appearing lighter in value, while a thick area of a transparent environment in the visual field includes more colour pigments inside it and is therefore more saturated and appears darker in value. The same occurs in transparent and translucent works.
- If a transparent work is made with the same colorant oxides in the glass batch, the thin parts of the work in the visual field will be less saturated in comparison to its thick parts and so, it will appear lower in value and dim (Fig. 3.20). Similarly, flat glass works made with the same colorants appear lower in value than the three-dimensional, cubic pieces made with the same colorants.
- If a transparent, coloured glass piece is designed to be thin in form, the surrounding colours behind it will be seen better than the thick ones as it will include fewer colour pigments in the visual field and thus, it will be less saturated and be positioned close to the white pole in terms of value. White is able to present all colours and fewer colour pigments in the visual field and is less able to disturb the perception of the colours behind in comparison to more pigments. In contrast, thick pieces include more colour pigments and so they will be more saturated and be positioned close to the black pole in terms of value. Black is able to absorb all colours and so it will disturb the perception of the colours behind more so than the thick ones. Similarly, colours close to light values make surrounding colours appear better than the colours close to dark tones, which is more obviously seen. This situation is more obvious in achromatic and

transparent pieces, which present all the hues of a light colour due to the fact that they do not include colour pigments. (see Fig. **3.19)**

Figure 3.19: Exhibition 'Tapio Wirkkala'

curated by Harri Koskinen, Marco Romanelli and Chiara Squarcina; exhibited in Murano Glass Museum (Url 3.5)

An example will be given from a coloured, translucent glass piece to demonstrate the above statements in relation to colour transparency and to visualise the effects of surface texture in relation to translucency.

Translucent, Coloured Glass Work of Art	**Light is Constant:** *an intense, white, direct light source is positioned behind the exhibit*
 **Figure 3.20:** Geometric Glass Sculpture by Artists Stanislav Libensky and Jaroslava Brychtová, 1997 (Url 3.6) made with a mixture of substances including colorant oxides; mould-shaping, kiln casting and sand-blast techniques. In their works Libensky and Brychtová would usually explore the interaction of light with glass and handles this relationship in contrast phenomenon such as transparency-opactiy, emptiness-fullness or negative-positive (Ağatekin, 2008).	- ***Saturation:*** The inside hole and curved line at the top are perceived to be lighter in value with a darker contour. In contrast, the outer form is perceived to be darker in value with a brighter contour in the parts behind it. This appearance is all about the thickness of the glass form because the total amount of colorant oxides is lower in the thin parts. However, the total amount of colorant oxides is higher in the thick parts, which alters the saturation of the colour and in turn altering the perceived value of the colour ranging from darker to brighter. Even the centre part of the glass form appears as if almost colourless as this part is the thinnest part of the glass form and closest to the light source. - ***The relationship between saturation and light intensity:*** The inside contour is not seen as being linear. It appears to be thicker in the middle parts due to shadows occurring in these parts. for the same reason, the curved line at the top of the work of appears darker, while, the linear line on the top of the artwork appears lighter. The intensity of the light distributed from a light source is directly related to the spatial position and direction of the light source. In this example, the closest lines of the artwork appear lighter in value because they are illuminated with higher intensity light. On the other hand, the lines of the inside holes appear darker and thicker due to shadows emerging on the inside lines. - ***Surface aspects:*** Due to translucent surfaces being able to diffuse and reflect light, transparent glass work appears dramatically and homogenously illuminated, darker in colour blurring the shapes and colours behind it (Ganslandt & Hofmann, 1992, p. 42).

As seen in the works of Libensky and Brychtová, the characteristics of the surface are also effective in the perceived value of the glass art work and in the perceived colour hue behind

it. A translucent surface has very little roughness on it so it blurs the colours and the objects positioned behind it. If it were transparent, the colour hue of the surfaces/objects behind could be seen better. However, this time it would interact with the hue of the artwork.

Moreover, the colour of the light source and the colour of the surrounding space is also effective in the perceived hue, value and saturation of the displayed glass artwork. This is caused by the interaction of colours due to colour transparency. With regard to the interaction of the surrounding colours with the colour of the artwork, the discourses of the colour theorists, who had experimented much on the interaction of colours to demonstrate the spatial illusions of colours, can be kept in mind. In respect to this, well-known colour theorists, such as Joseph Albers, mentions the following:

> *"This way of searching will lead from a visual realisation of interaction between colour and colour to an awareness of the interdependence of colour with form and placement; with quantity (which measures amount, respectively extension and/or number, including recurrence); with quality (intensity of light and or hue); and with pronouncement (by separating or connecting boundaries)." (Albers, 2013, p. 2)*

In this context, the following statements can be asserted:

- If a transparent, red work of art is illuminated with a green light, the exhibit will appear as greyish since illuminating with a complementary hue (green) makes red lose its intensity and thus, they both will become dim in terms of value. For this reason, white light should be used in such displays.
- If a transparent, flat, red work of art is juxtaposed with a transparent, flat, green exhibit, the same neutral grey effect occurs because the amount of red pigment inside flat glass is equal to the amount of green pigment. When they are juxtaposed, they decrease each other's intensity and become dim in terms of value. Therefore, the surrounding space should not be coloured with contrasting hues.
- Similarly, if a transparent, flat, red work of art is placed behind a grey space, the exhibit will appear greenish because the addition of grey into a red glass batch reduces the intensity of the red and produces tones of red. This situation creates the same effect in the visual field. Therefore, grey ought to be avoided in the surrounding space (Ching & Binggeli, 2012, pp. 109-112; Holtzschue, 2009, p. 45; Ocvirk et al., 2015, pp. 192-193).
- If a transparent, flat, light coloured exhibit is placed behind a white space, the exhibit will appear lighter in value due to loss of its intensity and appear to be a tint of the colour. Therefore, the light colours (e.g., yellow or orange), achromatic transparent glass works of art and opaque glass works of art should be displayed not in the 'white cube' concept but in the 'black box' concept. In a similar manner, dark, transparent

works should be displayed in the 'white cube' concept due to the fact that they can lose their intensity in front of a black surface and thus appear as shades of that colour (Ching & Binggeli, 2012, pp. 109-112; Holtzschue, 2009, p. 45; Ocvirk et al., 2015, pp. 192-193).

To conclude, the perceived hue, value and saturation of displayed glass exhibits in relation to colour transparency have a direct relationship with the following parameters:

- The dimension (thickness) of the transparent environment and the geometric/organic form of the work of art;
- The texture and materials of the surface;
- The background colour and pigmentary colours inside the work; and
- The colour rendering properties, size, choice, number, direction, spatial location, distance of the light source and intensity, colour and texture of the light.

3.2. Perceptual and Technical Assessment

> *"Nothing creates an experience by itself; everything depends on the surroundings, the series of events that cause it and the memory of the past experiences."* (Brooker & Stone, 2012, p. 57)
>
> Kevin Lynch

Technical assessment in exhibition design is mainly comprised of lighting design and the organisation of technological devices in exhibition spaces, such as digital displays, video screens or monitors, audio-visual equipment (such as speakers), electrical equipment, projectors, and so on. Lighting design is necessary to know by both the exhibition designers and the interior architects as well as architects. Lighting design together with colour preference in space creates ambience and models glass artworks in displays, particularly in the scope of the 'white cube' and 'black box' concepts in exhibition design. Therefore, lighting design will be handled in this thesis in terms of a technical assessment. It is actually at the same time a perceptual assessment together with one selected element of spatial design, namely colour. For the perceptual assessment, brief information will be given to clarify further the reasons for its selection.

Perceptual processes consist of a series of neurological, physiological and cognitive mechanisms. As in any other event with which visitors interact in glass museums, the context of a glass art exhibition is also acquired in our minds as multi-sensorial experiences being the sum of the data acquired by the five sensory organs and their interpretation through perceptual processes. Ahmed Olla states: "The sensory experience can be considered as the apprehension of space and can be understood in terms of the individual's total perception of the external physical and social surroundings and the constant monitoring of one's internal environment."

(Olla, 2014, p. 20) Alexander Styhre likens perception to the language and mentions it as a human faculty which borders between the self and the other, inner and outer, the body and the environment (Styhre, 2008, p. 1). Similarly, in a glass art exhibition, exhibited glass works within a space are interpreted as sensorial experiences by visitors. To visualise simply how all these can be realised in a glass art exhibition within the context of the 'white cube,' 'black box' and 'total work of art' concepts, an illustration might be drawn as a 'dynamic triology,' as seen in Fig. 3.1. The triology consists of three main parameters: the exhibited artworks, the exhibition space and the visitors who have dynamic, three-dimensional interactions with each other, which means that any of change between one of them affects the other two. For example, if visitors move through the exhibits in order to be closer, they will perceive the exhibits in a more detailed fashion and the space will be perceived in less detail and vice versa. Moreover, each of the two parameters, such as the exhibited works and the visitors or the visitors and the exhibition space, have a two-way relationship with each other or the exhibition space and the exhibited works. Any change in the two-way dialogue affects the perception of the others due to perceptual processes because the brain tends to perceive things as a whole and attempts to bring everything into balance in the visual field as it was before.

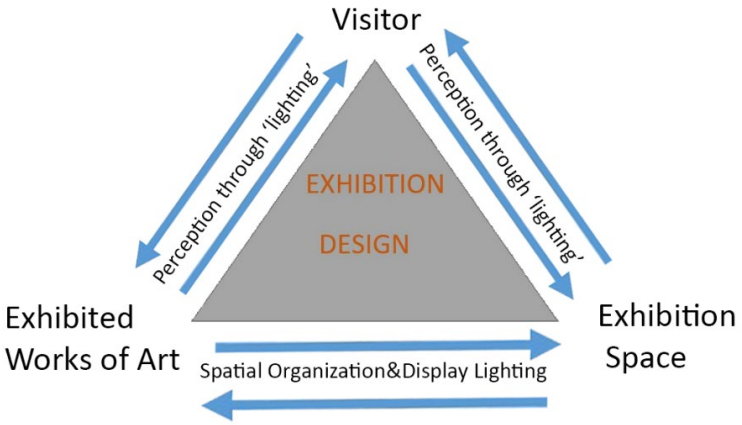


Figure 3.21: Three-dimensional and Two-way Relationship between Exhibited Works of Art, Exhibition Space and Visitors

As can be seen in the diagram (Fig. 3.21), the effect and interpretability of the perceptual process in an exhibition design can be considered in the context of the exhibited works and exhibition space, which are two important elements regardless of visitors. Although visitors dynamically participate in this interaction to perceive the exhibition concept, they should be excluded in the process of the spatial design of an exhibition. Each individual might interpret the same exhibition differently because of the differences in "previous experiences, intellectual and philosophical background, culture, subjective impressions, attention, awareness, curiosity, interests, bias, beliefs, attitudes, point of view and the emotions" (Demirörs, 1994, p. 13;

Erdemir, 1993, p. 27; Hall & Page, 2014, p. 257; Soliman, 2013, p. 4). John Berger states in his book, *Ways of Seeing* that "Our thoughts or beliefs affect our visions of objects" (Berger, 2017). Even if a special exhibition design is created for a predefined group of the same social group, of the same age, of the same gender and with the same cultural background, each individual within the group may perceive the exhibition concept and the individual concepts of each work of art differently from each other. An exhibition cannot be designed for all people at the same time. Perception is a complex phenomenon and scientists from various disciplines, such as neurologists, psychologists, neuropsychologists, physicists, etc., still work on the neurological and psychological processes of the perception to examine clearly how an artwork is perceived by people (Amheim, 1974, p. 3; Ganslandt & Hofmann, 1992, pp. 28-29; Pepperell, 2012, p. 131; Solso, 2003, p. 2; Wördenweber et al., 2007, pp. 9-10). For this reason, the perceptual approaches within the scope of exhibition design must be handled in terms of the exhibition space and the exhibited works of art in equal importance while excluding visitors from the scope (see Fig. 3.21).

In a similar manner, lighting design is also handled in equal importance to the exhibits and the space due to the fact that light plays an essential role in human perception. Based on this, perceptual processes are able to interpret everything in the visual field as an integrated whole body in every situation in a manner that considers the similar and different physical features of each of them. The physical features of exhibits and the exhibition space in addition to the visual and spatial interactions, engagements, relations, associations and the communication between art objects and the space, among art objects themselves participates in the 'total data' in acquiring internal representation of an exhibition by visitors. Ching states, "A space by itself is formless and diffuse, but it forms if the elements placed inside this space by our perception of the relationship between these elements and the space and perception of the relations among the elements themselves" (Ching & Binggeli, 2012, p. 2). The same situation is valid for exhibited glass exhibits. Brian O'Doherty, a sculptural, installation artist and a commentator, emphasises the role of the exhibition space in the perception of the exhibits in his book *Inside the White Cube* and mentions that even if a slice of bread is exhibited in a museum or gallery, the museum would transform that slice of bread into an artwork, at least during the exhibition process (O'doherty, 2010, p. 12). Therefore, it is stated that the gallery space affects the perception of exhibits and that exhibited works of art change our perception of the gallery spaces (Stejskalová, 2016). Even if they were designed as separate systems as seen in the 'white cube' and 'black box' concepts, the physical properties of another (especially light and colour) will be effective in the perception of the others. For this reason, in both the 'white cube' and in the 'black box' concepts, the colour of the exhibition space is selected from neutrals (white or black) in order to prevent colour interaction and provide an accurate

representation of the colours of exhibits. On the other hand, in the 'total work of art' concept, the colour preference in both the exhibit and space is designed to support an 'overall exhibition concept' with a holistic design approach. In a similar manner, lighting design is specially done in three emerged exhibition concepts depending on requirements. This might be aimed at emphasising only works of art (in the black box concept), to emphasise works of art and allowing space perception for safe circulation and well-being of visitors (in the white cube concept). Alternatively, the aim might be a complete overall atmosphere to provide an overall experience of exhibitions (in the total work of art concept).

3.2.1. Light and Colour Duality and the Role It Plays in Visual and Spatial Perception

> *"All material in nature, the mountains, the great rivers and we ourselves are extinguished light, and this decayed mass that we call material casts a shadow, and the shadow belongs to the light."* (Zeytinoglu, 2011, p. 41)
>
> Louis Kahn

Light and colour are the defining spatial elements in space. They play a role in creating a perceived atmosphere rather than just being auxiliary elements. For many years, light has been used as one of the defining elements of spaces and fundamental mode of expression. It gives a spirit (genius loci) to a space and makes it functional and pleasing. Similarly, to light, colour is also very defining, expressive and functional. Sauerbruch Hutton Architects draw attention to the importance of colour in a space and mention that "colour is a definer in a space as much as its physical dimensions and spatial systems of a building" (Spankle, 2012, p. 129). Regan Forest states that "colour alone constitutes the major basis of visual assessments and subconscious responses" (Forrest, 2015, p. 51). In addition, both light and colour have the ability to alter visual and spatial perception of a space in an intellectual manner. In a space, colour can affect the perception of time, temperature, crowding, flavour and size, whilst light can affect perceived appearances of a body whether a work of art or a space itself (Forrest, 2015, p. 51). Hence, they both affect the emotion and feeling of a space. Based on all these factors, literature findings suggest that "light and colour are significant elements in the determination of the overall perceptions of an exhibition environment, the general feel of spaces and the subsequent visitor experience in particular to focus on the visual and for spatial perception (Forrest, 2015, pp. 9-52).

Light and colour were used as mere auxiliary elements prior to the developments in perceptual physiology, psychology and semantics. Now, the perceptual ability of light and colour are recognised and they are considered to be the most effective elements of a space (Spankle, 2012, p. 131). Accordingly, they both are the major determinants in defining the overall

character of an exhibition environment that effect its general feeling and subsequent experiences of visitors (Forrest, 2015, pp. 9-52). Artists and designers may alter the perception of the form, shape, size, dimension of the emphasised object by using the variables of light and colour (Spankle, 2012, pp. 129-131). This means that the overall perception of an exhibition may be intensified with light and colour or it may be altered by manipulating the light and colour depending on the requirements of the exhibition. If desired, visual illusions and paradoxes can also be created in the space.

In museums and galleries, exhibition designers benefit from light's fundamental aspects to create a spiritual atmosphere, an effective ambience or they can highlight exhibited works of art. With a proper settlement of artificial light sources owing to its controllable aspects, a mood can be generated either by completing a natural light source or by isolating it (Coles & House, 2012, p. 119; Dodsworth & Anderson, 2018, pp. 154-155; Russell, 2012, p. 21; Spankle, 2012, pp. 122-123). In this manner, exhibition designers may alter the perceived colour, form and texture of a work of art in a desired context and provide an overall exhibition experience in space by means of neutralising the space as much as possible from the visual field. Since light has a mutual relationship with form and colour and these are in turn structured by light, any alteration in light may alter the perceived saturations, values and hues of a colour and perceived size, dimension and texture of a form. During all these events, the form and colour of displayed works and the space itself are perceived by patterns of light through the instrument of visual perception, while through the instrument of spatial perception, the three-dimensional shape, texture, reflectance and transmittance properties of the displayed works of art and the space itself are perceived by means of the interaction of them with the light (Anderson, 2011, p. 9; Karcher et al., 2010, p. 12).

In the scope of exhibition design for glass art, the light and colour duality acquires a more important role due to the interactive ability and transparent aspects of glass, which is extensively used in exhibition spaces in order to design exhibited works of art, display cases, digital displays, lighting sources and building facades.

3.2.1.1. Perception of Light, Light in Space

Light is very vital for the existence of human beings due to its role in illuminating the outer world (Fies & Mathers, 2009, p. 5). It is a fundamental requirement for vision and most of the information from the outer world is perceived through sight (80%). By working with the visual system, light generates a substantial part of people's experiences. In this cooperative work, light makes the outer world visible while the role of the visual system is to extract retinal images on the eyes due to the interaction of material surfaces with light and transfer these images to the brain in order to be interpreted.

In fact, exhibition design requires knowledge about how visual systems work. Visual systems are able to cope with different amounts of light via visual adaptation (Abu Dhabi City Municipality, 2014, pp. 24-48; Raynham & Boyce, 2009, pp. 24-25). They are able to change their sensitivity and can operate over a range of luminance levels of 1,000,000,000,000 to 1 in order to recognise images in different light conditions (Raynham & Boyce, 2009, p. 24). In this way, the lightness, colour, shape and size of an object remains constant in a wide range of lighting conditions (such as in dim environments, under sunlight, and so on) (Amheim, 1974, p. 337; Ganslandt & Hofmann, 1992, pp. 30-31; Merleau-Ponty, 1981, p. 13; Petru, 2010; Raynham & Boyce, 2009, p. 42; Wördenweber et al., 2007, pp. 10-17). This situation is explained with perceptual constancy phenomena that produces flexibility particularly in lighting designs for exhibitions. However, this adaptation process, known as transient adaptation, is temporary (Ganslandt & Hofmann, 1992, p. 77; Gordon, 2003, pp. 31-33).

In the processes of physiology and perceptual psychology, this changing state of adaptation provides information for both visual and spatial perception (Ganslandt & Hofmann, 1992, p. 77; Gordon, 2003, pp. 31-33).

Based on this, perceived colours, shapes, forms and sizes of the objects may be altered with any alteration in lighting conditions (Ganslandt & Hofmann, 1992, p. 77; Gordon, 2003, pp. 31-33).[44]

As for how light is perceived, it is perceived on forms while bringing them to life. Light is perceived as brightness on forms and it becomes visible by means of reflected light from surfaces because all three-dimensional forms are seen as a pattern of brightness contrasts that often consist of highlights and shadows (Gordon, 2003, pp. 31-33). Based on this, the following inferences can be easily made:

- ✓ *The material structure in any form provides people with knowledge about light or with an awareness of light.*
- ✓ *'Perception of light' refers to the perception of forms. In fact, light and form have a mutual relationship such that light makes visible the forms by illuminating them and form makes light visible by reflecting light from surfaces and edges. This situation makes light sine qua non in proper perception of the forms and their structural details;*

[44] The eyes are in equilibrium when the three primary colours are present in a space. If one is missed, the missed colour or colours are temporarily provided by an especially photochemical adaptation and the eyes come to equilibrium again. Due to different combinations of retinal photoreceptors operating at different retinal illuminance levels, the spectral sensitivity of the visual system can change. For example, somebody can read a book because of the dark inks printed on white paper even if both materials received the same quantity of light. A reader distinguishes the shapes of the letters because of the contrast in colours. The same person can do the same when more light is applied on the pages. Only white paper reflects more light and so appears brighter. Dark inks reflect very little light in this case. However, it should be borne in mind that the visual system is not able to adapt to all conditions; its capability is limited.

e.g., textures, patterns, colours, etc. (Ganslandt & Hofmann, 1992, p. 77; Gordon, 2003, pp. 31-33). *At the same time, this indicates the role of lighting not only in visual perception but also in the spatial perception of itself and of forms and spaces in the outer world. The visual environment before visitors has a three-dimensionality of character and including a number of individual areas from the extension of the space around the observer to the location and orientation of objects within the space, down to their spatial form and surface structure* (Ganslandt & Hofmann, 1992, p. 77).

In this context, the perception of brightness, actually light on forms, appears as luminosity. By looking at forms, the attribution of the emitting light without heating is defined with the term luminosity (Holtzschue, 2009). The luminosity on surfaces and forms can emerge from direct light that comes from light sources and/or from indirect light which occurs due to the radiation of light from light-reflective materials (such as water colours, glossy surfaces, etc.). This situation clarifies the effects of lightness-darkness in the perception of the forms in the surrounding world and in the perception of the light itself. However, it is necessary to know about how the field of physics explains it.

In physics, lightness and darkness are the differences between a great amount of light and less or no light and are solely the differences in the quantity or amount of light (Russell, 2012, pp. 31-32). The term 'brightness' is commonly used to describe perceived lighting effects on surfaces, but it is not an absolute property of the surface (Russell, 2012, pp. 31-32). In other words, brightness is a result of the intensity of light in space as to whether it is low or high and whether it comes directly from light sources or indirectly via reflections in space.

The term 'luminance' refers to the objective measurement of intensity per unit projected area. It can also be defined as the ratio of the luminous intensity of a surface (cd) to the projected area of this surface (m^2) (Ganslandt & Hofmann, 1992, p. 42; Gordon, 2003, p. 25). Luminance is fundamental to describe perceived brightness; however, brightness is a subjective sensation which is perceived consciously by an observer. The sensation of brightness can only pertain to the intensity of light that enters the eyes and is caused by the contrast ratio of its surroundings and the content of the perceived surface. Brightness is a result of three factors:

1- The intensity of light which falls on a given area of the retina at a certain time;

2- The intensity of light to which the retina has been subjected in the recent past, called adaptation; and

3- The intensities of light which fall on other areas of the retina, called contrast (Gordon, 2003, p. 8).

In addition, each object reflects light differently and people can therefore recognise where an object starts and where it ends due to the adaptation ability of the visual system to different lighting situations. Therefore, qualitative lighting design simply considers not only light as a measurable quantity, it particularly considers it to be a medium of information and expression (Gordon, 2003, p. 8; Karcher et al., 2010, p. 5; Russell, 2012, pp. 31-32).

Light in Space

Light is a natural and mystical phenomenon. In the past, light was usually associated with the spiritual world, the sky, creation and with the concept of the good and pure (Japee & Schiler, 1997). Even the use of stained glass in buildings emerged as a result of this understanding. From past to present, the sequence of day and light or lightness and darkness creates a fundamental rhythm for life and nature.

The metaphors of darkness and lightness with their philosophical and the spiritual expressions may refer to the contrast phenomena of visibility and invisibility in space. In total darkness, invisibility emerges. People can feel uncomfortable or even afraid. In this case of being stable and immobile in a space, a building loses its function and a person can perceive only his or her own material substance and emotions; they hear only inner voices. Without penetrating light inside an interior space from sources such as windows or other light sources, the space itself is a 'black box,' dimensionless, limitless, out of form, undetailed, lifeless, with nothingness, substanceless, emotionless, impassive, unfeeling and colourless (Spankle, 2012, p. 122). However, light brings objects and spaces to life and enables users to perform in those spaces, while allowing them to satisfy their visual and emotional needs. Natural light also has psychological and physiological impacts on people and provides safety and well-being. It affects moods and attitudes in spaces (Coles & House, 2012, p. 120; Dodsworth & Anderson, 2018, p. 122; Russell, 2012, p. 21; Shishegar & Boubekri, 2016, p. 73; Spankle, 2012, pp. 122-123). Through light, whether artificial or natural, all feelings and emotions come to life.

As a design element, lighting plays a very important role in the interpretation and decoration of a space in order to create pace and ambience. It also has the role in modelling different forms to meet with respective functions (Url 3.7). In fact, creating well illuminated spaces suitable for their functions requires an understanding of the physics of light, how the human eye perceives light and how they react to light (Coles & House, 2012, p. 142) as both the perception of interiors and objects depends on how they are illuminated (such as dully and gloomily or bright and airily) (Ganslandt & Hofmann, 1992, p. 76). Owing to the effects of lighting in the perception of spaces, interior architects must know about the quality and quantity of light in order to be able to design their lighting effectively (Grey, 2004, p. 10).

In space perception, lighting should be borne in mind as being both a subjective and objective phenomenon that is based on 50% fact and 50% psychology (Fies & Mathers, 2009, p. 6). Subjectively, the users of a space can judge the quality of a lighting system as being 'good' or 'bad' lighting depending on their aesthetic preferences, visual and physical comfort, etc. since decisions pertaining to lighting are affected by the complexity of the human perception process, individual abilities and psychological effects. Therefore, lighting designers cannot aim to create a good lighting design; however, they can aim to make a proper or accurate lighting design depending on requirements.

The quantity of light can be measured objectively by science in the field of photometry. However, the quantity of light is indicated subjectively (Ganslandt & Hofmann, 1992, p. 46; Naredi-Rainer & Hilger, 2004; Phillips, 2000). Photometry measures light in terms of its perceived brightness to the human eye and analyses the sensitivity of the eyes for each wavelength providing that the human eye is not sensitive to all the light waves. The quality of light is determined from light sources and thus, lighting requirements in spaces for different tasks have been defined clearly in the literature (Ganslandt & Hofmann, 1992, pp. 40-74; Naredi-Rainer & Hilger, 2004; Phillips, 2000, p. 62). As a general rule, the quality of light in interiors depends on a high degree of design of the room surfaces, which includes dimensions of light distribution, object perception and the limitation of glare (Naredi-Rainer & Hilger, 2004, p. 123). In fact, the quantity of reflected light depends on the reflected properties of surfaces and this may contribute to the overall brightness of a space since the overall brightness in interiors consists of light coming directly from light sources and reflected light from secondary light sources. Objects and surfaces reflecting and transmitting light to their surroundings are referred to as secondary light sources, such as the moon, which does not produce its own light, but can still increase or reduce the total amount of light in a space. For example, a light-coloured floor when combined with direct downlights, reflects light back to the ceilings, so the space is illuminated with this indirect light. In this case, the surfaces must be kept clean because the resultant effect in illumination depends more on the reflected light in a space rather than the initial distribution of the light from a light source.

Moreover, the quality of light is a determining factor in the appearance of the forms due to the mutual relationship of light with forms (Grey, 2004, p. 12). Therefore, the quality of light is often considered subjectively in studies even if the quantity of artificial light can be measured because the perceived appearance of forms varies from person to person. In this context, there are some factors that need to be known to influence the quality of light through perception in space:

- ✓ size
- ✓ position
- ✓ direction
- ✓ previous experiences
- ✓ colour
- ✓ colour of interiors[45]

The above factors are clarified as follows:

Size: The size and number of light sources affect the amount of light and the light intensity which illuminates a certain volume. The size of a light source may lead to variations of shadows. The effective size of a light source depends on both the physical size of the light source and its position and distance in relation to objects or spaces (Grey, 2004, p. 12).

Position: The spatial position of a light source affects the amount of light and its angle and direction in relation to its distance from exhibits. Light produced from luminaries located close to a lighted surface, mentioned as "grazing light," strengthens the highlights and shadows. This enhances the perception of depth by emphasising the textures and sculptural relief of the surface. Grazing light also shows blemishes and errors in workmanship. Because of this, it can also be used to demonstrate fine craftsmanship of artworks in which parts have more detailed textures or drawings on them. In a space, grazing light is appropriate to illuminate heavily textured surfaces such as masonry, rough plaster or concrete; it is not proper for illuminating flat surfaces such as gypsum board, acoustical tile ceilings or smooth plaster (Coles & House, 2012, pp. 142-159; Gordon, 2003, pp. 33-34; Grey, 2004, pp. 12-35; Phillips, 2000, p. 14).

Direction: The direction and distribution of light may alter the perception of surfaces and objects in interior spaces. A lighting fixture (luminaries) can distribute light in two different ways, in a concentrated manner or diffuse manner, and it can emit light in three different directions: downward, upward or multidirectionally. Downward light has a restricted spreading angle and prevents direct glare due to the angle. Upward light often illuminates a large part of the ceiling and the ceiling spreads a low-luminance light back into the space. Upward light mostly does not cause distracting glare. Multidirectional light unfortunately emits light in all directions and causes objectionable glare in lateral directions. Both upward and the downward light are variously emitted in patterns from narrow to wide. A concentrated

[45] The colour of the interior space is examined in detail under the topics of visual comfort in lighting design and colour perception in perceptual approaches.

distribution focuses light into a narrow pattern and a diffuse distribution spreads light in a wide pattern. Therefore, upward and downward light luminaries are suitable in general museum and gallery lighting and the use of concentrated direct light can be appropriate for illumination or for modelling individual exhibits (Gordon, 2003, pp. 25-31).

Previous experiences: The perception of objects can vary according to individual and socio-cultural factors of the observers, including the previous experiences, memories, emotions and feelings, preferences, etc. of observers. For example, people expect each day that sunlight springs from the east and falls to the west side and that it emanates from overhead starting at an angle of less than 45° through to straight down at midday as a concentrated light source. They also expect from a skylight a diffuse light and know it as a multidirectional source (Coles & House, 2012, pp. 122-142; Gordon, 2003, p. 35).

Colour: The colour of a light source and its colour rendition affects the quality of light in a space. The use of a natural colour (e.g., white) in interiors also affects the perceived quality of light; applies reality that is associated with daylight (Coles & House, 2012, p. 142; Grey, 2004, p. 13; Phillips, 2000, p. 64).

Colour of Interiors: The colour of an interior affects the overall brightness in a space and its effect depends on the reflectivity of surfaces. The lighter the space, the more reflective the space; similarly, the darker the space, the more absorbent the space (Holtzschue, 2009, p. 23).

3.2.1.2. Perception of Colour and Colour in Space

Colour vision is as old as vision itself. (Hurlbert & Ling, 2017, p. 130) Through visual perception, eyes record approximately 90% of sensory information, which makes colours vitally important for meaning to the environment and for human interaction with it (Petru, 2010, p. 165). Among mammalian species, humans, baboons, macaque monkeys and gorillas perceive colours with three different types of photoreceptor cones in the retina: L, M and S type cones. These three cones, so-called ‘opsins,’ are sensitive to the long, middle and short wavelength ranges of the visible spectrum. They record the relative amounts of light in each of the three spectral bands as well as the resulting triplet of specific responses as the spectrum (Hurlbert & Ling, 2017, p. 130). Average people, who have three photoreceptor cones, have trichromatic vision and they can distinguish many millions of colours as three-dimensional images through spatial perception. However, some rare people have four photoreceptor cones in their retinas known as *tetrachromat* or *super vision*. They can distinguish 100 times more colours than people with trichromatic vision (Grzymkowski, 2017, p. 12; Petru, 2010, p. 165).

Owing to the three photoreceptor cones, the eye is in equilibrium when viewing under sunlight and it is very sensitive to solar radiation (Ganslandt & Hofmann, 1992, p. 43). Since sunlight includes all the colours in the visible spectrum deriving from the three primary colour hues, it appears white. Even if the brilliance, colour values and drift angle of the sunlight is altered continuously throughout the day and altered depending on the season and weather conditions as regards to changing amount and intensity of light, sunlight is accepted as being the ideal state of light and colour vision and is adjusted to only the sun as a light source for the following reasons:

- ✓ Sunlight has certain shades and brilliance in colours and thus, it allows one to see sharply (through visual and spatial perception)[46] and
- ✓ Sunlight appears as white and the whiter the lighting, the more purely unabsorbed wavelengths are reflected, and the purer the intrinsic colours appear (through visual perception) (Itten, 1970, p. 80).

For the above reasons, colour perception is attuned to the continuous spectrum of sunlight (Ganslandt & Hofmann, 1992, p. 43). The same reasons can also be considered as proof of why sunlight or artificial white light is preferred in museums and galleries to modelling works of art on displays. Even the famous impressionist painter Claude Monet stated that: “The real subject of every painting is light.” (Kleiner & Mamiya, 2009, p. 656) However, colour perception also depends on the material structure on surfaces as well as the quality of sunlight.

Colour perception is therefore a physical process and a sensory phenomenon. Physically, visual stimuli of colours is represented in relation to the spectral content of the light illuminating the surface and the spectral reflectance of the surface (Raynham & Boyce, 2009, p. 42). Therefore, the ability of the surface in the transmission, scattering, reflection and absorption of the light affects the perceived colour of objects. As a sensory phenomenon, colour perception is a cognitive response to reflected light at different wavelengths coming from the surface of materials (Holtzschue, 2009, p. 31; Ocvirk et al., 2015, p. 184). How human beings perceive the colour of an object or image is explained by subtractive colour theory such that the known colours are acquired thanks to the ability of material components on or within the surfaces are able to transmit, scatter, reflect and absorb light. Ching states that colour is an inherent visual property in all forms as shape and texture (Ching & Binggeli, 2012,

[46] Because white light includes all the colours of the spectrum, the use of white light is preferred in exhibition spaces to enable the proper perception of the colours of the artwork. In some museums and galleries, white light is obtained from sunlight by through green initiatives. On the other hand, white light can be provided by artificial white light in current exhibition design techniques in many art museums where more controllable and stable illumination on exhibits is needed and to avoid the uncontrollable effects of sunlight. Moreover, some glass artists prefer their works be illuminated with different light sources, such as ultraviolet light in order to achieve an appearance beyond normal human vision. By doing so, they aim to show the colours of their glass artworks in an invisible spectrum.

p. 107). The role of colour is to provide energy to objects and make them more vivid (Petru, 2010, p. 165).

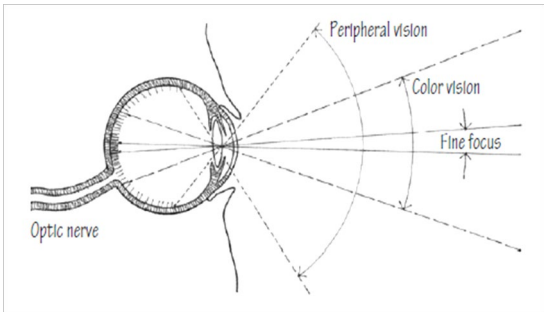


Figure 3.22: Angle of Colour Vision and Peripheral Vision (Ching & Binggeli, 2012, p. 84)

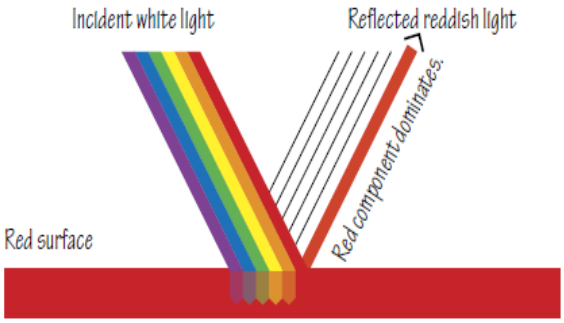


Figure 3.23: Interaction of Light with a Red Surface (Ching & Binggeli, 2012, p. 108)

As seen in Fig. 3.23, colour perception occurs owing to the perception of the reflected light on material surfaces and this situation is explained with Colour Subtraction Theory, (Ching & Binggeli, 2012, p. 107; Japee & Schiler, 1997, p. 217; Singh, 2012, p. 49) which clarifies that the colour of solids perceived by an observer depends on the colorants of a surface (pigments or dyes) which absorb some of the wavelengths of light and reflect other wavelengths to an observer's eye. This refers to pigments and dyes applied onto or into the surfaces that remove or block certain wavelengths of light to show only the selected colour (Grzymkowski, 2017, p. 11).

In the example (Fig. 3.23), the perception of a red surface is demonstrated. An incident *white* light (e.g., sunlight) falls on the surface of a solid object, then the red pigments inside it selectively absorb or subtract all wavelengths of the colours except for the red ones and then, it reflects to an observer's eyes only the red wavelengths. As a result, the surface is perceived as being *red*. This situation is valid for all colours of the spectrum. For example, if an object's surface appears as white, it means none of the wavelengths is absorbed and all wavelengths are reflected since every colour pigment is present on the surface. Accordingly, if an object's surface appears to be black, it means every wavelength is absorbed and none is reflected since every wavelength is absorbed (Ching & Binggeli, 2012, p. 108). In illustration below on the left (Fig. 3.24), the three primary colour pigments (blue, green and red) absorb all the wavelengths of the light rays and all the coloured rays are reflected from the surface and white is seen. In the subtractive mixture of pigmentary colours, *black* is seen (right in Fig. 3.24).[47] Although black results in theory, the same mixture results in a grey-black in practice, the greyness of which depends on the physical properties of the object in relation to its roughness

[47] Therefore, a black background might be appropriate for displaying colourless glass exhibits and the white background might be appropriate for displaying coloured exhibits.

or the inability of the surfaces to absorb all wavelengths (Ching & Binggeli, 2012, pp. 109-112; Holtzschue, 2009, p. 45; Ocvirk et al., 2015, pp. 192-193).

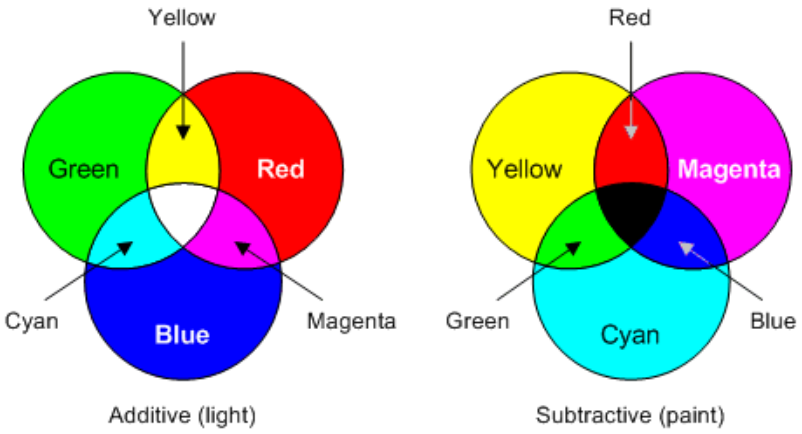


Figure 3.24: Combination of Additive Colours and Subtractive Colours (Brown & Brown, 2008)

In contrast to Colour Subtraction Theory, colour perception can also be explained with Colour Addition Theory, which is based on the perception of coloured light rays in the visible spectrum and merged colours known as light colours. (Itten, 1970, p. 20) According to the colour addition theory, the colours of solids being perceived by an observer depends on the wavelengths of light emanating from a light source, interact with a solid and travel from that solid to the observer's eye. Even if the sunlight is apparently colourless, it is mostly seen as white (Ching & Binggeli, 2012, p. 107). This appearance is caused by its comprehensiveness, which includes all the colour of the light rays. As seen on the left of Fig. 3.17, an additive combination of the three primary light colours, red, blue and green, are perceived as white. Similarly, a mixture of two complementary colours also produces white owing to the fact that they include the three primary colours (Itten, 1970, p. 20). Based on the same information, black is defined as a lack of all colours. Accordingly, whiteness and blackness can be altered with the addition of coloured light rays at certain wavelengths with their quality depending on the property of the light. Therefore, if a small amount of light is reflected from a surface, grey occurs and if a large amount of light grey is reflected, dark grey occurs through visual and spatial perception because grey is formed as a result of the reflection of only a part of all the colour wavelengths. Based on the information given in both theories, the neutrals, white, black and grey, are not mentioned as individual colours due to their not being alone as pigments nor being in the spectral composition (Ocvirk et al., 2015, p. 190).

In addition to the alteration in perception of white and black in relation to physical content of colours, it should be known that colour perception is not absolute; it is variable and temporary.

In relation to this, one of the renowned colour theorists Josef Albers, who approaches the perception of colour from an artistic point of view, states that:

> *"In visual perception a colour is almost never seen as it really is – as it physically is. This fact makes colour the most relative medium in art. In order to use colour effectively, it is necessary to recognise that colour deceives continually." (Albers, 2013, p. 1)*

In fact, colours are naturally dynamic and changing in every new situation and use (Holtzschue, 2009, p. 1). As seen in Fig. 3.22, colour vision is realised in a narrower angle than the peripheral vision, hence it can be altered depending on the spatial position and distance to observers. Colour perception can also be varied from person to person because of the effects of individual and cultural differences. Each individual perceives colours within their own perceiving capacity (Coles & House, 2012, p. 136). For example, the red colour is the most arousing colour, capable of producing the strongest emotional, physiological and perceptual responses (Forrest, 2015, p. 51). However, the red colour means potential danger and urgency in U.K, whereas it means happiness and luck in China. Companies consider colours in the context of brand value and identity, whereas the individual employers consider colours in the context of personal evaluations: liking or disliking (Coles & House, 2012, p. 136). As for another example, white is associated with death in some cultures, while others perceive it as the colour of life and joy and associate death with black. (Petru, 2010, p. 165) Therefore, each colour evokes different meanings and connotation in terms of semantics and each colour stimulates different feelings, emotions or moods in terms of psychology. Simon and Stephan touch upon the semantic effects of colours and mention as: "While designing the space, one should be aware of the symbolism of colours but it should not be forgotten that this is a part of the whole." (Dodsworth & Anderson, 2018, p. 146). Based on all these factors, the effects of colour perception can be summarised as follows:

- *attribution of light (colour, texture and intensity of light);* (Holtzschue, 2009, pp. 22-23)
- *pigmentations on the material surface;*
- *spatial locations and distances of the coloured object, light sources and the observer in relation to each other;*
- *the viewing angle of the observer;*
- *individual attributes (personal evaluations and preferences, previous experiences, memories, ability of colour perception, light sensitivity of the eyes, gender, age, emotions and feelings, points of view);*
- *cultural differences (cultural structures, beliefs, traditions, religion, fashion)* (Coles & House, 2012, p. 136; Dodsworth & Anderson, 2018, p. 146; Forrest, 2015, p. 51; Tilley, 2011, pp. 23,434-442).

Colour in Space

he colours have been examined in the context of their psychological, perceptual, semantic and physical properties in the fields of art and science. As for art, colour aesthetics may be approached from three directions: impression (visual), expression (emotion) and construction (symbol) (Itten, 1970, p. 13). As for space, Hulbert and Ling emphasise that "colour enriches and enlivens the forms and it affect mood and well-being in spaces, therefore it is used in lots of fields alongside art and design." (Hurlbert & Ling, 2017, pp. 130-131). In a similar manner, Birren emphasises that the "colour of a space introduces what the designer would intend to transfer to the observers." (Birren, 1999)

Due to exhibitions being an interface between art and space, exhibition designers benefit from all these comprehensive studies because all these tellingly affect perceptions of the space and perceived ambience and perception of each work of art as well as perception of the exhibition as a whole. A proper colour selection should result in proper presentation of an object's importance, which uses colours properly to imply the exact meaning of the exhibition context (Safavi, 2013, p. 39). By doing so, interior architects/exhibition designers attempt to stimulate these familiar feelings and motivate visitors to comprehend the context of an exhibition.

For all the above reasons, some general effects of colours are defined in the literature that can be used to manipulate the spatial perception of a space to achieve a desired concept. In the following, these general effects are given with respect to spatial arrangements in a space:

1. Warm colours (reds, yellows, oranges) tend to advance and show the space as being smaller. In contrast, cold and deep colours (blues, greens and purples/violets) tend to recede, appear to contract and show the space as being larger. Neutral colours may be either warm (brownish) or cool (bluish) if it is not a pure neutral, so they may behave as advancing or receding depending on temperature. The use of advancing colours may emphasise the existing features of the space and the use of receding colours may hide the existing features of the space.

2. Dark colours (including dark grey and black) and saturated colours tend to advance and show the space as being smaller, whereas light tones (including white) tend to recede and show the space as being larger.

3. Light values tend to be cheerful, middle values tend to be undemanding and dark values tend to be sombre.

4. Light colours appear lighter than dark colours in weight. Both light and warm colours tend to expand and so increase the apparent size of objects, especially when seen against black.

In an enclosed space, light values, cool hues and greyed colours appear to recede and increase apparent distances. Therefore, these colours are used to enhance the spaciousness of a room and increase apparent size, width, length or ceiling height. Spaces with low ceilings appear more spacious or airy when light or receding (cold) colours are used. Spaces with high ceilings may appear to be lower when dark or advancing (warm) colours are used.

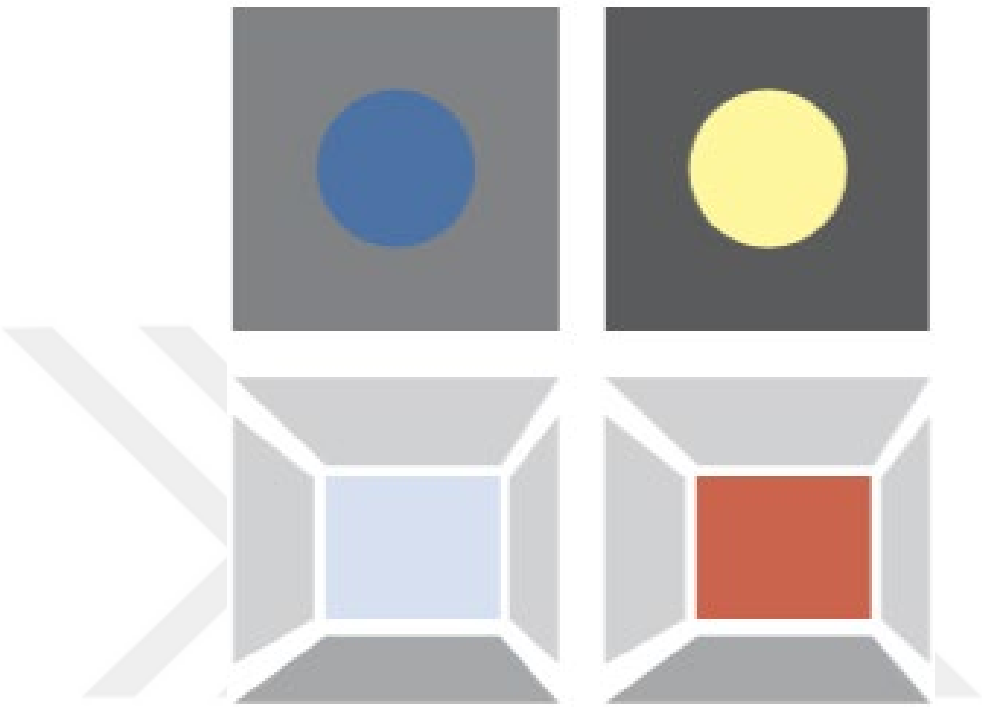


Figure 3.25: Interaction of Cooler and Warmer Colours with Grey Coloured Space
(Ching & Binggeli, 2012, pp. 109-117)

5. The use of receding colours between other colours with low contrast generates a perception of spaciousness. In contrast, the use of advancing colours between other colours and strong contrasts decreases the perception of spaciousness.

6. Using colour in corners alters the perception of the space. Structural details can be invisible and the space dimension can be changed in terms of perception.[48]

7. Large intervals between coloured spaces generate lively contrasts and dramatic effects, whereas small intervals generate subtle contrasts (Figures 3.26 and 3.27) (Ching & Binggeli, 2012, pp. 109-163; Dodsworth & Anderson, 2018, p. 152; Forrest, 2015, p. 52).

[48] Some light and space artists such as James Turrell and some concept artists working with glass such as Rui Sasaki, Olafur Eliasson often apply this effect in their works and create 'perceptional illusions in spaces.'

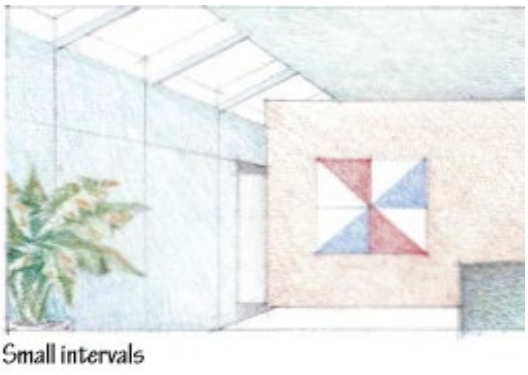


Figure 3.26: Small Intervals between Coloured Spaces

(Ching & Binggeli, 2012, pp. 109-119)

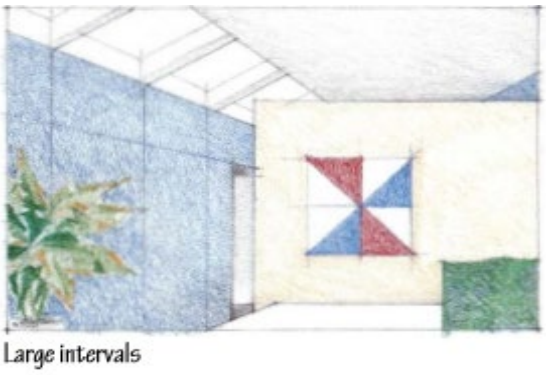


Figure 3.27: Large Intervals between Coloured Spaces

(Ching & Binggeli, 2012, pp. 109-119)

All the above principles are general effects of colours in spatial perception and they are able to alter the perceived form, shape, dimensions, depth, size, scale and weight and lightness of spaces. Nevertheless, these are also very useful for designing an exhibition space because object recognition in forms and shapes is realised with the help of colours in addition to forms, shapes, characteristics, dimensions and placements of exhibits.

However, spatial interactions of colours can also affect the perceived size, depth, dimension or distance of the objects among themselves and objects in the space. According to Condillac, "the perception of colours alone does not constitute coloured places, situations, motions, or coloured objects, it just constitutes a continuum of coloured surfaces limiting one against the other. It is our memory which allows us to see two or three different colours and to make a journey from one colour to the other" (Plümacher & Holz, 2007, p. 28) . The expressionist colour expert Howard Hodgkin also explained in an interview about what David Hockney mentioned on colour interactions: "It doesn't matter which colour you use. The point that he wants to draw attention to is that the relations of colours with each other are important, not the colours alone used in an interior design" (Coles & House, 2012, p. 136) .

In addition, spatial interactions of colours can affect the perceived mood and wellbeing in a space. For example, dark ceilings can seem oppressive but the same shade on the floor feels secure and supportive (Forrest, 2015, p. 52). With regard to this, the following should be considered in spatial design:

1. The use of analogue colours near or next to each other creates harmony (Itten, 1970, pp. 19-21) in architectural/artistic spaces and provides integration of different spaces, but the use of different colours in a space can differentiate spaces (Edwards, 2004, p. 25; Holtzschue, 2009, pp. 53-54).

2. The use of contrasting colours near or next to each other may create visual illusions or special effects (e.g., colour contrast) or it may create harmony in architectural or artistic spaces. Even contrasting hues, values and saturations make one aware of forms and shapes (Ching & Binggeli, 2012, p. 116; Edwards, 2004, p. 25; Holtzschue, 2009, pp. 53-54).

The above factors need to be given more importance in the design of glass art exhibitions as a glass art piece may interact with the surrounding colours due to its transparency and thus its perceived colour might be altered since the brain tends to perceive a totality and seeks harmony. The eyes tend to see everything in similarities and jointly. In this context, Goethe clarifies thus:

> *"When the eye beholds a colour, it is at once roused into activity, and its nature is, no less inevitably than unconsciously, to produce another colour forthwith, which in conjunction with the given one encompasses the totality of the colour circle…In order to realise this totality, in order to satisfy itself, the eye seeks, beside any colour space, a colourless space wherein to produce the missing colour. Here we have the fundamental rule of all colour harmony."* (Edwards, 2004, p. 90)

In fact, the eyes are in equilibrium and satisfied when three primary colours or two complementary colours are present in the visual field. This is a resting state for the eyes. Based on these biochemical and physiological progresses in the brain and in the eyes, a distinct perception occurs by means of comparisons and contrasts. Distributable contrast may realise colours, textures, shapes, forms, areas, distances and accents in an exhibition design (Edwards, 2004, p. 12; Plümacher & Holz, 2007, p. 28).

In terms of colour, large differences in value, saturation and hue are easily perceived and distinctions can be made. However, small differences can hardly be perceived and thus, they are encoded in similar groups and perceived wholly as being the same. As for the design of the space and the spatial location of each art piece, colour contrasts can mainly be arranged in the following five ways:

- Simultaneous contrast;
- Contrast of hues (e.g., yellow- purple);
- Warm-cold contrast;
- Light-dark contrast (value contrast); and
- Contrast of saturation (Ching & Binggeli, 2012, p. 114; Holtzschue, 2009, pp. 55-56; Hurlbert & Ling, 2017, pp. 132-134,163; Itten, 1970, p. 52).

Excepting for light-dark contrast, the perceptual phenomenon of spatial interaction of colours has been excluded from this thesis. Light-dark contrast will be mentioned under the topic of

'Modelling Displays in relation to the 'White Cube' and 'Black Box,' as it is a fundamental component in both concepts.

3.2.2. Material Glass and the Role It Plays in Visual and Spatial Perception

> "Light…transparency…reflection…distortion…magic…poetry. Glass is much more than just a useful material, it has to do with feelings and memories, mystery and mysticism." (King, 1996)
>
> Gerard Pascal

In ancient times, people satisfied their needs by using natural glass in contrast with today's artificial glass usage. Natural glass (such as obsidian, quartz, pumice, perlite, tektites, lechatelierite, fluorite, flint, opal, etc.) spontaneously occurs in nature due to volcanic eruptions, lighting strikes, etc.; therefore, they cannot be present in a pure form naturally (Aalto-Setälä, 2018, pp. 41-42; Cummings, 2011, p. 240; Kocabağ, 2002; Olcay, 1998). Obsidian is the first and most used natural glass in history. It has also been mentioned as the first long-distance export good. However, people started using man-made artificial glass (Aydın, 2008, p. 30; Gagg, 2013, p. 71; Olcay, 1998; Richard, 2004, pp. 67-68,166; Url 3.2; Url 3.4) after they had discovered glass-making.

Unlike most other materials, glass is an easily-shaped material that allows it to be manufactured in different forms. Since the first discovery of inventions in the production and technical stages of glass-making, not only the purity but also most other properties were revealed in the product of glass. The content and property of a glass can be changed with some differences in raw materials, and with differences in production techniques and methods. In terms of content, there is no composition in science which characterises every type of glass. It might be a light transmissive, reflective, refractive or absorptive material, a colour producer and multiplier material, a flexible, soluble, non-toxic, anti-microbial, corrosion-resistant, impermeable, long-lasting, fairly strong, hard, soluble and sustainable material. As a versatile medium, some of these features can be found in the same type of glass and some may not. However, all produced types of glass are used today in the hands of artists, designers, architects and engineers. Depending on the intended usage, glass can be used in:

- the manufacture of daily-use products (e.g., kitchenware, decorative objects, etc.);
- the field of communication and technology (computer and telephone screens; fibre optic cables, fibreglass; insulation material, glass-ceramics; lighting products, etc.);
- the field of science (optics, lenses, telescopes, glasses, laboratory equipment; bioactive glasses for implant, glasses); and
- the fields of art and design (functional, constructive, decorative and artistic media).

In the Glass Age, the versatile use of glass has resulted in the extensive use of glass in the architectural and technological designs of glass art museums in addition to its artistic usage in construction of displayed exhibits. Architectural and technological glass (Coles & House, 2012, p. 113; Dodsworth & Anderson, 2018, p. 126; Mesher, 2013, p. 98) is used by architects and designers in the construction of buildings (such as in walls, floors, ceilings, separators, etc.), elevators, bridges, display units/showcases, digital displays, lighting products and site-specific installations in glass museums. Art glass is used by artists in the construction of the works of arts as well as in installations (Aalto-Setälä, 2018, pp. 41-42; Cummings, 2011; Kocabağ, 2002). In fact, it can be interpreted that glass can stand in art and design as follows:

- ✓ It stands as a building material in terms of functionality;
- ✓ It stands as an aesthetic material in terms of art and design;
- ✓ It stands as a metaphoric medium in terms of conceptualisation;
- ✓ It stands as an expressive material in terms of communication; and
- ✓ It stands as a source of inspiration in terms of emotion and feelings.

- ✓ ***Functional material:*** Architects have been using glass as a functional material in order to illuminate interior spaces thanks to its ability to allow light to penetrate into a space without causing any optical destruction in the visual field. In addition, craftsmen and designers have been using glass to produce functional objects (such as kitchenware, vases, war tools such as knives, etc.) thanks to its ability to be shaped easily (Bird, 2016, p. 42; Gagg, 2013, pp. 76-79; Richard, 2004, p. 116).
- ✓ ***Aesthetic material:*** Craftsmen and designers have been using glass as an aesthetic material in order to produce desirable objects to satisfy aesthetic needs (such as jewellery made with beads, decorative objects, etc.) thanks to the physical and optical properties of glass.
- ✓ ***Metaphoric material:*** With the effects of modernism, architects have been using glass as a metaphoric medium since particularly the last 150 years. A metaphor through glass may refer to fluidity, honesty, clarity, purity, mystery, wealth, spiritual, magical, vitality, luminosity, freedom. Thus, glass has achieved its own individual place in architecture and it gives a much deeper meaning to it. In addition to the functional use of glass in building construction, architects are using glass as a spatial organisation element. The same is being applied by designers to the design of showcases, vitrines, etc. In parallel to these developments, modern and contemporary glass artists are using glass as a metaphorical medium differently from the glass craftsmen who had been using it for functional reasons.
- ✓ ***Expressive material:*** Artists have been using glass as an expressive material to present their inner ideas, thoughts, beliefs, emotions and feelings about a concept. They are also

benefiting from its illusionary ability that may reflect outer scenery as if real or possibly alter the spatial dimensions of a form. As a result, the perception of glass art in terms of form or design will be altered by the viewer through visual and spatial perception (Bird, 2016, p. 42; Gagg, 2013, pp. 76-79).

- ✓ ***Source of inspiration:*** Architects, designers and artists also use glass as a source of inspiration that evokes the feelings and emotions of users. In terms of content, a building or a work of art might be designed to remind everyone of water or air but which physically resembles glass. Thus, it may evoke a memory in users or it may comfort and relax them.

Today, in the so-called Glass Age, material glass is handled mainly as a metaphoric medium and as an inspirational source in art and design. However, it is also used as a functional and aesthetic material in the architecture of glass museums. All this occurs thanks to the versatility of glass in terms of its chemical, optical, mechanical, thermal and electrical properties as well as its physical aspects. All these factors affect the physical structure of a glass-made form and in turn the visual and spatial perception of it. Moreover, a design may alter the perception of a work of glass art because of differences in form and structure (size, dimension, shape) and in surface structure (texture, pattern).

The use of glass in art and architecture is directly related to its perceptual abilities caused by the optical properties of glass. In a similar context in architecture, glass is usually categorised as transparent, translucent and opaque. Visually and spatially, each has different roles in the perception of themselves and their surroundings. For example, while a transparent glass artwork allows one to see the surroundings visually and spatially, an opaque glass work of art does not do so. On the other hand, glass is a reflective material not too dissimilarly to most solids. Depending on the differences in the chemical and physical structure of glass be it transparent, translucent or opaque, each type of glass may reflect light in different directions and in different amounts. For example, when comparing an opaque, glossy glass panel, a transparent, colourless glass panel and a translucent, coloured glass panel, the transparent, colourless one will be the most reflective. To provide a clear appearance of surroundings through visual and spatial perception, the translucent, coloured one will be less reflective for the same reason. This situation, in terms of differences in reflective properties, may alter any perceived colour and/or brightness level of a glass form through visual and spatial perception.

Moreover, a surprising range of coloured shadows can occur on surrounding surfaces through the transparency of coloured glass, so the perceived colour of a surrounding object (e.g., a display case) can also be modified by reflections coming from a transparent piece of glass (Tilley, 2011, p. 91).Therefore, the role of material glass in visual and spatial perception will

be examined in this thesis under the sub-categories of 'transparency and reflectivity, translucency and reflectivity and opacity and reflectivity.

Transparency and Reflectivity: The word 'transparency' is identified with glass; therefore, most conceptual evolutions of glass are related to the use of transparent glass. The expressionist writer Paul Scheerbart illuminates the role of glass in relation to modern architecture and so, illuminates it in relation to transparency in his book *Glass Architecture* written in 1914 (Miller, 2015). He wrote about the practical and technical issues related to glass construction. He also wrote about the meaning of glass and glass architecture and thus, touched upon the positive effects of glass on individuals and collectives because of its capability to transforming the human environment (Bletter, 1981).

Transparent glass allows one to see everything in the visual field without any detectable change (Holtzschue, 2009, pp. 19-25). Accordingly, in the contemporary architecture literature, the word 'transparency' means a 'simultaneous perception of different spatial locations' and mostly implies a broader spatial order. Therefore, it is often used as a synonym with such other words as 'space-time,' 'superimpositions,' 'interpenetration,' 'ambivalence,' etc. (Rowe & Slutzky, 1997, pp. 23-38). Similarly, in contemporary art, transparency evokes simplicity, purity, clarity, honesty and minimalism and it also recalls visually similar materials such as air and water.

In both architecture and art, transparency acts as a metaphoric medium with an illusionary character. Transparency is mostly used to create a visible spatial order of a figurative or geometric form through spatial perception, which actually appears as if it were an invisible space through visual perception without the lines and dimensions of the forms inside forms (such as optical glass, crystal glass, barosilicate glass, etc.). Therefore, transparency brings glass to a special position among other materials in terms of its physical, optical and conceptual properties.

Figure 3.28: Farnsworth House

by Architect Ludwig Mies
Van Der Rohe, USA, 1951
(Gagg, 2013)

In the design of Farnsworth House (Fig. 3.28), modernist architect Mies Van Der Rohe benefited from the transparency and colourlessness of super clear glass [49] for spatial organisation in space (Url 3.8). The building is harmoniously integrated into its surroundings because the glass walls stand as a gap in the outer space, which appears as 'nothingness' or 'absence,' hence it allows one to see everything in detail without borders, which are present in front, within and behind it. In this context, transparency can be associated with honesty. By eliminating itself from the visual field, it highlights the surroundings. A similar approach is used in vitrines and showcases in order to allow the perception of the displayed objects with their intrinsic character while at the same time protecting them.[50]

All this ability is caused by the fact that transparent glass directly transmits and reflects light at the same time (Ganslandt & Hofmann, 1992, p. 42). For the same reason, transparency plays an important role in the interplay of light, colour and glass. Differently from translucent and opaque glasses, surroundings are reflected on transparent glass with their intrinsic colours and these images may be perceived as if they were real images of a transparent glass itself. However, they are only the virtual reflections of the surroundings and the transparent glass itself does not possess these images in a manner that a painting or print does. The benefit of

[49] See Appendix I: Glossary

[50] If a high amount of direct light comes onto a transparent glass surface, direct glare occurs on the surface and causes visual disability and discomfort. Thus, any images or objects behind the glass may not be perceived clearly through visual and spatial perception. This situation is mostly seen on glass enclosures of paintings when they are illuminated with high intensity light in galleries.

this aspect is that transparent glass has come to be used in architecture to achieve a mirror-like or rainbow effect by means of coatings or colouring on one side (Bird, 2016, p. 81; Coles & House, 2012, p. 132; Tilley, 2011, pp. 41,91). With coatings, the light transmission property of the transparent glass is prevented, while reflectivity is maximised.[51] Thus, specular reflections can occur on glass. Apple Store Fifth Avenue is a good example of this. It was designed as a collaborative work by the renowned architecture and engineering team Foster and Partners and the design team of Apple (Url 3.9).

Figure 3.29: Apple Store Fifth Avenue in Iridescent Glass by Architecture Firm Foster+Parners, New York (Url 3.9)

Figure 3.30: Apple Store Fifth Avenue in Iridescent Glass by Architecture Firm Foster+Parners, New York (Url 3.8)

The iconic Apple Store also has designed super-clear glass walls. However, they were coated with mirror-like coatings in some parts to produce a mirror-like effect (Fig. 3.29). Later, they were coated with iridescent coatings in 2019 to achieve a rainbow effect (see Fig. 3.30). In both of them, the Apple Cube stands as a metaphor in New York City; it reflects the city on its coloured specular surface (Fig. 3.30) or without colour (Fig. 3.29). At the same time, it dynamically interacts with people, representing them until they move as if they were temporary exhibitions. As seen in Fig. 3C, the bottom of the cube can almost not be seen because of the higher illumination caused by the direct illumination of the back light from below the cube by the nearest building in the outer space. Thus, the form of the cube becomes more evident thanks to the diffuse illumination from below. These illusory results are perceived via visual and spatial perception, which occur due to the transparency of the glass and its relationship with the intensity, direction and position of the light. In a similar manner,

[51] The mirrors are based on this aspect. They are produced from transparent glass by coating them with reflective substances such as silver nitrate ($AgNO_3$). Thus, they honestly represent the objects placed in front of them.

the design of the infinite mirrors is also based on the information about transparency and the relationship between light and transparent glass.

In short, in terms of visual and spatial perception, transparent glass can be used in art and design to create spatial illusions in form, spatial order inside a 'nothingness,' an interplay of light, colour and glass or mirror-like or rainbow effects.

Translucency and Reflectivity: Translucency gives glass a more mysterious structure (such as sand-blasted glass or frosted glass). In contrast with transparency, translucency allows one to see surrounding images and objects in silhouette presented in front, within or behind a glass-made form. Because translucent surfaces are able to diffuse and reflect light, they blur the surroundings (Ganslandt & Hofmann, 1992, p. 42). As a result of the diffuse reflection of light in translucency, the intrinsic colours and surface details of the surroundings (texture, pattern, etc.) cannot be visually and spatially perceived properly. However, the linear and dimensional aspects of the form (shape, size) can still appear through spatial perception, albeit as a shadow since translucent surfaces can create light and shade with a single material or colour (Holtzschue, 2009, pp. 22-23).

Additionally, light spreads diffusely and smoothly in a translucent environment, which has a matte character due to its surface roughness (Holtzschue, 2009, pp. 22-23). Light is distributed in pieces and in various directions, hence less light reaches the eyes. As a result, a translucent glass appears darker and homogeneously dramatic in terms of perceived brightness levels. The darkness level depends on the roughness level on its surface. This makes it more appropriate for displaying as lighting design for displays aims to achieve a homogenous illuminated dramatic effect on exhibits to present visitors with an attractive visual scene in a manner that allows then to see works of art in detail in terms of form, colour and surface characteristics. Moreover, light colours cannot emerge on or within works of art in a translucent environment, which can occur in transparent environments during the direct transmission of light. Therefore, translucency highlights the material structure of a glass-made form in contrast to transparent glass. For this reason, it is more useful for it to be used in glass art pieces or installations or designs made from glass (including luminaries, decorative objects, wall separators, etc.), which requires them to be highlighted in displays.

In terms of visual and spatial perception, transparent glass can be used to create spatial illusions in form or to create spatial order in a translucent space. By doing so, the transparent environment at the same time behaves as if it were an attractive display case in and of itself that presents internal holes, figures or curves.

Opacity and Reflectivity: Opacity gives the glass a conservative, concealing, intimate, separating and two-faced structure (such as opal glass). An opaque glass has a glossy and reflective surface and produces specular reflections (Tilley, 2011, p. 41). It is able to diffuse and transmit light (Ganslandt & Hofmann, 1992, p. 42).

Glossy surfaces reflect light directly into the eye and diffuse better, whereas a reflective surface reflects light directly. As a result, intense, diffuse light occurs in opaque glasses and appears white through visual perception. However, the reflections on a reflective surface make it difficult to perceive intense colours. Therefore, objects or images placed in front of opaque glass will be seen sketchily and appear as if they were shadows. The opaque glass surface creates 'light-shade' with a single material or colour (Holtzschue, 2009, pp. 22-23).

On the other hand, objects or images placed behind or within an opaque glass cannot be seen via visual or spatial perception because, unlike transparency, the opacity blocks the images. Opaque glass is widely used in the lighting industry as a luminous material. It increases inter-reflections of light in space as well as perceived brightness. In a similar approach, opaque glass walls are used in the bottom or upper side of display cases to provide a diffuse illumination on art pieces while hiding electrical details in the visual field.

In terms of visual and spatial perception, opaque glass can be used in spaces such as a separator to hide undesired details (such as cables, electrical devices, etc.) that are used in or behind the opaque glass form.[52] In art and design, the use of opaque glass creates a dynamic light box effect through visual and spatial perception due to its luminosity. It highlights itself in space, so it is useful in creating glass artwork.

3.2.2.1. The Interplay between Light, Colour and Glass with regard to Transparency

In an examination of glass art, a dynamic relationship is noticed between light, colour and glass due to transparency. Even if it was not mentioned previously as a whole interplay in literature sources, artists and architects have always been interested in it in practice.

In the field of art, some of the earliest examples such as the Lycurgus Cup, which dates from the late Roman period, presents this interplay effectively. Although the stained-glass works might be mentioned as the latter examples, they were mainly designed for spiritual aims to describe sacred stories in an expressionist manner (Bugler et al., 2017, p. 80; Tilley, 2011, pp.

[52] In terms of exhibition design, it affects colour preferences in space. An opaque glass work of art cannot interact with surrounding colours that are different from glass works made with transparent or translucent glass; therefore, the space can be coloured with different colours. On the other hand, a glass artwork made with opaque glass is white by itself; therefore, a white, luminous exhibition space is not suitable to present an opaque glass work of art or installation. A coloured and lightly lit environment would be more suitable. In fact, the 'black box' concept is the most suitable for the exhibition of opaque glass works of art.

192-193,297). However, this relationship has been consciously examined in art in modern times by innovative artists such as Louis Comfort Tiffany. The renowned glass artist, designer and manufacturer Tiffany touched upon the richness of colours in the following sentences that are actually caused by colour transparency.

> *"Rich tones are due ...in part to the uneven thickness of the glass, but still more because the glass maker of that day abstained from the use of paint." (Url 3.10)*

After all, contemporary artists have noticed the 'metaphorical' aspects of this relationship and have started to examine them more. Among them, some renowned artists, such as Ólafur Ellison and James Turrel, are interested ability glass in terms of its interaction with light in their works, while some others are interested the ability of glass in terms of presenting colours; e.g., Stanislav Libensky and Jaroslava Brychtová. While artists are handling the relationship between light, colour and glass in terms of its aesthetic capabilities from an artistic point of view, architects had always been interested in this relationship in terms of its metaphorical capabilities in a more technical way. One of the earlier examples in architecture is made in the context of the 'total work of art' concept by Expressionist architect Bruno Taut in his *Crystal Pavilion* in Germany in 1914 (Bletter, 1981, pp. 20-43; Miller, 2015, p. 88). He designed its glass dome as a 'kaleidoscope of colours' that presented indoor space and all the colours of the transparent glass walls by means of sunshine. Similarly, to his artistic approach to glass architecture, the expressionist writer Paul Scheerbart had also handled glass with a versatile approach by describing glass as being capable of being "a bearer of colour and multiplier of light." Scheerbart had touched upon its ability in architecture as being capable of "exposing the structural elements of buildings." In fact, the indispensable interplay of glass with light and colour can be perceived apparently thanks to the honest character of glass. A transparent glass represents everything it touches, but still tells more than what it shows (Bletter, 1981, pp. 20-43; Miller, 2015, p. 88).

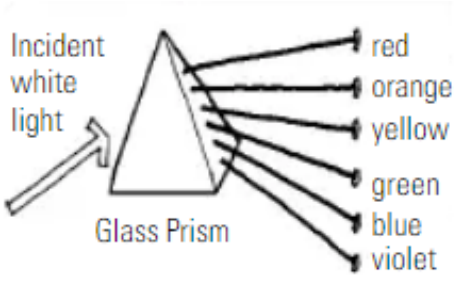


Figure 3.31: Visible Spectrum
(Japee & Schiler, 1997, p. 5)

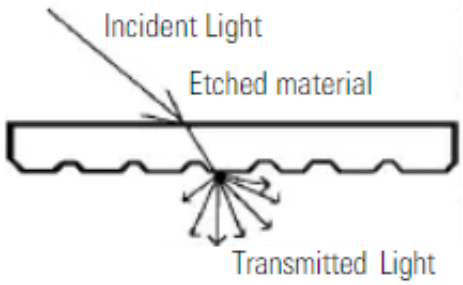


Figure 3.32: Refraction on an Etched Surface
(Japee & Schiler, 1997, p. 5)

As seen in the illustrations, incident white light is divided into light colours after passing through a transparent glass prism (Fig. 3.31), but the incident white light can only be scattered

without separating into colours after passing through an etched glass[53] surface, which might have a rough, translucent or matte surface (Fig. 3.32). Therefore, the interplay between light, colour and glass is more effective in transparent glass art pieces be they coloured or colourless (achromatic).

Accordingly, the perceptual effects of colour transparency[54] and achromaticity in transparency may alter this dynamic relationship and make the work of art more 'illusionist' in character. In this way, a glass form is able to present the interaction of colours of each glass piece that constitutes a glass work of art itself and presents at the same time all the interactions between its colours and the colour of the surroundings. It even presents all the interactions between its colours and the colour of the light source. All these factors affect the visual and spatial perception of this three-dimensional interplay between light, colour and glass. In addition, it might also be altered depending on the differences in form and texture of the surface. In brief, any alteration in light, colour, form and texture alters the visual and spatial perception of the exhibited glass works with regard to it being an 'observed subject' (Amheim, 1974, p. 6).

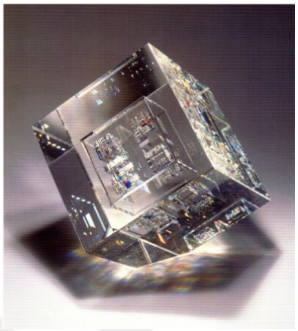
In this context, two distinct art glass examples are selected to demonstrate the interplay between light, colour and glass in terms of visual and spatial perception. Between them, the *Lycurgus Cup*, a historical artefact, will visualise the interplay of light, colour hue and glass with regard to colour transparency, which is a topic of Colour Subtractive Theory, while the 'Glass Cube' of contemporary artist John Kuhn will visualise the interplay of light, colour and glass with regard to achromaticity in transparency, which is a topic of Colour Additive Theory and based on the glass prism experience.

[53] See Appendix I: Glossary

[54] As mentioned previously, colour transparency is a subcategory of the saturation of colours and it is actually related to the amount of colour pigments in a transparent environment located in a visual field. However, the interrelationships between value, saturation and hue are also effective in colour transparency.

A. The 'Lycurgus Cup' (dichroic glass)	**Interpretation through Visual and Spatial Perception**
 **Figure 3.33:** The Lycurgus Cup (a) The Lycurgus Cup in reflected light (left); (b) The Lycurgus Cup in transmitted light (right) (Tilley, 2011, pp. 192-193,297)	The Lycurgus Cup is a dichroic glass[55] item which is composed of glass components including colorant oxides and metal nanoparticles. As a dichroic glass, it presents observers with varied colour hues through visual perception. Simultaneously, the cup presents observers with varying values of colour both through visual and particularly through spatial perception thanks to the differences in the dimensions of the reliefs on it when illuminated with direct light. Accordingly, the interplay between light, colour and glass is dynamically altered depending on the texture of light. The Lycurgus Cup: - appears jade green in reflected light (under diffuse light) and as a deep wine-red in transmitted light (under direct light); - if it is examined in reflected white light, the Lycurgus cup appears dark, because the light is absorbed by the way of entering to the solid and just a little light is reflected back from the surface to the eye. These reflections which come from the surface also looks shiny and a slight ruby colour in appearance. All these colouration differences are caused by the physical processes of absorption and scattering by the metallic particles (such as silver, copper, gold, etc.) embedded in the glass batch in order to make up the glass body (Tilley, 2011, pp. 192-193,297).

[55] See Appendix I: Glossary

B. Glass Cube (Transparent, Colourless Glass Work of Art)	**Interpretation through Visual and Spatial Perception**
 **Figure 3.34:** Glass Cube by Artist John Kuhn, Tampa Museum of Art (Url 3.11) (made with multiple pieces of colourless, transparent glass using a cut-glass technique. Light is constant with intense, direct, white light coming from the above at an angle (probably *30°*).	Owing to the material component, a transparent glass simultaneously has both a transitive surface and reflective surface (Ganslandt & Hofmann, 1992, p. 42). As a result, some of the light rays are reflected back while some are transmitted through the transparent glass. This situation causes many reflection centres in varying dimensions and extents inside the glass cube, which appears fluorescent through visual perception. Here: - light comes to life thanks to the glass material and it is perceived as radiation in the shape of spotty sparkles, linear luminescence or strip-like glare at the corners, borders and edges of the inside pieces (through visual and spatial perception) (Atalayer, 2008, p. 25); - the colourless, transparent glass cube is perceived with colours due to the light (through visual perception). [56] In this context, the glass material assumes the role of a 'bearer of colours' or 'multiplier of colours' and acts as a display screen of coloured light rays.

As seen in the example, the interplay between light, colour and glass emerges thanks to the transparent aspect of glass and it is realised in two ways: with pigmentary colours in a transparent environment or with light colours in transparent environment.

In the scope of the interplay made with light colours in a transparent environment, this relationship is obviously seen in geometrically designed forms made with multiple pieces and with smooth surfaces that have even edges, borders and corners. This kind of artwork is mostly made with cut glass techniques (see Fig. 3.34), laser engraving, etc. and does not include pigment oxides, metal oxides, fluorescent or luminous substances since the light colours

[56] Because light and form as well as light and colour have a mutual relationship through visual and spatial perception, lighting and colour preference in space become the most important factors in the exhibition design of glass artworks in terms of modelling on displays.

appear on the edges, corners and lines of each piece within a whole glass piece and occurs through visual and spatial perception.

In the scope of the interplay made with pigmentary colours in a transparent environment, this relationship is more obvious when some metal oxides were added inside the glass batch in addition to the colorant oxides (e.g., dichroic glass, colour changing glass, photosensitive glass, photochromic glass, etc.) or when some of the luminous elements were added inside the glass batch in addition to colorant oxides as colorants (e.g., phosphore (P), uranium (U), etc.). In these examples, the interplay occurs with hue of colours. Even the same interplay occurs when only the colorant oxides are present in the glass batch; however, this time the perceived colour hues of the glass work cannot be changed and only the value and saturation of the intrinsic colour can be altered depending on any alteration in lighting settlement as in the example given in the topic of colour transparency with respect to the displayed glass work (Fig. 3.20).

In parallel with the above examples in art glass, a similar interplay is also seen in the technology and science of glass in the Glass Age, namely 'smart glass.' One type of smart glass is photochromism glass, which is used in the health industry to produce eye glasses and in architecture for the design of building facades. It is a transparent glass that is sensitive to light intensity and darkens outdoors if the glass is exposed to ultraviolet (UV) rays of sunlight and reverts to a clear, transparent state when indoors or behind a UV filter on windows. Thus, it protects the eyes when used in eye glasses and it controls the intensity of light in interior spaces, thereby preventing glare and overloading in HVAC systems as well as providing cost efficiency (Url 3.12; Url 3.13; Url 3.14; Url 3.15). In this context, the use of photochromism glass might be useful in museum and gallery façades, especially in the facades of contemporary glass museums. If it were to be used, it could reflect the current situation of glass (developed in art, science and architecture) in the Glass Age and thus, it could demonstrate the interdisciplinary approach of the current age in architecture and it could simultaneously help to create a 'total work of art' concept in the design of glass museology.

3.2.2.2. Factors Effecting Visual and Spatial Perception of Glass Work of Art on Display

Based on the above examination of the interplay between light, colour and glass and based on the overall research in the scope of the thesis, a general judgement can be made under the following headings for factors affecting the visual and spatial perceptions of glass artworks on display (with regards to their perceived brightness and colour and the revelation of their forms and surface details):

- ***Factors related to colour preference in space (with regard to the properties of colour and colour temperature):*** The colour of the space itself (in terms of space elements, e.g., walls, floors, ceilings, etc.), the colour of display units or display cases and furniture, the colour of the nearby works of art and the colour of the clothing of visitors affects the visual and spatial perception of any displayed glass artwork.
- ***Factors related to lighting design in space:*** The intensity, texture and colour of the light, the colour rendering properties and colour temperature of the light source, the size, number and choice of light sources, the direction of the light, its spatial position and the distance of the light source affect the visual and spatial perception of the displayed glass artworks.
- ***Factors related to material composition and physical features of the surrounding surfaces (including the surfaces of the space itself e.g., walls, ceilings, floors, etc.):*** The colour of the surrounding surface and the amount, size and dimensions of the raw material components in the surrounding surface (e.g., display cases) affect the perceived brightness and colour of an exhibit. For example, a glossy, white surface reflects more light than a matte, black surface. As a result, the glossy, white surface would first provide a diffuse illumination of an exhibit. Secondly, it would increase the intensity of light on it as if it were a secondary light source; and thirdly, it results in coloured shadows of exhibit on its surface, which causes a complete perception of the exhibit juxtaposed with its surface. In addition, a red exhibit can be seen as if it were greenish red when exhibited on a grey display unit owing to the fact that green and red are complementary colours. This situation is explained as simultaneous contrast phenomena in the literature.
- ***Factors related to the material composition of glass exhibits:*** The amount, size and dimensions of the raw material components in a glass batch affects the visual and spatial perception of the glass exhibit. Because they may cause different type of glass with different reflective properties (such as transparent glass or translucent glass or opaque glass). In addition, they type and amount of colorant (metal oxides, metal elements or luminous elements such as phosphorous or uranium) in the glass composition effects its perceived saturation, value and hue.
- ***Factors related to the physical properties and design of a glass work of art (with regard to its form and surface texture):*** Depending on the design, an exhibit might be rough or smooth, or perhaps thick or thin. It might have a glossy or matte surface. It could be geometrically or organically shaped. It might comprise multiple pieces or components, or it may be a single piece. It might have inside holes or inside figures or it might include other forms made with different materials such as copper or ceramic figurines placed inside frozen transparent glass. It might have patterns or

printed/painted images on it or it might not. All these factors affect the visual and spatial perception of a glass exhibit.

- ***Factors related to the production technique and method of the artists made the displayed glass work of art:*** The production technique(s) and method(s) of the artist during the creation process of an exhibit affects the design and physical features of an exhibit, which in turn affects its perception.
- ***Factors related to the spatial arrangement in space:*** Spatial location, position and relative distances of the displayed exhibits themselves, the spatial location, position and relative distances of the display units and nearby works of arts in space, the spatial location, position and relative distances of the light sources, and the spatial location, position and relative distances of visitors (with regard to the arranged area around the displays for the circulation of visitors) affects the visual and spatial perception of the displayed glass artworks.
- ***Factors related to the observer:*** Individual factors of the observers (personal evaluations and preferences, previous experiences and memories, ability of perception, light sensitivity of the eyes, gender, age, emotion and feelings, point of view), the socio-cultural factors of the observers (e.g., their culture, beliefs, traditions, religious, fashion, etc.), and the viewing angle of observers affects the visual and spatial perception of the displayed glass artwork.

3.2.3. Lighting for Glass Art Exhibitions

Lighting is the process that integrates light into the fabric of architecture and it is designed to enable the efficient performance of visual and physical tasks while providing visual comfort to users of a space (Ganslandt & Hofmann, 1992, p. 236; Gordon, 2003, pp. 208-209). In glass museums and galleries, lighting is designed to achieve a significant performance and often dramatic improvements in aesthetics owing to the fact that the interaction between exhibition design, exhibited works of arts and lighting design requires a coherent perception (Karlen et al., 2017, p. 151; Naredi-Rainer & Hilger, 2004). Due its significance in curatorial aspects, lighting is mostly designed by a team of architects, interior architects and electrical engineers in museums and galleries to achieve ideal and optimum lighting conditions on displays, to attain the highest visual quality for glass works of art and to stimulate visual interest on exhibits. In this respect, exhibition designers or lighting designers specialising in glass art displays can benefit from the following general notions of lighting design in museums and galleries:

- Providing an accurate and clear appearance of exhibits in order to reveal their colours, forms and surface structures and to highlight their unique properties;

- A preference for the most proper lighting installation for tasks depending on the types and necessities of the exhibits;
- Stimulating the visual interest and attention of visitors and encouraging concentration and awareness;
- Providing flexibility in the lighting system in order to organise easily the setting and positioning of light sources in different exhibitions;
- Avoiding glare and undesired glimmer to ensure visual comfort;
- Controlling reflections and mirror-effects on exhibits, as well as, shadows on surroundings in addition to creating accurate brightness contrast for modelling exhibits;
- With the exception of the exhibition walls, avoiding the presence of evocative shadows and patterns of light on the walls or ceilings in the space;
- Avoiding the occurrence of reflections and undesired cast shadows that fall on neighbouring exhibits;
- Controlling the level, intensity, direction and distribution of light and controlling colour rendering, colour performance and colour temperature properties of the light source;
- The use of daylight-supporting artificial lighting arrangements to provide energy efficiency and cost savings;
- Providing a safe environment to assist wayfinding through exhibitions and to create an appealing atmosphere in exhibition spaces (Elhawary, 2014, p. 14; Fielder & Jones, 2001; Fies & Mathers, 2009, p. 5; Ganslandt & Hofmann, 1992, p. 236; Karlen et al., 2017, pp. 106-125; Kurtay et al., 2003, p. 96; Licht, 2000, p. 8; Naredi-Rainer & Hilger, 2004, p. 123).

When the above parameters are provided, designers benefit from natural daylight and/or varying artificial light sources (e.g., spot lamps, indirect luminaries, wall washers, cove luminaries, stained and textured glass, luminous ceilings with opal glass enclosure, etc.). Each has its advantages and disadvantages; therefore, lighting preferences will depend on a variety of factors, including requirements, desired effects, other aesthetic and practical goals, as well as the maintenance requirements of the light sources, cost and energy efficiency, power consumption and distribution of light in terms of the texture of the light (see Appendix VI). In context, the benefits and disadvantages of artificial light and natural daylight have been compared in detail in the literature (see Appendix VI) (Anderson, 2011; Coles & House, 2012,

p. 120; Licht, 2000; Naredi-Rainer & Hilger, 2004). Each may also distribute light from different directions, be they direct light sources, diffuse light sources or both that can be positioned in upward, downward, side-light, front-light or back-light positions.

Lighting is generally examined under two headings for glass art exhibition spaces, namely ambient lighting and accent lighting, which are characterised by alterations in the distribution of their respective light.

- Ambient lighting refers to room lighting in exhibition spaces characterised with diffuse lighting. It provides access to displays and provides way-finding, circulation and orientation within work areas. However, except for special exhibitions taking place in darkened rooms, it also serves as a fill light for exhibits. As a rule, soft (diffuse) ambient lighting should support accent lighting in exhibition spaces. In this case, lighting in an exhibition space would comprise direct and diffuse lighting (Licht, 2000; Naredi-Rainer & Hilger, 2004, p. 123).

- Accent lighting refers to display lighting or lighting in showcases used to highlight and emphasise exhibited glass art works as a key-light for modelling them. An accent light is commonly known as direct-lighting; however, it might also provide diffuse or diffuse and direct illumination on displays depending on the type of light source(s) selected according to the needs of exhibits. In relation to spatial location and the relative distance of the light source, an effective accent light is aimed at the centre of an attraction using an angled luminaire mounted approximately 1 metre from the wall for every 0.05 metres that the centre of the object is mounted below the light source (Karlen et al., 2017, p. 62). That replacement produces a flattering light about 30 degrees from vertical that is generally considered the best accurate position for illuminating art. However, other angles may be better in some cases for the appearance of exhibits (Fig. 3.35) (Licht, 2000).

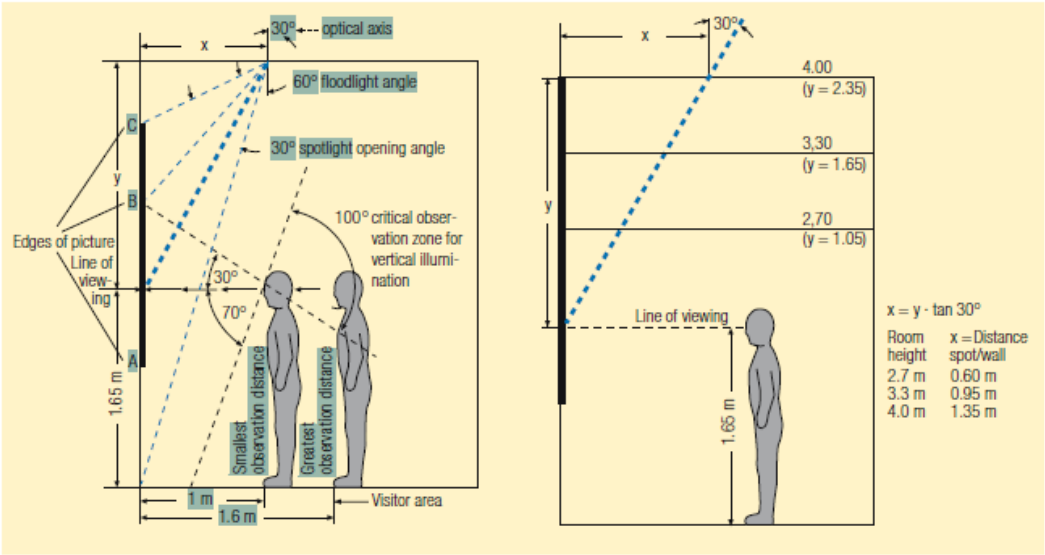


Figure 3.35: Calculation of the Optimal Positioning of a Luminaire for Pictures on a Wall (Licht, 2000)

Room height, observation zone, size of picture and optimal viewing angle (left) are the parameters defining the optimal position for a wall-lighting luminaire. The upper edge of the picture determines the opening angle of the spotlight (B: 30°, C: 60°) with a constant angle of inclination of 30°. Angles less than 30° can result in reflections at the upper edge of the picture (critical observation zone). The mathematical formula for calculating the distance x between the spotlight and the wall to illuminate a picture of height y is $x = y \tan 30°$ (Licht, 2000).

In exhibition rooms, a proper mixture of directional and diffused lighting is suggested as a rule. Thus, an overall impression is created and a stimulating spatial experience is provided since the mixture of diffuse and directional light in relative amounts determines the harshness of shadows cast by frames and display cases, there is a three-dimensional impact on the sculptures and spatial objects (Naredi-Rainer & Hilger, 2004).

On displays, a direct, diffuse or diffuse/direct illumination may be preferred depending on the physical and perceptual requirements as well as the aesthetic satisfaction. In this context:

- ***Diffuse illumination*** distributes light in all directions, determines the distribution of brightness in a space and sets the lighting accents in the horizontal plane. It is mostly generated by ambient lighting; however, it might also be provided by illuminated display cases or it may even be the result of reflections of the direct light on the room surfaces. Since the direction of the light cannot be clearly defined by diffuse illumination, little or no shadowing will be generated on the space, particularly when the radiant surface is large and when the light comes from several directions (Licht, 2000).

- ***Direct illumination*** distributes direct light that creates clearly defined cast shadows and hard-edged contours on neighbouring exhibits or surfaces, particularly uneven surfaces, which can be disturbing. It is generated by point light sources (i.e., lamps, spots) that are used to accentuate exhibits. The directional light partly or completely strikes exhibits at an angle to the geometry of the lighting arrangement and sets a dramatic effect in the visual scene. To increase the impact of three-dimensional sculptures, uneven surfaces can be used; however, the position of the light source should be carefully arranged. If the light source is too dominant or too large or placed in front of the visual field, light interfering the visual field produces glare that should be avoided.

  Moreover, cast shadows and hard-edged contours can be disturbing. To avoid cast shadows, a proper mixture of diffuse and direct light, the correct positioning of the direct light sources and the appropriate position of the exhibited works in relation to other exhibits should be taken into account in lighting design on displays (Licht, 2000).

- ***Diffuse/direct illumination*** distributes a combination of direct and diffuse light that fill each other. It is suggested as being ideal for all kinds of artwork. In this case, the direction of the light cannot be clearly defined as being completely diffuse or completely direct, particularly when the radiated surface is neither large nor functional (e.g., spots with a diffuser disc). The resulting shadows can be narrower or wider, harsher or softer depending on the distance of the lighting and the size of the radiating surface. The mixture of diffuse and directional light can be achieved with diffuse/direct luminaries; however, it can also be achieved when the surface is illuminated or back-lit to produce diffuse light and part of the light is radiated in a particular direction. In this case, the direction of the light on an exhibit can easily be determined, while the shadow is less clearly definable (Naredi-Rainer & Hilger, 2004).

3.2.3.1. Visibility

Art objects and exhibition spaces are three-dimensional forms that have their particular physical properties, such as colour, shape, texture, etc. which depend on their respective material features and design characteristics. Form and light have a mutual relationship. Light is structured by how it interacts with a three-dimensional shape as well as with the reflectance and transmittance properties of objects and vice versa (Anderson, 2011). We can perceive objects only when they are visible due to the interaction between direct and indirect light and form of the object. The greater the luminance, the stronger the visual stimulation, and the easier the object is to see. (Elhawary, 2014, p. 14; Fielder & Jones, 2001, p. 8) In this context, visibility is required at a minimum level of illumination as well as good contrast (without

shadows), good colour rendering and the avoidance of glare (Naredi-Rainer & Hilger, 2004, p. 123). Depending on the type of exhibit, the material being displayed and the desired ambiance, these requirements in relation to the lighting level can be varied to a large extent (Url 3.7). For example, as Mules and Schmitz state:

> *"The three-dimensional microstructure of the surface of a two-dimensional painting needs lighting conditions quite different from those required by a three-dimensional object such as a sculpture that needs to be viewed from all sides. Objects made of light or video installations must be shielded from light that would distract the observer, while large objects such as monuments or excavation sites should be shown in as natural light as possible, without, however, being exposed to damaging weather conditions."* (Naredi-Rainer & Hilger, 2004, p. 123)

However, the required levels of light have been defined as an international standard in order to satisfy the needs of vision for each task (such as reading or crafting, etc.) (Phillips, 2000, p. 9) It should be borne in mind that the required amount of light increases with age. Nevertheless, lighting design is arranged according to recommended international lighting standards depending on the type of task.

In these international standards, suggested lighting levels are also defined for museums and galleries but in these places, a lighting designer should balance between the requirements of a display and conservation necessities and decide on the required lighting level in accordance with the type of exhibit. The recommended minimum light levels for the Glasgow Museum of Glass are presented in Table 1.

Table 1: Lighting Requirements in Museums for Different Tasks

(Naredi-Rainer & Hilger, 2004, p. 123; Url 3.7)

Task	Maintained Illuminance	Limiting Glare Rating	Min. colour Rendering
Ambient Lighting	50-300 lux	28	80
Visitor Circulation Routes	100-300 lux	28	80
Display (accent) Lighting	sensitive to light: 50 lux	-	no UV light
	less sensitive to light: 150 lux	-	-
	insensitive to light: maximum 300 lux	-	-
Work Surface (general)	300-400 lux	-	-
Work Surface (detailed work such as artists workstation)	400-100 lux	-	-
Text Panels	100-300 lux	25	80
Directional Signage	200-300 lux	19	80
Ramps, Stairs	150-300 lux	25	80
Reading Areas	500 lux	19	80

As seen in Table 1, task lighting for displays and showcases can vary from approximately 50 lux to 300 lux depending on the light sensitivity of exhibits to protect light sensitive exhibits from radiation damage. Similarly, ambient lighting of the exhibition rooms can also vary from approximately 50 lux to 300 lux for the same reason.

In addition to illumination levels, the visibility of objects increases with some other physical factors, including size, time, colour and contrast between the object and its background (Wördenweber et al., 2007, pp. 69-70). The relative size in relation to the closeness of an object and duration of the time to look at exhibits may affect the visual acuity of the objects (Fielder & Jones, 2001, p. 4; Wördenweber et al., 2007, pp. 69-70). For example, larger objects can be perceived easily due to more light being reflected or the discernment of an object taking more time in lit environments. Any differences in brightness, colour, pattern, movement, etc. or a combination of these can be visually more attractive between exhibits and spaces. Contrast is another important issue makes visibility a relative higher level: the greater the contrast, the more noticeable the object is. It is the simple difference between an object and its surrounding space. With the help of a distinct contrast, the brain easily differentiates between areas of strong and mild visual stimulation. Contrast can be created via contrast of brightness, contrast of colours, contrast of pattern or texture, contrast of shapes, contrast of forms and contrasts in

relative movement between exhibits themselves and exhibition spaces (Ching & Binggeli, 2012, pp. 86,163; Tregenza & Loe, 2013, p. 102; Wördenweber et al., 2007, pp. 69-70). Movement and flicker in or on objects in front of a stable background can also affect the visibility of objects. This can be created through planning or it can be created simultaneously due to perpetual changes of illumination on reflective exhibits such as glass (Amheim, 1974, p. 231; Wördenweber et al., 2007, pp. 69-70). However, two kinds of contrast are very important for modelling in an exhibition design: contrast in brightness and contrast of colours. Although contrast provides visual acuity of objects in detail, it is avoided in extreme contrasts in lighting and colour in most galleries because it adversely affects visual comfort. Both colour and light in relation to glass art have crucial effects on the perception of exhibits. In galleries, lighting aims mostly to create visual uniformity or gradual changes, such as a transitional lighting zone between the external and generally low lighting levels because the highest levels of illumination cause glare and the lowest reduce the visibility of details. Any information gained from a visual scene can be reduced by reducing the contrast between the art object and its background by using too much light or too little light (Phillips, 2000, p. 4). When contrasts in pattern, texture, etc. are also eliminated, the visibility of an object will be minimal.

Table 2: Object/Background Effects in Displays.
(Tregenza & Loe, 2013, p. 11)

Visibility on Display	Contrast of Brightness / Pattern
Maximum object visibility	High brightness contrast Different pattern
Minimum object visibility	Similar brightness Similar pattern
Maximum visibility of detail within object	Similar brightness Different pattern

According to Table 2, the visibility of detail in an object will maximise under the same lighting conditions. This situation is valid for other differences under the same light source. In equal brightness, different patterns create the maximum visibility of details in an object. To provide contrast between works of art and the space, the exhibition spaces are mostly designed as simply as possible to make remain as a background. By simplifying the space, the interactive role of the exhibition area is suppressed via visual clarity by designing them to be smooth, fluid, etc. spaces and the detailed features of the exhibits are emphasised by placing them as foreground elements in the space. It should be borne in mind that both patterns and colours of display floor surfaces should give accurate information about the depth, height and condition of the floor surface in an exhibition design. Therefore, patterned carpets and floor tiles should be avoided, particularly on uneven surfaces and in low-lit areas (Url 3.7).

In addition to all these factors, the spatial position of visitors also affects the visual discernment of exhibited works. Visitors are looking from a fairly narrow cone of vision (Ching & Binggeli, 2012, p. 84). While a work of art in front of a visitor is visually discerned in detail, more distant exhibits cannot be clearly visible and they are seen as being smaller. Through movement in the space, a mutual change in spatial position occurs and so visible details spontaneously will alter depending on distance (Ganslandt & Hofmann, 1992, p. 34). Movement is particularly very important for the visibility of three-dimensional exhibits.

Based on all the above factors, visibility of the glass works of arts in space is affected by the illumination level, colour rendering properties of the light sources, size, number, position and relative distance of the light sources, colour of the work of art, colour of the light source, colour of the space, contrast of brightness on displays, contrast of colour on displays and movement. Due to the transparent and reflective character of glass art objects, colour preference in space and lighting particularly gain importance. Moreover, for surfaces in exhibition spaces, matte would be preferred over glossy since glass art objects are for the most part made from highly reflective materials. Moreover, glossy surfaces increase inter-reflections in space and undesired images can be produced in the exhibits and surroundings.

3.2.3.2. Visual Comfort

Visual comfort can be achieved by reducing any glare and distracting luminance in the field of view. Physiologically, excessive contrast tends to be disconcerting and reduces a viewer's ability to see details accurately. The quality and comfort of vision depends on the avoidance of distracting or disabling luminance. (Gordon, 2003, p. 38) Therefore, in exhibition spaces, the luminance ratio of accent lighting of displays to general lighting is important in terms of visual comfort (Coles & House, 2012, p. 125). Luminance must be in the range associated with the level of adaptation determined by the entire visual field. A reasonable amount of light attracts attention. However, an increased variety of brightness in interior spaces might enhance the whole interior space. A large difference between them creates an uncomfortable feeling (not to dissimilar to watching TV in a dark room). A small difference between them makes it difficult to focus on a task and the space will be perceived as being too bright. The extremely high brightness would dazzle and cause viewers not to see details where the surfaces are darker than the lower limit. Only when the designer balances the need for visibility of detail with the need for a dramatic visual effect can a higher brightness be perfectly acceptable (Tregenza & Loe, 2013, p. 106). In a general context, visual comfort depends on a number of factors:

1. Size (particularly height), depth and the shape of the room;

2. The position and viewpoint of visitors;

3. Reflection on the ceilings, walls and floors in the room;
4. The choice, number and luminous intensity of light sources,
5. The colour performance and colour rendering properties of the light sources;
6. The pattern of the light in the space;
7. The colour of the walls, floors and ceilings in the room (bright or dark); and
8. The location, distribution and direction of the light sources (Gordon, 2003, p. 39; Licht, 2000; Tregenza & Loe, 2013, pp. 106-107).

Light source requirements change depending on the type of exhibit. For two-dimensional or three-dimensional exhibits, a few luminaries would be sufficient for a single-direction view display. However, for three-dimensional displays around which visitors can move freely, the direction of downward pointing spotlights should normally be angled not more than 45° from the vertical and the luminaire could require some form of baffle to minimise spill light (Tregenza & Loe, 2013, pp. 106-107).

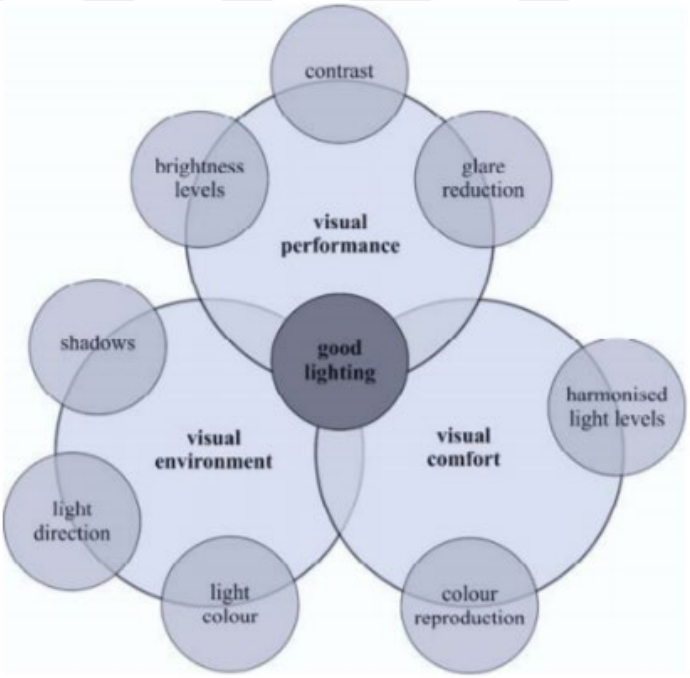


Figure 3.36: Quality Criteria for Lighting of Interiors Explaining Interior Automotive Lighting Design (Wördenweber et al., 2007)

Fig. 3.36 shows how good lighting should be in relation to other parameters in interior lighting in relation to automotive lighting. It can also be used to show the quality criteria for exhibition spaces. In museums and galleries, the absolute requirement of light or illumination of objects on display depends on the luminance of the surrounding space in the visual field. The key

variable factor is the ratio of the object to its background brightness. Providing good visibility or gaining optimum visual performance, it has been found that a ratio task illuminance to its surrounding/background illuminance should be 3:1 in general (Naredi-Rainer & Hilger, 2004, p. 123; Phillips, 2000, pp. 9-10; Tregenza & Loe, 2013, p. 100). That ratio (3:1) may change in some cases. When the object is to have dominance visually over its surroundings or when a surface has low reflectance properties, the ratio should be far greater (Phillips, 2000, p. 10; Tregenza & Loe, 2013, pp. 100-101). For displays, the displayed object is illuminated with accent lighting that is significantly brighter than its background due to the lighting or reflectance or both. The lighting design needs to be more dramatic and created with a greater contrast between the exhibited object and its surroundings. The display must attract attention rather than rely on visitors' prior intention when the display is seen for only a short time due to visitors' being on the move or when the display is seen from a greater distance or positioned in only a small part of the field of the view (Tregenza & Loe, 2013, p. 106).

Table 3: Illuminance Ratios for Different Strengths of Accent Lighting for Displayed Objects (Raynham & Boyce, 2009, pp. 193-196; Tregenza & Loe, 2013, pp. 102-106)

Luminance Ratio (Object illuminance/Background illuminance)	Strength of Accenting in Display
1:1	No difference
2:1	A small noticeable difference
5:1	A distinct or significant difference (low theatrical)
15:1	An emphatic difference (theatrical)
30:1	An emphatic difference (dramatic)
> 50:1	An emphatic difference (very dramatic)

According to Table 3, the higher the luminance ratio, the more likely the display is to gain attention.[57] (Raynham & Boyce, 2009, pp. 193-196; Tregenza & Loe, 2013, pp. 102-106) However, higher luminances can create discomfort in a space due to the light sensitivity of the visual field. Excessive uncontrolled illumination can create undesired glare, sparkle and veiling reflections and it can reduce accurate visibility of exhibits. Glass art works are affected more by a reduction in visibility, especially for transparent pieces. However, sparkle and veiling reflections are desirable in some cases. Glass art is appreciated when it is highlighted. It is well worth mentioning these effects in relation to visual comfort.

[57] The table is adopted and extended from two sources: Raynham & Boyce, 2009; Tregenza & Loe, 2013.

Glare

Glare is the presence of excessive contrast or illumination above the average for a visual field. It is distracting and annoying and causes discomfort. Glare reduces the ability to see accurately. Glare exists if high light densities from light sources or reflections overlap with exhibits in the viewer's field of vision (Naredi-Rainer & Hilger, 2004). Glare can exist as direct glare or as reflected glare depending on the direction, location, size and number of light sources and size of the luminance area (Abu Dhabi City Municipality, 2014, p. 54; Gordon, 2003, p. 36; Naredi-Rainer & Hilger, 2004). While direct glare is a result of light sources, reflected glare consists of both reflected luminance from an object and interior surfaces and the luminance of the lighting system (Abu Dhabi City Municipality, 2014, p. 57; Gordon, 2003, p. 36; Raynham & Boyce, 2009, p. 39).

In museums and art galleries, glare is present as a distinct possibility with the widespread use of spotlights. The problematic distribution of light sources, particularly in large rooms, presents difficulties in adaptation even with indirect lighting when entering a gallery space, such as a very light ceiling surface or illuminated surfaces. The pupil's contracts and adjusts to the lightness of exhibits until coming closer to them. The continuous re-adaptation leads to *fatigue* when faced with strong contrasts. Even if the exhibits appear in contrast to be dark from the beginning when entering the room, it becomes difficult for the eyes. When spotlights are positioned not more than 35° above the downward vertical, glare caused by the spotlights can be avoided (Raynham & Boyce, 2009, p. 200). When there are no visible light sources or visible indirect light sources in the visual field of the observers, glare cannot occur through the illumination of the rooms. That is, no light source should be placed in front of visitors so as to avoid impairing the perception of the overall exhibition. For this, the avoidance of glare can be achieved with low intensity lamps or natural indirect lighting systems and matte surfaces (Naredi-Rainer & Hilger, 2004).

Lighting sculptures that are mostly glass art sculptures generate a flat effect and shiny exhibits actually require reflections in order for the surfaces to be perceptible (Naredi-Rainer & Hilger, 2004). To avoid glare while providing reflections on glass, matte surfaces can be used in exhibition design. Moreover, to illuminate three-dimensional works of art, the use of several low-powered spotlights is better than fewer high-powered spotlights in this context.

Sparkle

Glare and sparkle are very similar to each other. Although glare can create discomfort in the visual field, very small occurrences of high brightness on works of art, known as sparkles, can be viewed without discomfort. Sparkles may be desirable in exhibition spaces distinct from

glare. In exhibiting glass works of art, small areas of sparkling on glass highlighting the material property of glass are desired in the lighting design of glass.

The fundamental difference between sparkle and glare is the relationship between the area and magnitude of luminance in the visual field. Light that is disconcerting and distracting in luminance in large areas causes glare. However, light of similar or higher intensity in relatively smaller areas creates points of sparkle and highlight. This effect creates visual interest and emotional excitement and when it is controlled, this light is preferred in exhibition spaces. Sparkle can occur in three ways: direct sparkle (e.g., Christmas tree lights, small, exposed, clear filament lamps, perforated shielding materials), reflected sparkle (e.g., textured metal, pebbled surface finishes) and transmitted sparkle (e.g., crystal chandeliers, sandblasted or etched-glass (frosted) diffusers around clear filament lamps). Therefore, sandblasted glass artworks especially made with etched-glass[58] techniques need to be illuminated indirectly (Gordon, 2003, p. 41).

Sparkle, highlights and shadows are the principal visual attributes making a sunny day simulating and interesting. The day becomes cloudy and overcast as well as flat and dull in the absence of these visual attributes. In interiors, these attributes are equally significant and emotional stimulation is provided by carefully controlled sparkles, highlights and shadows (Gordon, 2003, pp. 41-42).

Veiling Reflections, Highlights and Shadows

Surfaces can have dramatically varied reflecting properties. High luminance reflections can often be seen in objects on display due to the reflecting ability of some surfaces with strong specular components, such as glass or glossy surfaces, while some surfaces produce only diffuse reflections. The reflected image causes a veiling image on the surface that obscures the detail in the surface and forms a visual barrier in front of the exhibited object. Highly luminous reflections from specular surfaces are called veiling reflections. Specular reflections can reduce the visibility of displayed objects and give them a mirror-like appearance not unlike that seen oil-painted paintings or on glossy paper (Tregenza & Loe, 2013, p. 107). Two factors, the specularity of the surface being viewed and the geometry between the observer, the surface and any sources of high luminance determine the magnitude and nature of veiling reflections (Abu Dhabi City Municipality, 2014, p. 57; Raynham & Boyce, 2009, p. 38).

Glass or other transparent materials have a specular reflection component, but diffuse surfaces (uniformly bright surfaces from all angles of view) cannot create specular reflections (Abu Dhabi City Municipality, 2014, p. 58; Raynham & Boyce, 2009, p. 38). Therefore, to avoid

[58] See Appendix I: Glossary

veiling reflections, diffuse or matte (low-gloss) surfaces can be preferred on display units and showcases, especially for representing glass Works of art (Abu Dhabi City Municipality, 2014, p. 57; Gordon, 2003, p. 36; Raynham & Boyce, 2009, p. 39). In contrast, glossy surfaces have a specular component that can be used when an entire representation, including images or objects in display units is the aim of a glass exhibit in the exhibition context. The veiling of reflections is often considered a negative outcome of lighting, but it can be used positively, such as in art installations. Display lighting of specularly reflecting objects pertains to the production of highlights to reveal the specular nature of the surface. (Abu Dhabi City Municipality, 2014, p. 58; Raynham & Boyce, 2009, p. 38) Most surfaces reflect light diffusely and specularly. A sense of transparency is achieved if surfaces viewed through glass and other transparent materials are higher in luminance than the reflected images. Diffuse illuminance is dependent on the amount of illuminance on the surface, whereas specular reflectance is dependent on the luminance of the source, that is, the reflected image of the lamp or luminaire. In contrast to transparent glasses, translucent glass materials, such as etched, sandblasted, opal or patterned glass, transmits diffuse light that may obscure vision. In sunlight or high intensity artificial light, many translucent materials become extremely glary (Gordon, 2003, pp. 60-186). They appear distracting when seen in focused, because they cannot be seen clearly from the outside in contrast to transparent glasses, hence they psychologically have minimal value.

Moreover, specular reflections can create strong shadows on exhibits, not those hanging on a wall and being displayed in showcases. Shadows can be explained by differences in luminance between views through windows, room surfaces and objects (Naredi-Rainer & Hilger, 2004). Shadows can themselves partly determine the ratio of an object to its surrounding brightness that is effectively able to extend the display into its surroundings (Tregenza & Loe, 2013, p. 107). The production of shadows is related to the object sizes, increasing inter-reflections in space and the position of light sources. Shadows can be produced in displays by considering these three factors (Abu Dhabi City Municipality, 2014, p. 58; Raynham & Boyce, 2009, pp. 40-41). Therefore, an understanding of the relationship between room surfaces and the light sources is a critical issue in the lighting design of displays (Gordon, 2003, p. 31). For example, if an object is large enough, it produces large shadows and the illumination over a large area is reduced by this shadow. If an object is smaller, shadows can occur over a considerably large area.

Moreover, a shadow can be hard-edged or soft-enhanced. Therefore, diffuse illumination can be achieved in the exhibition of display surfaces with a proper quantity of light. Reflectance on display surfaces can be controlled through the proper location of lights, which reduces reflected glare from objects (Abu Dhabi City Municipality, 2014, pp. 57-58; Gordon, 2003, p. 36; Raynham & Boyce, 2009, pp. 39-40). Therefore, light openings and light sources should

be placed correspondingly high to prevent shadows cast by visitors, installations or fittings. In exhibition spaces, extremely soft, non-directional lighting (such as high amount of reflected indirect lighting) or an overly contrasting lighting (such as a huge light source) should be avoided.

Directional lighting with corresponding shadowing can be useful for spatial orientation (general lighting) and for the perception of objects (spatial forms, surface structures) (Naredi-Rainer & Hilger, 2004). The famous painter, sculpture and architect Leonardo da Vinci spoke of shadows thus (Da Vinci, 2012):

> *"A shadow may be infinitely dark, and also of infinite degrees of absence of darkness. The beginnings and ends of shadow lie between the light and darkness and may be infinitely diminished and infinitely increased. Shadow is the means by which bodies display their form. The forms of bodies could not be understood in detail but for shadow."*
>
> Leonardo Da Vinci

Although high luminance reflections on glass enclosures reduce visibility in paintings and information presented on computer monitors, high luminance reflections are essential for glass and silver objects in order to reveal the nature of the material. This special aspect of glass enabled its effective use with most light sources. Clear filament lamps combined with crystal glass, particularly when that glass is faceted, introduce subtle colour highlights via the dispersion of white light into the rainbow of colours that comprise it (Gordon, 2003, pp. 41-42). In a similar manner, transparent glass art pieces, especially those made with a cut-glass technique, are able to produce a spectrum of colours under direct sunlight or in white artificial light.

In museums and art galleries, windows and luminaries are the most usual high luminance sources. Unnecessary reflections and glare should be eliminated on glazed objects such as glass art objects, highly polished objects such as metal or glass art objects, display cases, video monitors, computer screens, etc. (Url 3.7). It is difficult to control high luminance reflections due to the movements of visitors, particularly children or seated visitors (whose heights may lie between 89 cm and 106 cm, which is close to the height of displays). However, these reflections can be minimised or maximised by arranging optimum locations relative to the object, and by controlling the distribution and choice of light source. Depending on the object, decisions can be made as to whether such a high luminance reflection is desirable. It is important to judge whether high luminance creates a highlighting and veiling effect on objects (Raynham & Boyce, 2009, p. 200). As a result, glass works of art need to be highlighted and small sparkles are desirable. Veiling reflections may also be desirable in some cases depending

on the representation context; however, glare is undesirable due to its property of reducing visibility of the forms of exhibits, especially partly or completely transparent exhibits.

3.2.4. Modelling in Displays in relation to the 'White Cube' and 'Black Box'

In the Glass Age, the two main concepts of exhibition design, the 'White Cube' and 'Black Box,' are widely applied in glass museums because the colour of an exhibition space and its surroundings affects the perceived colour of displayed works; therefore, the use of certain colour combinations is avoided in such places (Url 3.7). The renowned painter and architect Leonardo Da Vinci said: "colours appear what they are not, according to the ground that surrounds them" (Edwards, 2004, p. 119). Moreover, it is known that 8% of the male population and 0.1% of the female population are red-green colour blind and a smaller number of people are blue/yellow colour blind (Url 3.7). Therefore, neutrals are preferred, except for grey, which can result in after-images of contrasting colour.

The two contrasting concepts of exhibition design in the 'White Cube' and in the 'Black Box' refers to the phenomenon of white and black and brightness (lightness) and darkness in architecture and harkens to the natural phenomenon of day and night. Therefore, the light and colour duality is used to create a visual ambience in both and is based on the knowledge about light-dark contrasts that refer to the value of a colour and the intensity of light. Even if the two pairings of white-black and lightness-darkness create the strongest light-dark contrast when used together in art and design, exhibition spaces are designed with white and total brightness or black and total darkness. In this context, the two concepts can be briefly clarified.

The 'White Cube' is the combination of white colouring space with total brightness which can make the space appear too bright. It is designed with light-coloured and high-reflectance finishes that reflect much more of the incident light that contributes to a higher brightness, better distribution and a greater diffusion of light with multiple reflections. This is a combination of full luminance and incident white light that provides full non-light objectivity on exhibited works of art. Thus, it allows the perception of intrinsic colours in an exact manner providing visibility to objects in detail and it also *gives visitors a feeling of spacious and calm space with feelings of lower crowdedness* (Ching & Binggeli, 2012, p. 86; Dodsworth & Anderson, 2018, pp. 149-152; Ganslandt & Hofmann, 1992, p. 40; Naredi-Rainer & Hilger, 2004, p. 123; Spankle, 2012, pp. 128-131).

The 'Black Box' is a combination of a black colouring space with total darkness making the space appear as an extremely dramatic scene. It is designed with dark-coloured and low reflectance finishes that absorb much of the light that strikes it and it reflects only a small amount of light to the eye. This gives an impression of a dark, high-contrast space regardless

of the amount of illuminance. Thus, it creates a dramatic ambience that highlights the detail of the structural forms of exhibits and gives visitors a feeling of being in a limitless, intriguing and exciting space (Ching & Binggeli, 2012, p. 86; Dodsworth & Anderson, 2018, pp. 149-152; Ganslandt & Hofmann, 1992, p. 40; Naredi-Rainer & Hilger, 2004, p. 123; Spankle, 2012, pp. 128-131).

In both, the ambience of the space is created as a whole by means of the complementary co-working of light and (a neutral) colour that distinguishes itself from the exhibits. As a result, the exhibition space pushes itself into the background and pushes exhibits to the forefront and thus, exhibits are highlights in space and their accurate representation is provided by revealing and reinforcing details in form and surface structure. That result is actually the aim of display lighting, which is to bring attention to exhibits by making them attractive and emphasising them in the space (Karlen et al., 2017, p. 125; Tregenza & Loe, 2013, pp. 101-103). In fact, the overall aim of display lighting is, according to Tregenza & Loe, to "create a unity with hierarchies of lightness and colour, in which chosen elements are dominant, where there may be complexity, where the essential natures of surfaces and forms are enhanced" (Tregenza & Loe, 2013, p. 100).

In exhibition rooms, the mood or spirit of a space is determined by brightness effects in space. The ambience that visitors can perceive in the space is shaped by light and shadow and how they these are mixed (Fig. 3.37) (Licht, 2000). In a similar manner, the targeted staging on the displays can be achieved by means of light intensity, directional lighting and the colour of the lighting, which are fundamentally provided by accent lighting (Fig. 3.38) (Naredi-Rainer & Hilger, 2004). This means that aspects of the brightness in an exhibition space determines how an exhibit appears to visitors, how an ambience is perceived by visitors and how a mood or spirit is created in the space, all of which may be provided by setting off an appropriate combination of brightness and background colour (Naredi-Rainer & Hilger, 2004).

Figure 3.37: The StreetKraft

by Artist Kim Harty at Habatat Gallery
(Url 3.16)

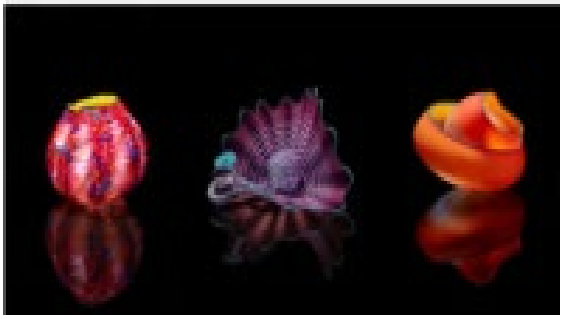


Figure 3.38: Ambiance is Determined by Light and Shadow; glass exhibits in organic forms

by Artist Dale Chihuly
(Url 3.17)

The shaping of the visual environment through patterns of light and shadows is defined by the term 'modelling,' which can be achieved depending on the relative strength of the light being delivered from different directions (Ganslandt & Hofmann, 1992, p. 236; Raynham & Boyce, 2009, p. 196; Tregenza & Loe, 2013, p. 102). The modelling is based on the decision on how lighting should be arranged in relation to the direction, size, intensity and position of the light sources on a display. The distribution of the lighting around three-dimensional objects determines the form and strength of shadow patterns, hence, the strength of 'modelling.' According to most lighting designers, the distribution of shadows is as important as the distribution of light to achieve an attractive and meaningful visual environment because the effect of light and the shapes of shadows appears in indirectly lit spaces that enables observers to perceive textures of the objects and spaces. An example can be given in a landscape such that towards evenings, under sunlight-lit illumination, the leaves and branches of trees appear even more dramatic with shadows on the darker parts of the tree under the crown and on the trunk. In a spatial context, a magnificent landscape appears even more spectacular when looking through the openings positioned in a very small illuminated wall. The space is perceived as being richer and more attractive through spatial perception in cases of the illuminated areas and shadows used in contrast. Similarly to this example, many studies have addressed the importance of shadows adding meaning to a space and human psychology (Coles & House, 2012, p. 134; Gordon, 2003, p. 31; Phillips, 2000, p. 1; Spankle, 2012, pp. 122-123). The same examination is valid for creating an accurate 'modelling' in exhibition spaces, theatres, photography and movie stages, performance halls, etc. They all aim to create dramatic, spectacular representations in order to highlight structural characteristic and details.

Similarly, as in the above cases, display lighting techniques are based on the idea of creating shadows and highlights in order to reveal structural details of form and surface of displayed works of art. On the other hand, modelling of works of art with light but without shadows allows perception of only a visual image rather than a spatial form. Therefore, strong light and shadow (brightness contrast) is desired in most exhibitions; however, if the shadow only creates discomfort on the display, then it is not desired. Any alteration in the pattern of brightness contrast, which can be caused by a change in the direction or distribution of light, alters the visual impression of the spatial form and surface structure. In this context, comparative examples will be given in relation to the 'Black Box' and 'White Cube' concepts based on each of the following:

- ✓ Shadows and lightness are maximised by being together in a narrow beam spotlight and a low reflectance background (Fig. 3.39). In contrast, they can be minimised by being together in a large area luminaire and a high surface reflectance background (Fig. 3.40) (Raynham & Boyce, 2009, p. 200).

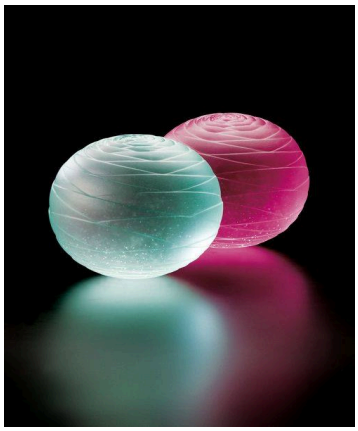


Figure 3.39: Translucent Glass Works of Art in Organic Forms

by Artist Alena Matějka
(Url 3.18)

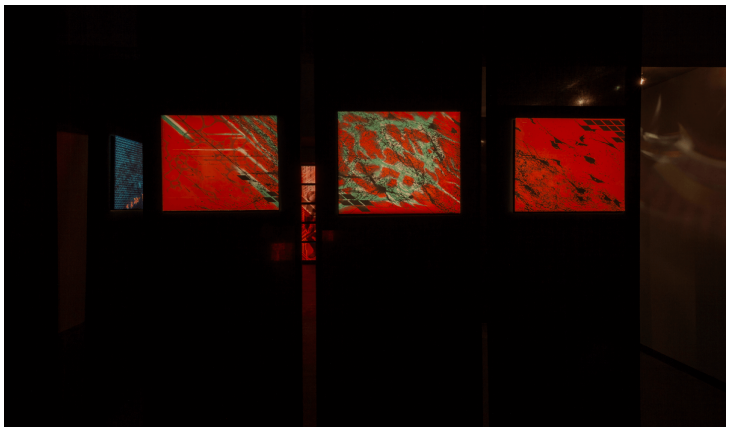


Figure 3.40: Stained Glass Works;

exhibited in the 'Black Box' concept

by Artist Piotr Ostrowski
(Url 3.19)

- ✓ Contrary to the requirement of brightness contrast, excessive luminance is undesirable in displays because it becomes difficult to perceive structural details and it can weaken colour perception (Holtzschue, 2009, pp. 22-23; Tregenza & Loe, 2013, p. 104).[59] Moreover, people with low vision and visual difficulties require at least 70% contrast in colour, meaning that they are not able to perceived details when the space is excessively illuminated (Url 3.7). For the same reason, excessive contrast is also avoided on displays. In this context, an example is given in Fig. 3.41 in the 'Black Box' concept in order to demonstrate how an uncontrolled excessive contrast causes difficulties in perception of form details and Fig. 3.42 shows another example, but in the 'White Cube' concept, to demonstrate how excessive luminance also causes difficulties in the perception of surface details. For this reason, colourless and opaque glass exhibits, as well as works with lighter hues (e.g., yellows), should be presented in the 'Black Box' concept (Fig. 3.43). In contrast, glass exhibits with darker hues (e.g., violet) should be presented in the 'White Cube' concept (Raynham & Boyce, 2009, pp. 195-196; Steuben Glass, 1983; Tregenza & Loe, 2013, pp. 104-105). Exhibits coloured with middle hues (e.g., reds, blues, greens) can be presented in either concept in a proper lighting setting. Moreover, exhibits are mostly presented in homogeneously illuminated boxes or display cases as glass is insensitive to light damage, unlike most other materials. If the illuminated box is also coloured white, more excessive luminance will occur on displays, as in Fig. 3.42. Therefore, if a colourless glass piece

[59] The excessive brightness causes temporary blindness due to the destruction of colour perception. Due to excessive illuminance, the combination of reflective surfaces and high light levels results in a particular type of dazzling called 'masking reflection.' Masking reflections are related to the direction of the light rather than the quality of light which can be increased or decreased depending on the change of the angle of the light source. However, excessive brightness can be improved by reducing the quality of the light, by changing the direction of the light source or light sources, or by adjusting the light sources.

is presented in the ‘White Cube’ concept, a brightness contrast should be created in light and shadow for accurate modelling of displays.

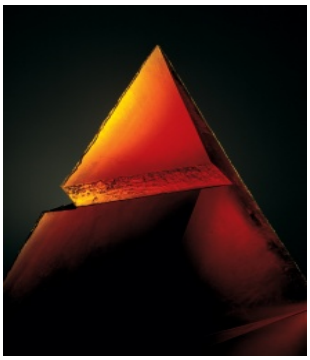


Figure 3.41: ‘Red Pyramid’

by Artistic duo Stanislav Libenský and Jaroslava Brychtová
(Oldknow, 2011)

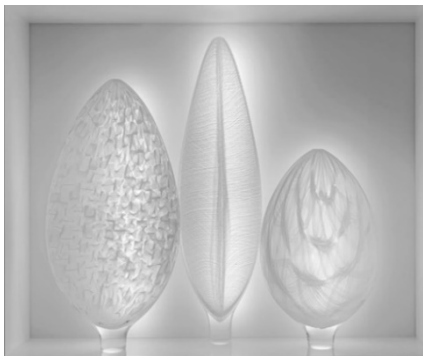


Figure 3.42: ‘The Three White Twill’, illuminated presentation box

by Artist Tobias Møhl
(Url 3.20)

Figure 3.43: ‘Vierzehn x 0’

by Artist Lena Feldmann
(Url 3.37)

- ✓ In general, intense light imparts vividness to its surroundings (Fig. 3.44), while weak light makes the appearance of colours and forms lifeless and pale (Fig. 3.45) (Coles & House, 2012, p. 120; Dodsworth & Anderson, 2018, p. 122; Russell, 2012, p. 21; Spankle, 2012, pp. 122-123). This is exemplified here in the context of the ‘white cube’.

Figure 3.44: Glass Art Installation in Figurative Forms

by Artist Ekrem Kula
(Url 3.21)

Figure 3.45: Glass Art Installation:‘Virtue of Blue’

by Artist Jeroen VerHoeven
(Sotheby's, 2018)

As seen in all the examples above, a proper modelling of the displays for the exhibition of glass pieces in both concepts can only be achieved by providing the appropriate brightness contrast. In fact, experimental studies have shown that a white background and a black background do not significantly change the perception of exhibited on the displays. This is based on the fact that in either situation, colour interaction is prevented between the exhibits and their surrounding spaces and the colour, form and surface structure of the exhibits can be properly represented with a proper lighting design. Moreover, the structural details of the space

are preferred in both cases so as not to interfere with the visual task on display in terms of perception (Licht, 2000). Accordingly, brightness contrast appears as the most important issue in both concepts in terms of modelling on displays. However, creating an accurate brightness contrast is more crucial when exhibiting glass pieces for two fundamental reasons:

- *Glass works of art present a wide range of physical properties (transparency, opacity, colour, colourlessness, etc.) and therefore, they can easily interact with light and surrounding colours. As a result, their perceived colour, form and surface structures might be easily altered depending on lighting conditions. Even the interplay between light, colour and the glass material varies easily.*

- *Glass works of art are insensitive to light damage, which allows them to be modelled in a variety of lighting conditions (e.g., UV light, phosphorescent light, coloured light sources, etc.)*

To achieve an accurate lighting design for modelling on displays, the following general issues should be analysed properly, in particular focus on glass works of art:

- *The key characteristics of the object on display: three-dimensionality or flat; form, texture, colour; sensitivity to light; delicacy, fragility, etc.*

- *The background colour: visually plain or complex; light or dark; involvement of competing displays, etc.*

- *Characteristics of visitors: intellectuality, job, age, etc.; near or distant viewing; moving or static: requirement to see full detail of object or only generally to enjoy viewing it* (Tregenza & Loe, 2013, p. 103).

To provide the above parameters on displays, light sources are positioned on different sides and in different numbers on displays. Each different combination provides differences in brightness, thereby producing different visual effects on exhibits. In this context, the usual approach in display lighting techniques is key-, fill-, background-lighting, as seen in Table 4 below, and up-lighting. Modelling is usually created through some combination of key-light, fill-light, back-light and up-light on displayed works, including glass (Ganslandt & Hofmann, 1992, p. 236; Raynham & Boyce, 2009, p. 196).

Table 4: Descriptions of the Components of Display Lighting

(Raynham & Boyce, 2009, p. 196)

Light	Description	Function
Key-Light	The principle source of directional illumination	To create sparkle and reveal texture
Fill-Light	Supplementary illumination from a different direction	To soften shadows so as to get the contrasts in the display at the desired level
Back-Light	Illumination from behind and usually above	To separate the object from its background, to reveal transparent elements
Up-Light	Light accentuating parts of the display close to the floor	To soften shadows, can be used for dramatic effects

As illustrated in Table 4, different visual effects can be achieved on displays by means of direction, position, number and intensity of light. Key-lighting is composed of a narrow beam that aims to illuminate the most important features of the exhibited object. It produces the highlights and shadows for accurate modelling of three-dimensional forms. Highlights reveal the nature of surfaces and shadows reveal forms and textures. As a rule, glass pieces should be highlighted on displays and the occurrence of sparkles is desired in presentations of especially sculptural exhibits. However, it should be noted that excessive highlighting can produce glare and strong shadows. In such cases, glare disturbs visual comfort and strong shadows can hide structural details. To reduce glare and soften any shadows, the key light is offset with fill-light and up-light. By balancing key-, fill- and up-lights according to direction and the amount of relative back-light, a wide range of appearances can be created (Naredi-Rainer & Hilger, 2004, p. 123). In this context, two main categories of glass art work will be examined, namely three-dimensional and two-dimensional glass art pieces.

- Three-dimensional glass artworks (e.g., glass sculptures) require illumination from several points in several different directions with a few light sources in order to provide an attractive visual impact from various viewing angles as an exhibit needs to be viewed from all directions (Licht, 2000). Only in this way can both the form of the sculpture and the texture details on its surface be emphasised by light and shadow that can be provided by accent lighting with concentrated light beams (directional light) that produce greater contrast and deeper shadows. However, when the expected relationship of highlight and shadow is interchanged or when an artwork is illuminated from a less conventional angle, the perception of a three-dimensional form can be disturbed (Gordon, 2003, p. 224).

As for preventing glare on displayed three-dimensional works of art, the object should positioned at eye level or lower and it should be lit from all sides with beam angles less than 30° from the downward vertical aspect (Raynham & Boyce, 2009, pp. 201-202). However, if the object is large and requires visitors to look upward, there is the possibility of seeing glare. In such cases, the problem can be dealt with by restricting the viewing directions to the object or using narrower beams for the key-light so that all the light is within the display or lighting from below as long as the object's appearance is not distorted. (Raynham & Boyce, 2009, pp. 201-202)

- Two-dimensional glass artworks (e.g., stained glass works) need to be illuminated with accent lighting along with a diffuse illuminated light wall positioned behind it as it should to be viewed from one direction (Fig. 3.40). If back illumination was not possible and a lighting designer has to illuminate it with spotlights in a track lighting system or with a wall washer positioned toward the top, it might be illuminated at an angle of 25-30° from the nadir (straight down) to eye level of the average viewer in order to provide uniform illumination and visual comfort and prevent glare. The same rule is applied in the illumination of wall-mounted paintings (Appendix V) (Blitzer, 2003, p. 13; Gordon, 2003, pp. 225-226; Licht, 2000; Raynham & Boyce, 2009, p. 201).

As for preventing glare on displayed two-dimensional works of art, lighting and exhibition designers should benefit from the following information, which are the general rules for illuminating wall-mounted works of art (e.g., paintings). An angle of 30° is proper for small to large size wall-mounted pieces and satisfactory conditions are for the most part provided by spotlights (Blitzer, 2003, p. 13; Raynham & Boyce, 2009, p. 201). However, large works mounted on a wall require more light. In such cases, higher power lamps or greater numbers of luminaries such as spots need to be spaced on the centres closer than or equal to the distance away from the wall (the so-called square rule) (Licht, 2000, p. 15). An angle of less than 30° (closer to being vertical) distorts art objects due to exaggeration of their texture and the disturbing shadows on their frames (Blitzer, 2003, p. 13; Gordon, 2003, p. 225). On the other hand, angles greater than 30° (closer to being horizontal) cause reflected glare on the surface of displayed works and so any details on them will be washed out. Moreover, shadows of visitors will be cast on exhibits because larger angles cause interreflections by making the light a source of glare to others moving through the space. A uniform illumination over an exhibit on a wall can also be achieved by using spotlights as key lights, and in such cases, spill lights around each picture would be preferred. This softens the effect on the wall and acts as a fill-light (Blitzer, 2003, p. 13; Gordon, 2003, p. 225; Raynham & Boyce, 2009, p. 201).

To provide the above parameter, in practice the various lighting techniques can be used both individually and in combination depending on the characteristic of the exhibits (Raynham & Boyce, 2009, pp. 195-196). Many techniques are also available for use in exhibition design for specialised cases, most of which are drawn from photography and stage lighting (Tregenza & Loe, 2013, p. 105) (Appendix VII).

For glass art exhibitions in particular, the table below can be useful for an exhibition or lighting designer as it illustrates the most common display lighting techniques according to the types of exhibited materials (Table 5).

Table 5: Common Display Lighting Techniques for Particular Materials
(Raynham & Boyce, 2009, pp. 196-197)

Materials	Display Lighting Technique
Uniformly transparent materials	Transmitted light from a lit background; up-lighting possibly in colour
Glass and crystal	Highlighting; up-lighting possibly in combination with translucent background lighting; coloured light
Transparent fibrous objects, e.g., fine textiles	Contour lighting from behind
Precious stones and jewellery	Small spotlight, black velvet background
Opaque, shiny objects, e.g. silver	Spotlights, black velvet background, highlighting
Opaque, textured objects	Light predominantly glancing across the surface

By looking at Table 5, the following statements can be proven about lighting for displayed glass works of art illuminated under the 'White Cube' or 'Black Box' concepts:

- Opaque and transparent and achromatic glass works of art (e.g., crystal glass, super clear glass, etc.) should be presented taking the 'Black Box' approach in order to highlight their structural details in space (Fig. 3.46). as they respond similarly to all opaque and textured objects predominantly requiring illumination across surfaces according to Table 3.11 (Raynham & Boyce, 2009, pp. 196-197). If the same kind of glass work were to be presented with the 'White Box' concept, this time the background would have to be lit to create brightness contrast in the displays (Fig. 3.47) (Tregenza & Loe, 2013)[60]. Additionally, lighting can be coloured or even be UV light

[60] This inference is interpreted especially for glass works of art from the following statements of Tregenza and Loe, who state: (1) If a dark sculpture is presented against a light wall or if a light coloured painting is hung on a light wall, the sculpture or painting will be seen in silhouette and very little of the detail of the object will be visible because the eye has difficulty

in a dim environment (Black Box Concept), as in Fig. 3.48 because the glass is insensitive to light damage (Ajmat et al., 2011, pp. 195-206; Ganslandt & Hofmann, 1992, p. 236; Naredi-Rainer & Hilger, 2004; Url 3.7). In Fig. 3.48, the hollow animal sculptures of Perron are displayed with UV up-lighting in display cases using the 'Black Box' approach in order to make more apparent the inner structure of the sculptures. The artist aimed to show her work as if it were a ghostly spinal structure due to their inside holes (Url 3.22).

Figure 3.46: Organic Glass Sculpture

by Artist Masahiro Nick Sasaki
(Url 3.23)

Figure 3.47: $H_2O.SiO_2$ Hollow Glass Sculptures

by Artist Dylan Martinez
(Url 3.24)

Figure 3.48: Glass Animal Sculptures

exhibition The Anatomy of a Glass Menagerie: Altaglass
by Artist Mireille Perron
(Url 3.22)

- The use of coloured light to display transparent and achromatic works of art is most obviously seen in plasma (Fig. 3.49) and neon glass exhibits (Fig. 3.50) which act as a coloured light source in and of themselves and are exhibited in the 'Black Box' concept. Only in this way can they be accurately presented and effectively highlighted in a black velvet coloured space since luminous colours (light colours) are more highlighted in a coloured background. Moreover, glass pieces made with phosphorescent materials (such as phosphorus, uranium, etc.) also should be displayed in a black velvet space (Fig. 3.51) in order to be highlighted in the space.

adapting to it. (2) If a white sculpture is seen against a light background, then because the luminance range is more limited, details of the sculpture can be appreciated.

Figure 3.49: Plasma Sculpture

in a group exhibition titled 'Light Charmer: Neon and Plasma in Action' (Url 3.25)

Figure 3.50: Neon Sculpture

in a group exhibition titled 'Light Charmer: Neon and Plasma in Action' (Url 3.25)

Figure 3.51: 'Liquid Sunshine/ I am a Pluviophile'

includes over 200 glass raindrops, including phosphorescent material by Artist Rui Sasaki (Url 3.26)

- Uniformly transparent and hollow glass works of arts (three dimensional) are displayed with transmitted, diffuse up-lighting (Figures 3.48 and 3.52). This is valid for the translucent art pieces. Only in this way, their inner holes and structures can be revealed. In addition, lighting from above adds a dimension to exhibits (Gordon, 2003, pp. 224-225; Raynham & Boyce, 2009, pp. 201-202). Otherwise, they can appear flat and lifeless. In most glass museums, therefore, displays are designed with diffuse, up-lighting to provide transmitted light within exhibits (Fig. 3.52). However, direct light can also be used in some other cases in which it is positioned under/in the centre of an exhibit. In this case, the exhibit by itself appears diffusely illuminated and behaves as if it were a coloured diffuse light source. This approach is mostly applied in the modelling of glass installations (Fig. 3.53).

Figure 3.52: Hollow, Green Glass Objects

modelled with diffuse, up-lighting on displays (Empoli Glass Museum) (Url 3.27)

Figure 3.53: Installation: 'Mille Fiori'

by Artist Dale Chihuly, in Chihuly Glass and Garden (Url 3.28)

Figure 3.54: Hollow Glass Cups (includes Murine),

by Artist Stephen Rolfe Powell at Habatat Gallery (Url 3.29)

- Non-uniformly transparent and hollow glass art pieces should be presented in the 'White Cube' concept with a direct, downward lighting (e.g., spotlights). By doing so, an attractive ambience is created with light and shadows and the inherent properties

of glass are highlighted and the pattern and texture details and intrinsic colours are presented (Fig. 3.54).

- Coloured, two-dimensional works of art (e.g., stained-glass) (transparent and/or partly translucent) are lit with diffuse back lighting similar to the lighting of transparent and fibrous objects and they are accurately represented with back lighting in the 'Black Box' concept (Fig. 3.40). By using back lighting, exhibits appear in silhouette. When a vertical surface behind a work of art is illuminated, a luminous backdrop is seen; this visually separates the art object from its background. The back-lighting determines the concept of the appearance of the exhibit and sets the required levels for key-, fill- and up-lighting to be noticeable (Gordon, 2003, pp. 224-225; Raynham & Boyce, 2009, pp. 201-202). When direct light is used as a back light for modelling flat glass exhibits, their intrinsic colours will not appear homogeneous and so the details of patterns will not be perceived accurately, as in Fig. 3.55. However, multi-coloured, opaque two-dimensional glass works should be presented in the 'White cube' concept to provide an accurate representation of colours and reveal pattern and texture details (Figures 3.56 and 3.57).

Figure 3.55: Stained Glass Art Work,
illuminated with direct light source behind it
ZIBA Prague Glass Experience Museum
(Url 3.30)

Figure 3.56: Glass Work of Art: 'Self'
glass and photography
by Artist Verena Schatz
(Url 3.31)

Figure 3.57: Glass Work of Art from the Series of "Glass Shield,"
glass and a thin layer of ceramics
by Artist Mustafa Ağatekin
(Url 3.32)

- Coloured two or three-dimensional works of art which do not have inner spaces can be presented in both the 'Black Box' and in 'White Box' concepts. Colours of lighter value (e.g., yellow and colours close to yellow or all the lighter values) should be presented in the 'Black Box' (Figures 3.58 and 3.59) concept and darker values (e.g., violet and colours close to violet or all the darker values) should be presented in the 'White Cube' concept in order to create a value contrast with the background colour. The middle values (reds and blues) can be presented in either concept. Similarly, white exhibits or installations should be presented in the 'Black Box'

concept in order to create a light-dark contrast in the space and black pieces should be presented in the 'White Box' concept for the same reason. Moreover, transparent pieces that present completely light colours and/or partly pigmentary colours should particularly be presented in the 'Black Box' concept (Fig. 3.60) since luminous colours are more highlighted in a black velvet coloured background. In fact, these kinds of exhibit behave in such spaces as if they were shiny, so they require highlighting in a black velvet backdrop with direct spotlights. However, iridescent glass pieces with hollow inner spaces and shiny surfaces should be presented in a 'White Cube' concept in order to show the structural details of the form accurately and prevent glare on them (Fig. 3.61).

Figure 3.58: Glass Installation: 'Listen to Me'

by Artist Jens Gussek
(Url 3.33)

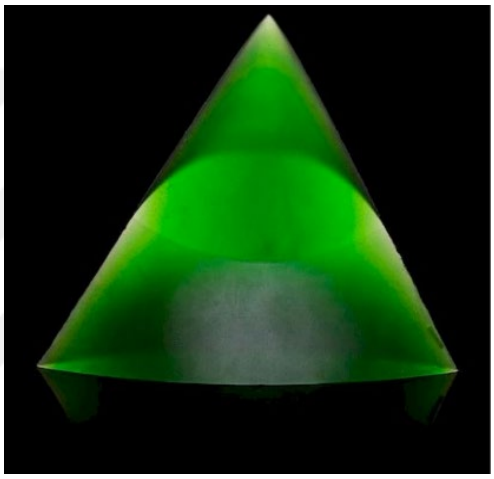


Figure 3.59: Glass Work of Art: 'Green Eye of the Pyramid'

by Artistic duo Stanislav Libensky and Jaroslava Brychtova
(Url 3.34)

Figure 3.60: Glass Work of Art: 'Hektor'

by Artist Jon Kuhn, at Habatat Gallery
(Url 3.35)

Figure 3.61: Glass Work of Art: 'Traps III'

dicroic glass

by Artist Jessee Magee
(Url 3.36)

In addition to all these, a track lighting system may be used to illuminate exhibits which distribute direct light (Elhawary, 2014, p. 14; Fielder & Jones, 2001, p. 8; Gordon, 2003, p. 225; Karcher et al., 2010, p. 39; Karlen et al., 2017, p. 130; Naredi-Rainer & Hilger, 2004; Raynham & Boyce, 2009, pp. 201-202). In such cases, the direction of the light should be carefully arranged in combination with key-light and fill-light in order to prevent glare on an exhibit but still provided sparkles and highlights on it. The following criteria can be helpful for a designer in arranging the direction of light in track lighting systems:

- Modelling with side lighting or light from above provides an added dimension to exhibits;
- Modelling with a back-light puts exhibits in silhouette;
- Modelling with a front-light at a 30° to 45° angle from the centre of the exhibit in the horizontal plane and 30° to 45° from the nadir in the vertical plane (Gordon, 2003, pp. 224-225; Raynham & Boyce, 2009, pp. 201-202);

Based on the above factors, an example will be given of an ancient, hollow, transparent, coloured, glass work of art was displayed with different directions of light. As seen in Fig. 3.62, the most effective presentation appears when light is transmitted from below allowing one to view the inherent colours of the work in addition to the organically shaped hollow designed form of the structure.

Figure 3.62: A Fragment of an Ancient Sculpture and a Red Vase in Different Lighting Conditions (Licht, 2000)

From the 'Red Vase' example in Fig. 3.62, some most important conclusions can be made about how glass art pieces ought to be displayed:

- Three-dimensional glass pieces should primarily be illuminated with transmitted lighting (provided by diffuse illumination on displays) in order to be highlighted in the space to reveal their physical properties. This should particularly be the case for transparent and hollow forms be they coloured or achromatic.

- Glass pieces should be illuminated primarily with artificial white light, ranging from 200°K (dimmed light bulbs) to more than 6000°K (daylight) in order to present exactly the intrinsic colours of the exhibits (Ajmat et al., 2011; Elhawary, 2014, p. 14; Fielder & Jones, 2001, p. 8; Itten, 1970, p. 80; Karlen et al., 2017, p. 5; Naredi-Rainer & Hilger, 2004, p. 8; Shishegar & Boubekri, 2016, p. 73). If desired, sunlight might also be used as a natural source of white light.[61] However, it should be borne in mind that sunlight changes depending on the hour of the day, seasons and weather conditions (Ganslandt & Hofmann, 1992, p. 43).
- Due to glass materials being insensitive to light damage, a variety of light sources (e.g., UV light, X-rays, etc.) can be used to illuminate glass art pieces, especially in modelling transparent glass pieces. If a work is colourless, it presents the invisible light rays of the electromagnetic spectrum on or in itself. If it is a coloured piece, its intrinsic colour will be manipulated and a different colour will be perceived. In a similar manner, coloured light sources can be used to model colourless or coloured pieces or installations depending on what is desired.

- All other factors related to perceived brightness of the displays (position and relative distance from the light sources, light intensity, size, type and number of luminaires and size of radiating surfaces, colour performance, colour rendering properties and colour temperature of the light source) affect the distribution and intensity of the light on the displayed pieces.

- The physical properties of the space and display cases (white or black; matte or glossy; rough or smooth; tall and broad; low and small; physical features of the roof and windows) also affects the perceived brightness on displays in terms of the production of inter-reflections in space. For example, a matte surface will illuminate works of art diffusely, while a glossy surface will reflect all the colours according to the intensity of the light sources (Tregenza & Loe, 2013, p. 105) because all the interior elements (walls, ceilings, floors, etc.) act as secondary light sources in the space and participate as fill-lights for the art pieces on display. For this reason, overall brightness and diffuse illumination are achieved with the ‘White Cube’ concept, while total darkness and direct illumination are achieved with the ‘Black Box’ concept.

[61] Colour perception is attuned to sunlight owing to the fact that sunlight possesses all the colours of the spectrum and it models exhibits properly with light and shadow. Thus, it allows a presentation of structural details with the intrinsic colour of a displayed piece.

CHAPTER 4
CASE STUDIES: A COMPARATIVE ANALYSIS OF GLASS MUSEUMS IN THE "GLASS AGE"

4.1. Criteria for Selection of the Cases

In the "Glass Age," contemporary glass art is often exhibited within the concepts of a 'white cube,' a 'black box' or a 'total work of art.' These three dominantly used concepts of spatial design[62] are distinctively seen in specialised exhibition spaces for contemporary glass art in specialised glass museums,'[63] specialised glass galleries, galleries of glass-art institutions and universities, glass centres for art, design and technology of glass and site-specific installations of glass (installed in indoor or outdoor spaces). However, glass museums may be considered to be 'role-models' among all other glass institutions in the manner of handling spatial design and representation techniques at a professional level.

The manner in which glass museums exhibit glass art can be summarised briefly thus:

Glass museums:

- organise only glass art exhibitions while holistically integrating art and architecture in special cases;
- exhibit varying concepts of glass art in exhibitions (e.g., historical scientific and industrial glass, modern and contemporary glass art);
- present glass works of art in real and virtual spaces, as well as, present glass works of art itself as real or virtual works;
- offer visitors experiences of glass art through visual, spatial, haptic, auditory or multi-sensory perception;[64]
- present interactive glass performance shows, demonstrations and workshops; and usually have so-called "glass gardens" which are usually made as outdoor site-specific glass installations.

[62] See Appendix I and Appendix V

[63] See Appendix II

[64] See Appendix I: Glossary

Based on the above information, it can be inferred that glass museums have been comprehensively exhibiting glass art in a wide-range of conceptual and spatial designs. On the other hand, exhibiting contemporary glass art while benefiting from the art, architecture and technology of glass is particular to the so-called Glass Age. Therefore, this thesis focuses on exhibition spaces of Glass Museums in the *so-called* Glass Age.

Today, in this Glass Age, about seventy specialised glass museums are active around the world. There are a number of similarities between each of them in terms of the content, concept and production techniques of the exhibited glass works of art, mission, vision, function and overall concept of these museums. They also differ particularly in terms of the design of the exhibition spaces and museum architecture. The criteria of selection of the case studies in this thesis are based on consideration given to these specific differences.

Accordingly, different kinds of glass museums have been selected for study, namely the Corning Museum of Glass in the Corning district of New York City, U.S.A, the Shanghai Museum of Glass and the Glass Park in the Baoshan District of Shanghai, China and the Swarovski Kristallwelten (Swarovski Crystal Worlds) in the Wattens District of Tyrol City, Austria. In these three cases, conceptual, technical (in lighting design) and spatial assessments of the exhibition design and architecture (in selected buildings of the museums) will be comparatively scrutinised.

The common characteristics of these three museums can be summarised as follows:

- They exhibit modern and contemporary glass works of art in addition to industrial glass in some ways; however, each selected building of each of the three museums is designed in the postmodern architectural period and they host exhibitions of only contemporary glass art work;
- The architecture of the selected buildings of each of the three museums is designed as works of art in themselves, respectively, inasmuch as the exhibited works of art in their exhibition space;
- They are private, multi-functional institutions and belong to the 'type two museums'[65] category; therefore, they are distinct from other traditional glass museums;
- Due to the multi-functional design of the museum complexes, they not only offer glass exhibitions but also offer various interactive, informative and entertaining activities themed on glass art and glass production, such as hot glass shows, workshops, libraries, research centres, specially designed restaurants and shopping centres, etc.;

[65] See Appendix I: Glossary

- In relation to their overall concepts, they offer not only visual experiences via object-oriented exhibitions but also multi-sensory experiences via interactive, responsive, dynamic and participatory exhibitions and installations;
- These three museums follow developments, news in the world of glass art, architecture and technology and apply these in the design of their display cases, exhibitions spaces and architectural designs;
- Due to the application of the current technology of glass in exhibition design, they reflect the most current states of contemporary glass art exhibitions in the so-called Glass Age, which is represented in both real and in virtual environments;
- Finally, all three of the cases were opened by the world's foremost glass companies in the regions where these glass companies were established a long time ago and played a role in developing a glass industry and which continues to the present time.

In addition to the abovementioned similarities, the three museums have been selected due to their different conceptual, spatial and technical approaches to the exhibition space and its perception with regard to 'white cube', 'black box' and 'total work of art'. These three emerging concepts are fundamentally based on colour and lighting design in space. Thus, they represent interactive relationships of light, colour and material glass. Within this context, the following remarks about the selection of the three museums in relation to emerging exhibition designs can be briefly made:

a. **Corning Museum of Glass (CMOG):** The *Contemporary Art and Design Wing* of the Corning Museum of Glass is selected for the assessment of conceptual, technical and spatial approaches in relation to the exhibition design and architecture of the building. The Contemporary Art and Design Wing reflects the concept of the white cube and displays contemporary glass works of art and installations in the Glass Age. Through the white cube approach, it simplifies the space, provides a white background to reflect all the colours in the most faithful manner and it emphasises artworks in a silent, bright, clear and visibly formed space.
b. **Shanghai Museum of Glass (SHMOG)**: The main building of the Shanghai Museum of Glass has been selected for the assessment of conceptual, technical and spatial approaches in relation to the exhibition design and architecture of the building. The main building of the Shanghai Museum of Glass reflects the concept of the black box and it displays contemporary glass works of art and site-specific installations in the Glass Age. Through the 'black box' concept, it eliminates any noise in the space and emphasises artworks in an invisible, dimensionless and unformed space.
c. **Swarovski Kristallwelten (Swarovski Crystal World):** The main building of the Swarovski Kristallwelten, known as 'the Giant,' was selected for the assessment of its

conceptual, technical and spatial approaches in relation to the exhibition design of its selected 'Chambers of Wonder' as well as the architecture of the building. Taken as a whole, the Swarovski Kristallwelten reflects the concept of a 'total work of art' in a holistic approach. It has been designed as a contemporary architecture of post-modernism and exhibits contemporary glass works of art and site-specific glass art installations in the Glass Age. Through the concept of the 'total work of art,' it combines exhibited works of art, space elements and space in a holistic approach using art, architecture and technology. By doing so, it creates an 'overall experience of glass' through multi-senses; similarly, it is perceived only as a *whole* body of art.

4.2. The Corning Museum of Glass

The Corning Museum of Glass (CMOG) was established in 1951 in New York, U.S.A by the Corning Glass Works (today known as Corning Incorporated) as a gift to the country on the occasion of the glass works' 100th anniversary. The museum is therefore a non-Profit organisation and a private museum. The Corning Museum of Glass may be considered the world's most important specialised glass museum due to its housing of the world's most comprehensive glass collection and having the world's most comprehensive library[66] on glass art and glass-making, the path-breaking Glass Centre[67] and the influential Hot Glass Studio[68]. With all these elements, it is simultaneously the largest glass museum in the world (Url 4.1).

From an interpretive perspective, the museum directs the glass art, science and technology of the world through the agency of its work, including broadcasts, conferences, demonstrations, movies, workshops, etc. Based on timely developments in the technology of glass and current explorations into the capabilities of glass, the museum promotes artists' and designers' new usage of glass as an art and design medium. In this regard, it is the first museum that announced the 21st century as the so-called Glass Age. It was also the first museum to have organised the first 'Glass 1959' international glass art exhibition. For this reason, the Corning Museum of Glass takes first place in the case study part of the thesis for conceptual, spatial and technical assessments of three selected glass museums.

4.2.1. Regional and Conceptual Context

In a regional context, the museum is located very close to Corning Incorporated mid-way between Niagara Falls and New York City and it stands as a centrepiece of the Corning District (The Corning Museum of Glass, 2014; Url 4.2). With regard to the establishment in the same

[66] Known as the Rakow Research Library.

[67] Known as the Glass Innovation Center; it particularly focuses on the scientific and technological exploration of glass.

[68] Known as the Studio, but also known as the Glass-Working School.

district with its founder company, it reflects a historical link between the past and present vision of Corning Incorporated in terms of glass, ranging from mass production to glass art.

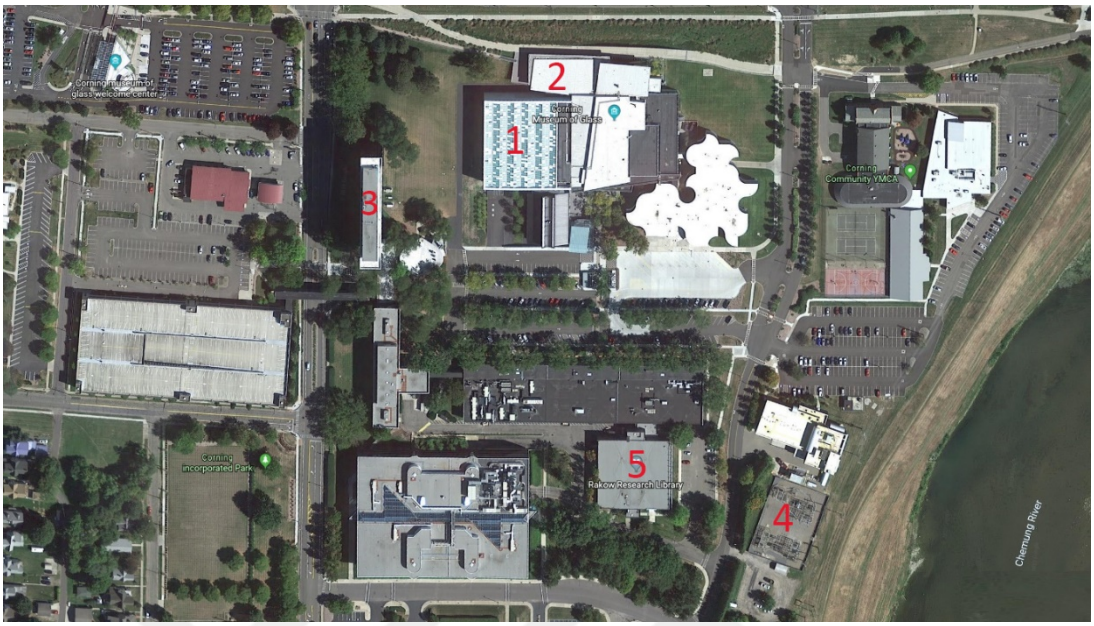


Figure 4.1: Aerial View of the CMOG

located in Corning, New York, U.S.A.: 1. Corning Museum of Glass; 2. Contemporary Art and Design Wing; 3. Hot Glass Studio; 4. Glass Innovation Centre; 5. Rakow Research Library

Conceptually, the Corning Museum of Glass has dedicated itself to the presentation, display and interpretation of the story of only glass and glass making (Item 1 in Fig. 4.1.)(Url 4.3) as only glass is able to explain the history, craft, art, design, science and technology of glass as a versatile medium.

As far as being a multi-functional museum in terms of its overall concept is concerned, the Corning Museum of Glass is a dynamic institution that performs the duties of collecting, preserving, exhibiting, educating, as well as, sharing experiences of glass through its Exhibition Spaces (Items 1 and 2 in Fig. 4.1.), the Rakow Research Library (Item 5 in Fig. 4.1.), the Glass Innovation Centre (Item 4 in Fig. 4.1.) and the Hot Glass Studio (Item 3 in Fig. 4.1) (Url 4.2).

Starting from the Exhibition Spaces, the museum exhibits the most comprehensive glass collection in the world coming from all around the world. It comprises almost 50,000 works in glass, including masterpieces of ancient Egypt, Rome, Greece, artefacts from Islam, Asia, Europe and America's great civilisations; modern and contemporary glass works of art ranging from the late 19th century to the present day reflecting the artistic movements of the respective periods. Therefore, the exhibited glass collection at the Corning Museum traces 3,500 years

of glassmaking history, art, industry and technology (The Corning Museum of Glass, 2014; Url 4.2).

In the Rakow Research Library, the world's most comprehensive documentary collection of glass and glass-making can be found, including many monographs, trade catalogues, multimedia slides, DVDs, videos and articles on the history, art and science of glassmaking. These are written in more than 40 languages from the 12th century to the present day. The Rakow Library is an active institution that regularly publishes valuable scholarly books, annual periodicals (such as *New Glass Review* and *Journal of Glass Studies*), journals, exhibition catalogues and videos in relation to the subject of glass and glass-making. Therefore, the Rakow Library is a significant part of the museum and has a fundamental role in permanently promoting the 21st century as the Glass Age through written and voiced documents (The Corning Museum of Glass, 2014; Url 4.2).

The Studio (Hot Glass Working School) and the Glass Innovation Centre are other important branches of the museum and exhibit a participatory glass experience. Although the exhibition spaces and architecture of the buildings present a glass experience through visual and spatial perception, The Studio and the Innovation Centre of the Corning Museum of Glass are more focused on the haptic and auditory perception of glass.[69] The Studio offers one of the most foremost glassmaking schools in the world and focuses on all levels of experience of glass. There are organised live-streamed and narrated hot glass blowing demonstrations, hot glass and flame working shows, glass-breaking and optical fibre demonstrations, glass design sessions, workshops, courses, lectures by international artists, and so on. Visitors of a variety of ages can have the opportunity to learn glassmaking techniques and shape glass art forms in their hands alongside professional glass masters. The artists in various fields as well as designers can also participate in these courses to learn, explore and experience the material of glass.

On the other hand, the Innovative Centre presents visitors with interactive science and technology exhibits that allow visitors to bend glass, bend light and bend imaginations through interaction. By means of the three fluid galleries in the Innovation Centre, namely the Optics Gallery, Vessels Gallery and Windows Gallery, visitors can explore the properties and chemistry of glass, the power of optical fibre and the innovations in architectural glass technology through interactions with spatially and technically designed exhibits (The Corning Museum of Glass, 2014; Url 4.2; Url 4.4).

[69] See Appendix I: Glossary

4.2.2. Architecture and Exhibition Design

As an overall concept, the Corning Museum of Glass presents a collection of modern glass architecture on its campus. With success in the architectural design of its buildings, the museum stands today in Corning, New York as the centrepiece of glass.

The buildings of the Corning Museum of Glass were designed by three distinct generations of architects who shared the goal of "creating a fluid space and use of incorporated glass wherever possible." (Url 4.5) With this main concept, each building was specifically designed depending on the needs, functions, inspirations and desires of the respective architects and time. The first of the buildings, the original museum building, was designed in 1951 by the Wallace K. Harrison architecture firm (Harrison & Abramowitz) to be a modern glass pavilion (see Fig. 4.2) and the third building, the Contemporary Art and Design Wing, was designed in 2015 to be a contemporary glass pavilion by renowned architecture firm Thomas Phifer and Partners (see Fig. 4.3).

In the thesis, the Contemporary Art and Design Wing of the Corning Museum of Glass has been selected in the scope of the 'white cube' concept; hence, its conceptual, technical and spatial assessment will be realised in terms of architecture and exhibition design.

Figure 4.2: Façade of the Original Building of the CMOG
designed by Architecture Firm Wallace K. Harrison (Harrison & Abramowitz) in 1951
(Url 4.5)

Figure 4.3: Façade Rendering of the Contemporary Art and Design Wing of the CMOG
designed by Architecture Firm Thomas Phifer and Partners in 2015
(Url 4.19)

The Contemporary Art and Design Wing is in actuality a white cube specially designed to be a house of contemporary glass art exhibitions. It may also be thought of as the 'a new interpretation of glass architecture in the Glass Age' that benefits from the 'century's glass' on its façades and in the ceilings (see Fig. 4.3, Fig. 4.7). In this way, the result is day-lit illuminated exhibition spaces. With regard to this, Architect Thomas Phifer mentioned that "contemporary glass is not harmed by the quantity of light" (Url 4.6) because when a great quantity of sunlight is distributed around a star-white coloured space, inter-reflections of light in space will occur and overall brightness will be perceived.

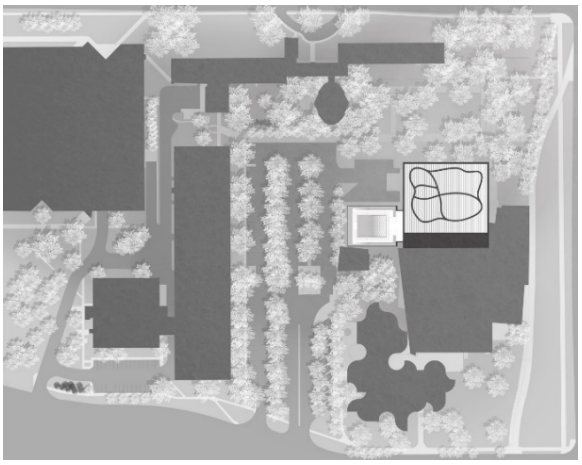


Figure 4.4: Site plan of the Contemporary Art and Design Wing designed by Thomas Phifer and Partners, 2015 (Url 4.10)

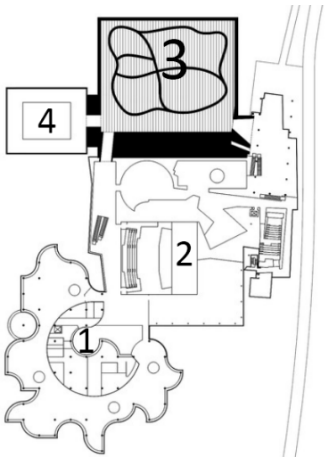


Figure 4.5: Plan of the Contemporary Art and Design Wing designed by Thomas Phifer and Partners, 2015(Url 4.10)

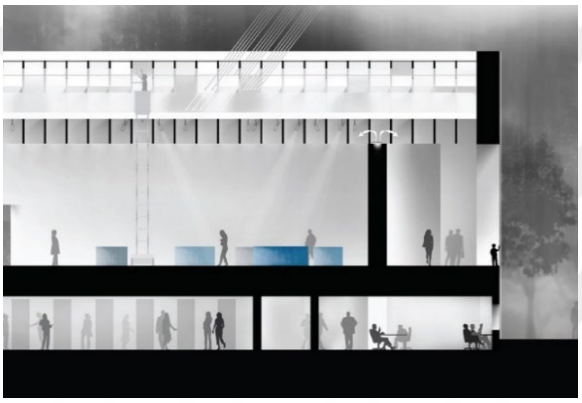


Figure 4.6: Section Plan of the Contemporary Art and Design Wing designed by Thomas Phifer and Partners, 2015 (Url 4.7)

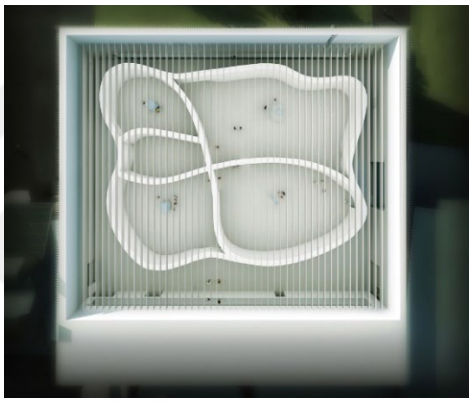


Figure 4.7: Overhead View Rendering of the Contemporary Art and Design Wing designed by Thomas Phifer and Partners, 2015 (Url 4.7)

4.2.2.1. The Contemporary Art and Design Wing of CMOG

- The Contemporary Art and Design Wing building itself is in actuality designed as a white cube with a square shape and appears as an evolution of the typical 'white-cube gallery' concept or even, as if it were the 'contemporary white cube of the Glass Age.' The interior elements, such as floors, ceilings, walls, display cases, are all painted stark-white (see Figures 4.3, 4.7 and 4.8). By doing so, the interaction of colours is prevented in between exhibits and its surrounding surfaces and thus, the galleries can present glass works of art with similar properties and their intrinsic colours as they are in reality (see Fig. 4.9).[70]

[70] Moreover, lighting with diffuse, white light sources helps the perception of glass works of art in relation to their intrinsic colours in addition to their original forms and textures.

Figure 4.8: Interior View of an Installation in the Contemporary Glass Gallery

(Url 4.8)

Figure 4.9: Detailed View of an Installation in the Contemporary Glass Gallery

(Url 4.9)

- The building represents the 'Natural Evolution of the Glass Architecture in the Glass Age' and features reflective aspects of glass such as space-art installation.
- Architect Thomas Phifer defined the building as a vitrine. (Url 4.1) In fact, during the day, the glass façade mirrors reflections of its surroundings. By doing so, the other three buildings of the museum are also presented on the exterior façade. During the night, the glass façade becomes transparent not unlike a grand display case (see Fig. 4.3).
- The façade of the Contemporary Art and Design building is made of aluminium with perpendicular blades of ultra-thin specialty glass; however, the building is covered with large, white glass panels to create a nearly seamless, softly reflective expanse (see Fig. 4.10). Under the glass panels, there is a layer of slotted, pale silicone to make the glass opaque in order to create a more reflective surface (see Fig. 4.11). By looking at the intelligently designed façade details, which were constructed using innovative materials of architectural technology (Url 4.10),[71] it can be inferred that the building is the paradigm of 'Glass Architecture of this century – a Glass Age.'

[71] The facade is made of glass, silicone gaskets, insulation, spacers, aluminium framing, structural silicone, stainless steel bolts, aluminium U channels, PVC shim insulation, cold formed metal framing, membrane waterproofing, exterior substrate and thermally broken fastener most of which are innovative construction materials of present architectural technology.

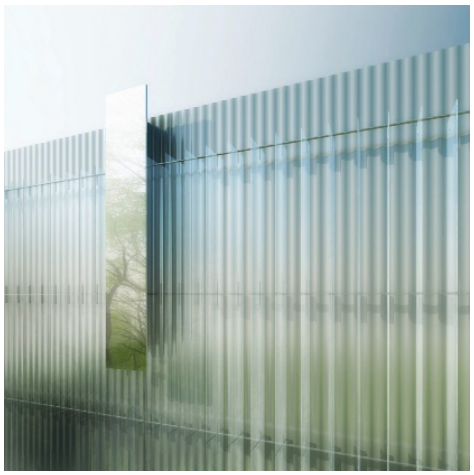


Figure 4.10: Construction of the Glass Façade of the Contemporary Art and Design Wing

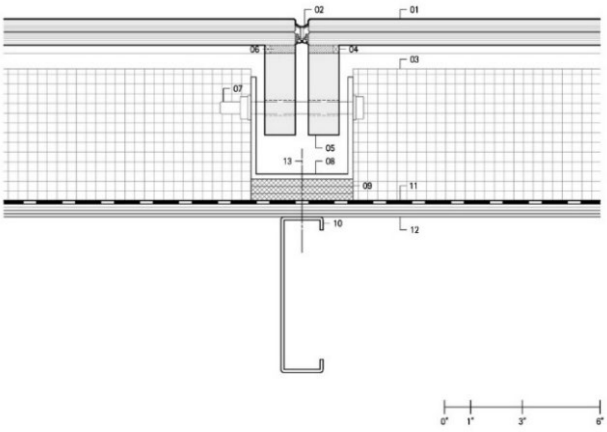


Figure 4.11: Opaque Wall Detail of Façade of the North Wing designed by Thomas Phifer and Partners, 2015 (Url 4.10)

- The Contemporary Art and Design Wing is an energy smart, green building (awarded with LEED Silver Certification). It provides an ideal environment in terms of temperature, air quality and lighting. Both the windows and the skylights are made of insulated double-glazed glass units coated with high performance low-E (low emissivity) coatings and UV filtering. As a result, heat gains during the summer and winter are controlled in the space and displayed works of art are protected from UV radiation.
- The Contemporary Art and Design Wing has the world's largest exhibition space of contemporary glass art with its 2415 m^2 usage area consisting of five galleries for temporary and permanent contemporary glass art exhibitions, as well as designs in glass (see Fig. 4.7 and Item 3 in Fig. 4.5). Around the galleries, a corridor (the porch) is designed with monumental, continuous, glass windows allowing visitors a view of the surrounding landscape and appearing as if inside a light box (Fig. 4.7, Fig. 4.14).

Figure 4.12: Contemporary Glass Gallery of CMOG with Daylighting

(Url 4.11)

Figure 4.13: Exhibition Space of the Contemporary Glass Gallery of CMOG with curved walls and display cases made with gorilla glass enclosures

(Url 4.12)

Figure 4.14: Rendering of the Corridor of Contemporary Art and Design Wing

(Url 4.11)

- The Contemporary Art and Design Wing also has dynamic spaces for live glass design sessions and glass blowing demonstrations. It has a gallery-level balcony around the perimeter of the venue that offers a 360-degree view of the glassmaking below. The entrance space of the contemporary gallery has retractable banked seating to accommodate 500 people (see Fig. 4.6). For this reason, the building as a whole focuses on multi-sensory perception and allows visitors an 'overall experience of glass' through exhibitions, demonstrations and workshops.
- The contemporary glass galleries are designed as 'fluid pavilions' (see Figures 4.7, 4.12 and 4.13)(Url 4.12) that are linked to each other with counterpart openings[72] on the curved walls and there are no columns placed inside it which may distract the vision of the whole exhibition.[73] The galleries appear as a simple, soaring, spacious, clear space' of an organic form through visual and spatial perception. In the design, the architects were inspired by an image of 'walking into a white cloud' giving the feeling of a 'continuous white void.' Its massive, curvilinear plaster walls are quite simple and vast (in the manner in which they stretch out and, in their height). Thus, the interior elements together provide a sense of continuity and flow in perception. According to Thomas Phifer, "the separation between the space, art, atmosphere and light are decomposed in this way." Although all these have simplicity and continuity, a texture contrast is created in space in between the glossy (glass) and matte surfaces (walls, floors, etc.). Thus, glass made objects (works of art, installations and display enclosures) are highlighted in the space (Url 4.1; Url 4.6).
- The Contemporary Gallery Building is designed as a vitrine in and of itself. The display cases are also specially designed in varied sizes with an innovative approach by using

[72] The openings are similar to each other in terms of size, shape and colour and are positioned in space in a linear order. Thus, they work together as a whole for the completion of the perception of the 'fluid form.'

[73] The vision of the 'whole exhibition' here refers to both the perception of the overall space with exhibited works of art and the perception of each glass work of art.

super-clear 'gorilla glass panels'[74] and white wood with the aim of protecting exhibits from damage while allowing visitors to view and experience exhibited glass works of art without interfering with them (see Figures 4.12, 4.13 and 4.15).

Figure 4.15: Display Units without Gorilla Glass Enclosures

(Url 4.13)

Figure 4.16: Glass Installations Mounted on the Ceiling

which is not seen in traditional most museums

(Url 4.9)

Figure 4.17: Display Units with Gorilla Glass Enclosures Placed in Niches

located in Corridors

(Url 4.9)

- In contemporary glass galleries, display units and glass art installations are placed in space partly dependent on traditional spatial design concepts,[75] which allows free circulation in the space (see Figures 4.12, 4.13, and 4.15). Instead of traditional wall-mounted displays, the works of art are displayed largely independent from the walls, and some of the glass installations are even mounted on the ceilings to provide 360-degree views (see Fig. 4.16). The display cases are positioned on the floor with sufficient distance between each other and they are not to positioned face-to-face in such a manner that they cannot interact with each other (see Figures 4.13 and 4.15) (Url 4.8). However, only in the corridor are a few of the display units are placed in the niches, which does not allow glass works of art to interact with each other while being diffusely lighted from above[76] (see Fig. 4.17).
- The contemporary galleries are designed with a sophisticated lighting system (Url 4.14); the majority of the light is provided diffusely as a key light by daylighting on exhibits and an artificial track lighting system is used as a 'fill light' additionally (Figures 4.18 and 4.19). In addition, white light (artificially supported daylight together with white surfaces) makes the exhibition spaces a luminous, light-filled

[74] The innovative product 'gorilla glass' is a thin, damage-resistant, optically pure glass produced by Corning Incorporated and used as screens in technological devices such as tablets, cell phones, notebooks, etc. and as a 'medium of technology.' Gorilla glass panels are extremely durable, two sheets of crystal-clear panels made from gorilla glass. In production, the sheets of crystal-clear panels are laminated with a material stiffening the bond between them and used in wall panels of elevators, lobbies, etc. as a 'medium of architecture. It is the first time it has been used in the Exhibition Space of the Contemporary Gallery of the Corning Museum of Glass through the 'application in display cases.' It has never been used in any museum in this way before. In contrast, tempered glass enclosures are widely used for display both in other galleries of the Corning Museum of Glass and in most other museums. However, tempered glass casts a greenish tinge to artworks and a distortion can be seen in some parts of the glass from where it was tempered or slumped.

[75] See Appendix I: Glossary and Appendix V

[76] The diffuse lighting is provided by lighting behind opaque glass surfaces as used in the design of most traditional showcases.

space due to the increased number of inter-reflections on the white surfaces. Creating a light-filled exhibition space is quite different from most other museums' methods, which restricts light in order to protect exhibits. This was realised thanks to glass being insensitive to light damage. As a result, kaleidoscopes of colours of displayed glass artwork can be created as shadows on surroundings if desired. This effect is more obviously seen on the glossy and white bases of display units that are juxtaposed with glass artworks (Fig. 4.20).

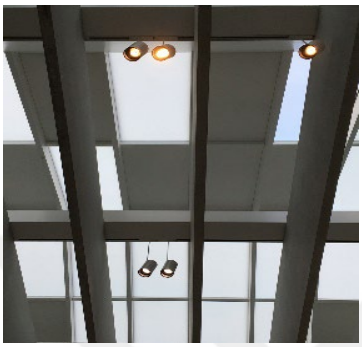


Figure 4.18: On the Top, Halogen Lighting is Used; On the Bottom, LED Lighting is Used.

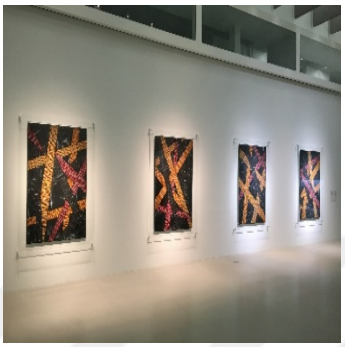


Figure 4.19: Lighting for 'The Portland Panels' of Klaus Moje

fused and diamond polished glass; on the left, halogen lighting is used, and on the right, LED lighting is used.

Figure 4.20: Coloured Patterns as Shadows on the Glossy, White Surfaces

(Url 4.15)

- To provide key light on the displays, the ceiling of the building was constructed with concrete beams located on the top of the exhibition spaces in the overall ceiling. It features skylights with its more than 900 skylight openings, which helps diffuse lighting (Figures 4.7 and 4.8); however, the daylight actually has a dynamic character. With regard to the dynamic effects of daylighting, Tina Oldknow, the Museum's curator for modern glass, explains that:

  > *"This is the first large-scale presentation of contemporary glass that takes advantage of natural light. The new daylighting system represents a dramatic change in how contemporary works in glass are viewed, and the Museum's monumental sculptures will have an exhibition space appropriate to their size."*
  > (Url 4.16; Url 4.17)

- To provide fill-light to the displays, high efficiency fluorescent lighting is used that is programmed to provide complementing daylight[77] and spotlighting of the exhibited glass works and the lighting is adjusted according to any changes in natural light levels. As a result, the more controlled brightness that is provided in the space, the

[77] Daylight is provided by the natural light source – the sun – which distributes white light which allows perception of exhibits with their intrinsic colours, thereby presenting them in the most accurate manner.

occurrence of glare on the exhibits and heat gain in the space are prevented as much as possible while dealing with the energy consumption. Through horizontal illumination (diffuse light), exhibits are put into silhouette, which limits the appearance of the form of the work. However, artificial (direct light) from above appreciates the 'material glass.' Architect Thomas Phifer clarifies why they opted to create a light-filled space, thus: "The more lighting, the more revealing the form, depth and reachness of the glass." (Url 4.1; Url 4.6; Url 4.14; Url 4.16; Url 4.17; Url 4.18; Url 4.19; Url 4.20; Url 4.21; Url 4.22; Url 4.23; Url 4.24)

4.2.3. Summary

The Corning Museum of Glass is a unique museum. It is a house of art for the design and technology of glass. It uses the 'white box' concept for a glass museum of the Glass Age. It is the world's leading glass museum which organised the first glass art exhibition in history, namely Glass 1959, and it is the first museum to be promoting this century as the 'Glass Age.'

The Contemporary Art and Design Wing of the museum has the world's largest exhibition space of contemporary glass art. It was designed as an actual white cube in the Glass Age. Based on the conceptual, technical and spatial assessment of the architecture of the building and exhibition design within it, the following results can be inferred:

- **As a 'whole,'** the Contemporary Art and Design Wing reflects a naturally evolved white cube concept as an indication of the Glass Age that can be used as a display screen through its façade. Additionally, it can, as a void, be used to exhibit contemporary glass artworks.
- **Solely in terms of the architecture of the Contemporary Art and Design Wing,** it reflects a new interpretation of glass architecture in glass museums in the Glass Age through the effects of the current technology of architecture (established in 2015).
- **In terms of exhibition design in the scope of the 'white cube' concept,** the following statements can be inferred from the assessment of contemporary glass galleries:

  - They reflect the natural evolution of the white cube concept in the Glass Age;
  - They feature as a luminous, bright, light-filled environment and are characterised with diffuse lighting on the displays with white coloured surroundings. Due to glass being insensitive to light damage, a light-filled space is specially designed to exhibit contemporary glass art in contrast with most other museums. Moreover, displayed works of art are diffusely lit mostly with daylight and supported with artificial light in order to display exhibits with similar properties in terms of form, colour and texture to have them be perceived properly through visual and spatial perception;

- Due to white reflecting every intrinsic colour of the displayed exhibits in the most proper manner, they cannot interact with the colour of the exhibits. Therefore, the space is designed with a 'stark white as a whole.' Interior elements (ceilings, floors, walls, display units), as well as the colour of the light source (white), are preferred to complete the overall atmosphere in the space under following the 'white cube' concept;
- The interplay of light, colour and glass appears in the displayed exhibits; however, this interplay may also be created in the surroundings with the help of lighting that can be set as shadows if desired;
- This white cube approach is more suitable for exhibiting coloured glass work, particularly for opaque, reflective glasses, and violet glass work as violet is the darkest colour in terms of value. In addition to violet, yellowish hues are not suitable for colourless, transparent glass works as the latter is the lighter colour in terms of value and should be displayed in front of a black velvet background to create a colour contrast in the visual field;
- The 'white cube' concept emphasises exhibited works in space by simplifying and whitening space.

4.3. Shanghai Museum of Glass (G+ Glass Theme Park)

The Shanghai Museum of Glass (SHMOG) is described as the first glass museum in China and also one of the first museums in China based on an interactive, modern exhibition concept. It was established in a renovated glass-making factory as an adopted reused building[78] in the Boashan district in Shanghai and opened in 2011. Similarly, the Corning Museum of Glass is also a private, glass-manufacture based glass museum. The Shanghai museum was initiated and sponsored by the Shanghai Glass Company Ltd., which played a role in the industrial development of glass in Shanghai's history. For this reason, the exhibitions in the museum can be thought of as a reflection of the contemporary glass art of China in the Glass Age as well as its exhibition design concept (Url 4.25; Url 4.26).

As a whole, the Shanghai Museum of Glass is unique museum. It is the central part of the so-called G+ Glass Theme Park (G+ Park), which is a glass, art, research and technology park that has developed from the initial museum buildings. Due to its multi-functional design and being classified as a type 2 museum, it offers a modern, interactive experience of contemporary glass art, in addition to various other facilities. It includes a 'black box' building and a 'white box' building that are linked with each other with an iridescent glass bridge. There

[78] See Appendix I: Glossary

is also the Kids' Museum of Glass and a comprehensive Glass Park (Url 4.27; Url 4.28; Url 4.29; Url 4.30).

In terms of architecture, the main building of the museum is a true 'black box building' in and of itself because of its artistic structure, unique design and innovative characteristics. It is at the same time the best example of a world glass museum in the scope of the 'black box' concept in exhibition design. In addition, it is one of the most unique and impressive institutions in Shanghai and it reflects the cultural scene of the city as a type of juxtaposing space between the past and present (Url 4.26; Url 4.31). In the scope of the thesis, the main building of the Shanghai Museum of Glass has been selected for the conceptual, technical and spatial assessment of exhibition spaces in the scope of the 'black box' concept and architecture of the building.

4.3.1. Regional and Conceptual Context

In a regional context, the Shanghai Museum of Glass was established in a former glass manufacturing and processing site in Chang Jiang Xi Lu, the northern district of Baoshan, Shanghai, China (Url 4.26; Url 4.31). In the region, glass is a nearly ubiquitous material and commonly used for applications in both art and industry (Url 4.32). This site covers a total area of 40,300 m^2, has a long glass manufacturing history and might be mentioned 'just as a glass-manufacturing site.' It consists of thirty industrial buildings that vary in condition, age and scale. From the industrial age to today, some of these buildings are still partly or completely functioning and most of them are still being used by glass related industries (Url 4.31). On the other hand, the city of Shanghai has been undergoing a massive transformation into the post-industrial era over the past 60 years. In the course of this transformation of the city, the old industrial buildings have begun to be transformed into new spaces around all of Shanghai. In order to honour the glass manufacturing history of this region both in craft and in industry by the founder glass company, the Shanghai Glass Co. desired to build a glass museum in the region (Url 4.26; Url 4.31; Url 4.32).

However, the site is located in an inconvenient and less known region far from the downtown area, so it is difficult to reach it with public transportation. Due to its being an industrial site, it was also an unattractive region. With the aim of upgrading this industrial site, a large strategic plan was presented by Logon Architecture to develop the site as a Glass Art, Research and Technology Park (G+ Glass Theme Park) and aimed to finished it phase to phase in 20 years (see Item 3 in Fig. 4.21) (Url 4.31). The first phase comprised the establishment of the Shanghai Museum of Glass and a space for hot glass demonstrations in a 5,785 m^2 total site area. Thus, the museum was established first in two old glass industry buildings as a kick start project in 2011. Due to the steadily growing series of artworks belonging to the gallery

and the requirement for additional display pieces from the permanent collection, another old building was brought into life as a New Design Wing in 2016. The new wing is coloured in white in contrast to the black main building of SHMOG and it connects to the main building via an iridescent glass bridge. However, the New Design Wing is not examined in this thesis (Url 4.33).

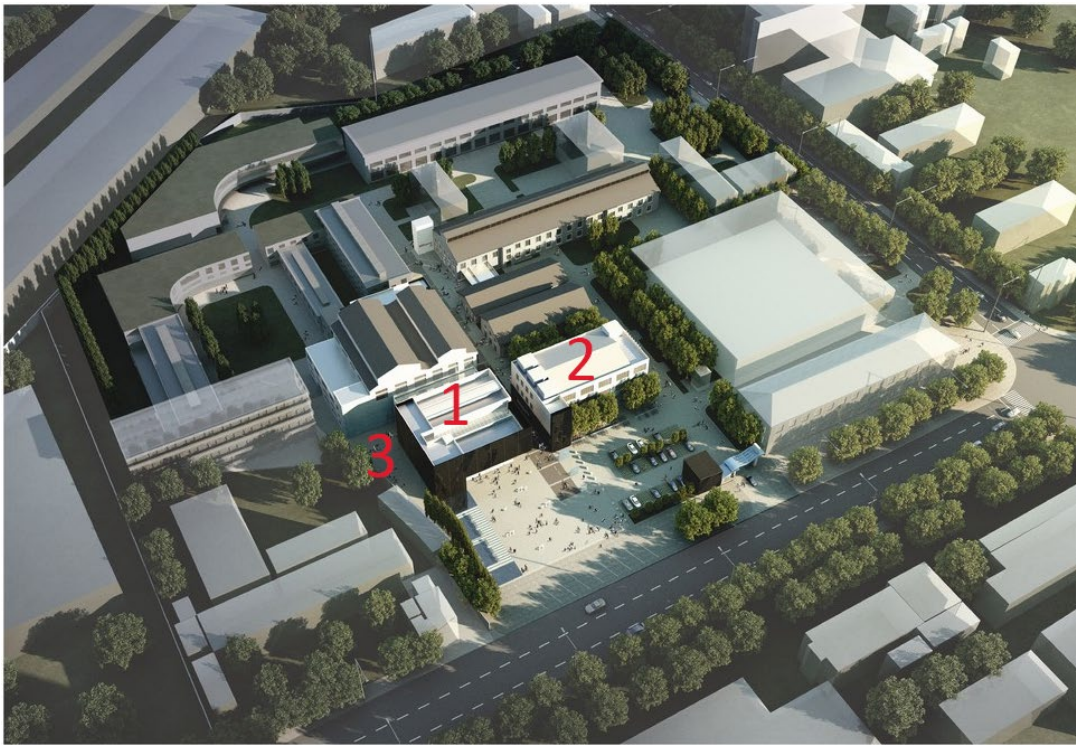


Figure 4.21: Aerial View of the Shanghai Museum of Glass and Glass Park

located in Boashan, Shanghai, China. 1. Main Building of SHMOG; 2. New Design Wing of SHMOG; 3. Glass Park of SHMOG (photograph from Google Earth)

As a concept, the Shanghai Museum of Glass has been constructed to create a brand awareness of the site and its surrounding land and to add value to the Baoshan district (see Item 1 in Fig. 4.21). A sculpture yard for phase two, a science park for phase three and a business park for phase four was planned and finished in 2018 and 2019. Today, the museum is spread over two new building sections in addition to the two existing buildings of the original museum (see Item 2 in Fig. 4.21) and includes 20 thematic halls in its permanent and temporary galleries, a Kids' Museum of Glass, other glass-inspired spaces of art in indoors and outdoors, workshop and hot glass demonstration areas for children and adult visitors and for artists, as well as cafés, offices and supporting facilities (Url 4.25; Url 4.31; Url 4.34; Url 4.35; Url 4.36; Url 4.37).

The overall concept of today's comprehensive Shanghai Museum of Glass is based on an interactive experience of glass art through contemporary exhibitions, hot glass demonstrations, workshops, interactive displays, site-specific glass art installations, etc. It is a space for artistic

creation, a place where ordinary glass is rendered in a creative manner with extraordinary imaginations and a place in which both the vision and true value of unlimited, endless possibilities of material glass are shared. In accordance with this concept, the museum is supported artistically and academically by Shanghai University, which steadily follows the current situation of glass art and exhibition design. As a result, a creative, unique, interactive, technology based exhibition space of contemporary glass art in a renovated, iconic, technology-based building of the Shanghai Museum of Glass has evolved (Url 4.28; Url 4.37).

In the scope of the thesis, only the main building of the museum has been selected for conceptual, technical and spatial assessment of the exhibition design where exhibits, especially contemporary glass installations, are exhibited in a 'black box' concept and focussing mostly on visual and spatial perception.

4.3.2. Architecture and Exhibition Design

The Shanghai Museum of Glass was created as a constantly evolving influential cultural institute by Zhang Lin, CEO of the Shanghai Glass Co. and president of the Shanghai Museum of Glass, and by Tilman Thürmer, founder of the responsible architecture firm Coordination Asia (Url 4.38). The original Shanghai Museum of Glass was established in two existing buildings of the Shanghai Glassware Factory (a factory building and a warehouse) in 2011 and it included a hot glass demonstration space in a 3,500 m^2 site (see Items 1 and 2 in Figures 4.23, 4.24 and 4.25). These original museum buildings have therefore at the same time been the first foundation of a strategic site-development plan and the central building of the Glass Art, Research and Technology Park (G+ Glass Theme Park) that was completed in 2019 and expanded in a 40,300 m^2 space (Url 4.34; Url 4.35; Url 4.36).

The Shanghai Museum of Glass is a unique museum and the first of its kind in China. It is classified as a type 2 museum due to its multi-functional design.[79] In the museum, functionality was handled in relation to phase 1 of the G+ Glass Theme Park development plan. The original buildings of the Shanghai Museum of Glass were developed as a multi-functional, type 2 museum[80] with contemporary approaches. Since type 2 museums are required to have more spaces, such as exhibition halls, workshop and hot glass demonstration areas, libraries, restaurants, coffee shops, etc., the two new existing buildings were added to the existing two buildings to enhance usability. The 'glass void' and the additional building were wrapped around one of the existing buildings in order to accommodate the required new

[79] The main building of the museum has received several awards: The Urban Regeneration Award from MIPIM Asia Awards 2011, the Platinum Award from China's Most Successful Design Awards 2011, the Certificate of Excellence from Perspective Award 2011 Hong Kong and the Annual Public Space Award from the 9th Modern Decoration International Media Award.

[80] See Appendix I: Glossary

functions (see Item 3 and 4 in Figures 4.23, 4.24 and 4.25). Today, the four integrated buildings serve as the main museum building of SHMOG and the central building of the G+ Glass Theme Park in its 5,785 m^2 site (see Items 1, 2, 3, and 4 in Figures 4.23, 4.24, and 4.25). This expanded version of the main museum building is characterised with an actual black appearance in terms of its façade design and design of the exhibition galleries.

In the thesis, the main building of the Shanghai Museum of Glass is selected in the scope of the 'black box' concept, hence, its conceptual, technical and spatial assessment will be realised in terms of architecture and exhibition design (see Items 1, 2, 3 and 4 in Figures 4.23, 4.24 and 4.25).

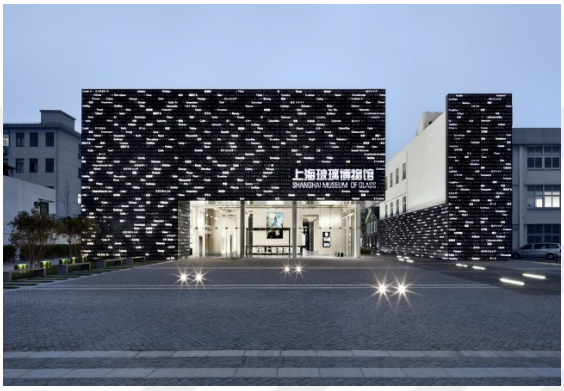


Figure 4.22: Exterior View of the SHMOG Main Building
Boashan, China, 2011 (Url 4.31)

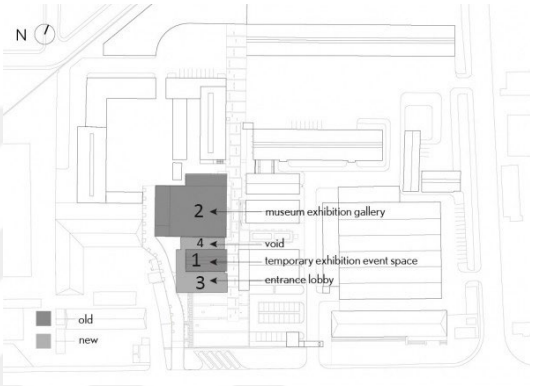


Figure 4.23: Site Plan of the SHMOG
Boashan, China, 2011 (Url 4.31)

Figure 4.24: First and Second Plan of the SHMOG
Boashan, China, 2011 (Url 4.31)

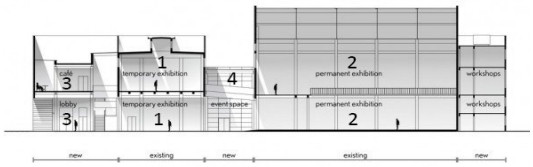


Figure 4.25: Section Plan of the SHMOG
Boashan, China, 2011 (Url 4.31)

The main building was designed by architecture firm Logon Architecture[81] in collaboration with the Shanghai-based architecture firm Coordination Asia in 2011. Its architectural design

[81] A German-Chinese design firm offering contemporary and innovative urban, architecture and interior solutions

is closely related to its regional condition and the site's overall conceptual plan was to create the G+ Glass Theme Park. Due to its regional condition and the cultural gap of glass museums in China, it became necessary for the museum to be more attractive and more functional rather than being solely an exhibition-based museum so that visitors would desire to come. Attractiveness was the first aim because the selected two buildings were located in a hidden deep part of the industrial site and surrounded by warehouses. For these reasons, a unique glass façade was designed at first in order to make the museum more recognisable and to turn it into a landmark (Fig. 4.22) (Url 4.38).

4.3.2.1. The Main Building of SHMOG

- The main building of the SHMOG itself is designed as a black box and houses exhibition spaces designed following the black box concept (see Figures 4.22 and 4.26). Tilman Thürmer, CEO of Coordination Asia and designer of the exhibition spaces, describes the concept thus: "The general design concept was to respect the existing building which was a glass workshop before and put a crystalline, black, deep reflecting exhibition body in the space" (Url 4.39). In fact, SHMOG is the only glass museum handling the black box concept in the Glass Age such that nearly all the surfaces are coated with black lacquered glass (floors, walls, display cases, etc.). Thus, a texture contrast is created in the space in between glossy glass walls, glass works of art and installations and the matte wall, floor and ceiling surfaces. As a true 'black box,' the main building might be considered spatialisation of digital media museums in glass museums in the Glass Age or basically the physical transformation of digital media museums into Glass Museums.[82]

[82] The SHMOG 'black box' concept is distinct from the 'black box' concept of other glass museums owing to the integration of technology into both the design of the displayed artworks and in the design of the building because the 'black box' concept first entered digital media museums as a concept under the effects of the Digital Age related to computers. This means that it is directly related to the technology of the age and it is a reflection of colours via light through mostly glass surfaces. This development followed the penetration of the 'black box' concept in art museums and glass museums. The indispensable interplay of light, colour and glass brings more importance to this special situation. Thus, technology integrated into contemporary glass artworks in addition to technology integrated into site-specific glass installations have found the most appropriate concept for themselves, namely the 'black box' concept.

Figure 4.26: Main Hall of the SHMOG Main Building

(Url 4.34)

Figure 4.27: Construction View of the Main Building during Transformation of the Glass-Making Factory into SHMOG

(Url 4.37)

- The main building was designed as an adaptive reuse building[83] in the context of an urban regeneration project (see Fig. 4.27). For this reason, it features an innovative and sustainable design. The main building was established in two existing buildings (a former glass bottle factory and a warehouse) covering a total area of 3,500 m^2. The two buildings are linked to each other by a glass corridor that is used as an events venue (Item 4 in Figures 4.23, 4.24 and 4.25) and they have two floors that can be accessed by a two-floor steel structure. The two existing buildings are directly integrated with two additional new buildings, namely the 'glass void' and a building section that is wrapped around one of the existing buildings.

The 'glass void' is designed as a clearly visible, representative and daylight-lit entrance lobby. It is located at the entrance of the building under the black exterior façade (Fig. 4.22). (The glass void is indicated as Item 3 in Figures 4.23, 4.24 and 4.25). It is open-space in character and in terms of function, the glass void provides information about the building (a glass museum), enables easy recognition for visitors, and serves as an entrance to the museum site and as a welcoming platform of the museum. Thus, it guides visitors into the museum to places such as the hot glass shows and the glass park. It also provides additional space for temporary exhibitions or events or spaces for gathering visitor groups and it provides visitors a convenient routing through the exhibition halls, hot glass place as well as the entire site. Thus, it acts as a 'service belt' for the museum.

The *wrapped building* is constructed around the former glass factory in order to accommodate newly needed technical functions, such as a lobby, restrooms, etc. (see Item 3 in Figures 4.23, 4.24 and 4.25). Therefore, it also acts as a 'service belt' for the museum.

[83] See Appendix I: Glossary

- The architectural design reveals the original details of two existing buildings, which were made of concrete and stone even if they had been redesigned with up-to-date building technologies (Fig. 4.27). However, it simultaneously presents a glass museum in a new, modern, symbolic form making use of mostly material glass taking a contemporary approach (see Figures 4.22 and 4.26). In fact, the building is a display of both the historical glass-making factory and contemporary glass art. With all these elements, the architecture of the building itself assumes the role of a 'juxtaposing past and present' and the exhibition spaces assume the role of presenting the transformation from an industrial legacy to a cultural destination of contemporary glass art (Url 4.27; Url 4.28; Url 4.31; Url 4.37).
- The architecture and exhibition design of the building appear as a 'Technological Evolution of Glass Architecture in the Glass Age' and represent a technological design language in a 'museum with plastic quality' in the design of both the outdoor and interior spaces (Figures 4.22 and 4.26). By doing so, it reflects the integrated approach that blends current technology in glass, glass art and design in glass via glass-made installations and exhibited glass artwork and its glass façade. In design, it benefits from the physical, spiritual and metaphorical aspects of glass. The museum does this in the most obvious manner in comparison with other glass museums.
- The main building acts as the museum image of the G+ Glass Theme Park and as a cultural beacon for Shanghai. Thanks to its innovative glass façade and glass void located at the entrance (see Fig. 4.22), the building stands as an icon or a landmark in the Baoshan District. It appears as a so-called 'temple of translucence' and thus, it distinguishes itself from the neighbouring industrial site.
- The building itself can be thought of as a display screen thanks to its specially designed glass façade. The illuminated multi-language glass related words are presented to visitors on the façade of the main building appearing as if it were a verbal communication screen (Fig. 4.22) (Url 4.31). The innovative façade is uniquely designed with U-shaped channel glass panels with the most standard and commonly used glass materials all over the world. In order to achieve the desired effect, these glass panels, imported from Germany, are treated in a unique way in Shanghai and turns them into an outstanding façade element. This process was performed by the owner of the building itself in Shanghai, who had relevant experience on glass treatment. After several artistic steps, the facade comprised over 500 individual façade panels. The following steps were performed in the process: cleaning and preparation of every glass panel to remove all remains from the surfaces of the material; coating of the inner side of the channel glass surfaces with black enamel; hardening of the coating in a kiln at 400°C for 120 minutes in order to for the coating to be permanent;

selection of languages (10 different languages) for glass-related keywords and application of the surface as plastic foil; sandblasting characters to reduce transparency; a sandblasting technique to remove the characters from the enamel by taking off the foil so that transparency remains in these areas for later LED backlighting with the other parts having transparency reduced; selected keywords being equipped with LED backlights in order to create stunning light effects during the day and night resulting in a truly unique visual effect. Thus, the new Shanghai Museum of Glass has become a landmark for Shanghai and China by means of a truly unique interpretation of glass (Url 4.26; Url 4.28; Url 4.31; Url 4.32; Url 4.37; Url 4.39; Url 4.40; Url 4.41).

- The interior spaces are designed as highly artistic and interactive spaces that house temporary and permanent exhibitions, site-specific installations and glass in design. However, there are also hot glass demonstrations, lectures, seminars, workshops, etc. The overall exhibition concept therefore aims to provide a living experience of glass art and design through multi-sensory perception. For this reason, contemporary glass art is presented in a variety of display methods both in virtual and real displays, such as interactive, responsive and participatory exhibitions on displays, object-centred and thematic glass work. Generally, the displayed glass work focuses on visual and spatial perception. However, a few site-specific installations made with glass focus also on auditory and haptic perception, such as the interactive media installation titled 'Fusion'[84] (Figures 4.28 and 4.29) and the Kaleidoscopic Glass Tunnel (Fig. 4.30) (Url 4.26; Url 4.28; Url 4.31; Url 4.32; Url 4.37; Url 4.39; Url 4.40; Url 4.41).

[84] Displaying an interactive media installation; the media installation 'Fusion' was created in collaboration with media artist Tobias Gremmler, who explores movements in computer art and touches upon the equal importance of interdisciplinary approaches in exhibition design (glass artists, multi-media artists, space designers, light artists, etc.). The interdisciplinary approach seems to be the approach of 21st century in academic fields on curating.

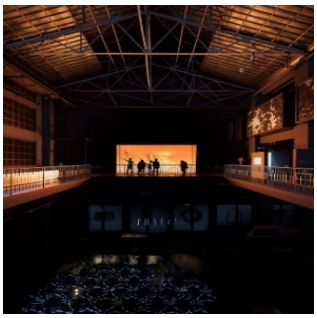


Figure 4.28: 'Fusion,' an Interactive Media Installation Presented on a Digital Display

located on the 2nd floor at the centre of the Main Building (Url 4.34)

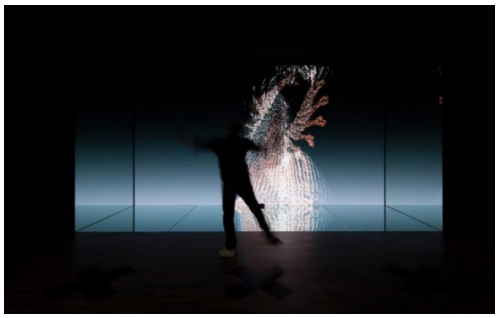


Figure 4.29: Interaction of a Visitor with the Multi-Media Installation 'Fusion'

Made using glass technology, a responsive exhibition displayed inside the glass walls through smart technology. It is sensitive to movements of visitors and translates movements into dynamic visualisations of elements and materials (Url 4.34).

Figure 4.30: Kaleidoscopic Entrance of the Main Building

a dynamic display located at the entrance of the building with a set of five screens that presents the movements of visitors as slow-motion footage (Url 4.42)

- The exhibition space features as an open-space with high ceilings with a U-shaped second floor (Figures 4.26 and 4.31). Based on the 'black box' concept, it appears as a dim, dark environment that gives the feeling of limitlessness and curiosity. In this manner, all the colours in the space are emphasised equally, which comes from the exhibited glass work and installations made from glass. Accordingly, the interplay of light, colour and glass materials is widely presented in dark interiors. In order to create colour contrasts between the black space and the exhibits, most of the site-specific installations are illuminated with white light LED strips, such as those in the House of Glass (Figures 4.31 and 4.32). Even some structural details of the interior design are also illuminated with stark white light and rarely with yellow lights to highlight the glass in it, such as the glass base floor (Fig. 4.33). As a result, the exhibition design offers visitors a 'glitzy and multi-dimensional space' due to the reflection of numerous LED lights (Url 4.26; Url 4.28; Url 4.31; Url 4.32; Url 4.37; Url 4.39; Url 4.40; Url 4.41).

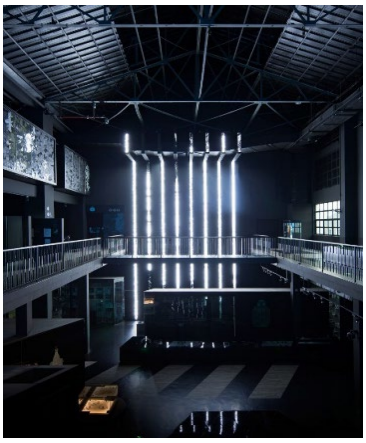


Figure 4.31: LED light Installation in the Centre of the Main Building

(Url 4.34)

Figure 4.32: Installation: the 'Glass House'

located in the Main Building of SHMOG

(Url 4.34)

Figure 4.33: Glass Base Floor at the First Floor of the Main Building

(Url 4.38)

- The lighting design in the exhibition space is provided by artificial light. A track lighting system is present there (Fig. 4.22); however, glass made installations and the digital display screen also act as an artificial light source in and of themselves (Figures 4.28, 4.31 and 4.32). The installations are illuminated with LED light lines (Figures 4.31 and 4.25) or white fluorescent lamps (Fig. 4.32 and 4.34). Some even comprise a neon glass installation (Fig. 4.36).

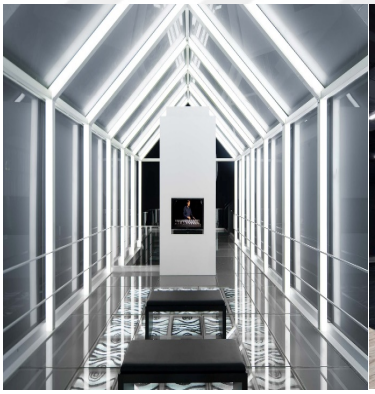


Figure 4.34: The 'Glass House' in the Main Building

(Url 4.34)

Figure 4.35: An Interior View of the Main Building

which can be used for seminars (Url 4.43)

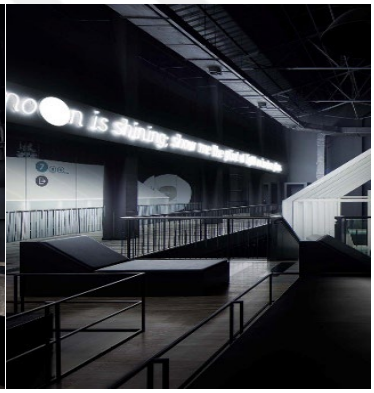


Figure 4.36: The Neon Light Installation

hung on the wall in the Main Building (Url 4.44)

- The direction and position of the light depends on what is required. For example, wall mounted works of art or a group of glass items in open displays are illuminated mostly from above with a track lighting system (Fig. 4.37). However, some can be illuminated from below (Fig. 4.38). Works of art, such as stained glass works that are hung on the wall, are illuminated with diffuse back-lighting (Fig. 4.26). In some cases,

displayed works of art can be illuminated from the front with a few artificial light sources (Fig. 4.39). Inside the display cases, lighting is provided mostly with light strips wrapped around the edges inside the display cases.

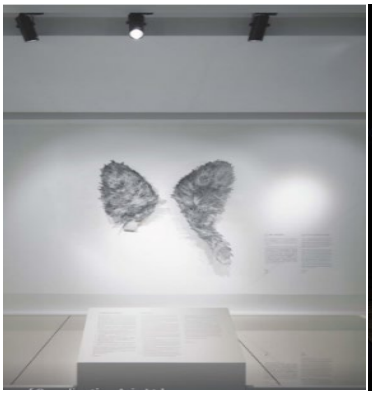


Figure 4.37: A Glass Work of Art is Hung on a Wall

illuminated with a few direct light sources from the upper side (Url 4.43)

Figure 4.38: Displayed Glass Works on the Table

(open-display) illuminated with a few direct light sources from above (Url 4.43)

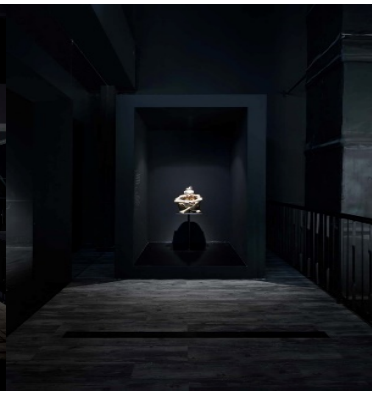


Figure 4.39: A Work of Art, Displayed Inside an Open-Display Unit

illuminated from the front (Url 4.45)

- In accordance with the 'black box' concept, both the digital displays and the display cases are positioned within the main hall in relation to the physical structure of the interiors independently from traditional spatial design concepts. The design of the display units change depending on need. They may be specially designed display cases or installations that can be displays in and of themselves or even a furniture such as a table might be used as if it were a display unit (Figures 4.34, 4.37 and 4.38).

4.3.3. Summary

The Shanghai Museum of Glass (G+ Glass Theme Park) is a unique museum and one of its kind in China. It can be referred to as a 'technology-based art and design centre' that integrates artistic glass, architectural glass and the technology of glass equally as a glass museum of the Glass Age. In fact, its uniqueness comes from its virtual and physical representation methods that are combined through site-specific installations based on a technological design language.

The main building of the Shanghai Museum of Glass is designed as a 'black box in the Glass Age.' Based on the conceptual, technical and spatial assessment of the architecture of the building and exhibition design within it, the following results can be inferred:

- **As a 'whole':** The main building of the SHMOG is the only glass museum that integrates virtual and real exhibitions harmoniously in the same place through the use of glass informed by the 'black box' concept. Although the 'black box' concept is also applied in some other glass museums, here exhibitions are handled selectively in the

same place, either for only hybrid glass work or for only exhibitions of media-installations. Due to the use of technology in glass in both the design of exhibited works of art and installations and in the architecture of the building itself, the Shanghai Museum of Glass represents the current situation of glass-art exhibitions in an exact, clear manner, which is the most important reason for its being selected for the assessment in the study of cases.

- **In terms of solely architecture of the 'Main Building,'** it reflects the technological evolution of Glass Architecture in Glass Museums in the Glass Age. It acts as a landmark and cultural icon in the Boashan District. Not unlike the 'Bilboa effect' of the Guggenheim Museum in Spain, the opening of the Shanghai Museum of Glass led to the development of the region and turned it into one of the most important tourist centres.
- **In terms of the exhibition design in the scope of the 'black box' concept,** the following statements can be inferred from the assessment of the Main Building of SHMOG:
  - It reflects the technology based black box concept in the Glass Museums in the Glass Age.
  - It features as a lit environment and is characterised by direct lighting on and in the displays and the black surroundings. The perception of a glass work might be affected by the lighting design, so a controlled illumination is provided in the space by means of artificial light sources and blocking daylight. As a result, any exhibited installations and works can be highlighted in space without any glare on them.
  - Since black absorbs all colours, the interior bottom parts of the display cases are coloured white in order to provide a better representation of the colours of any displayed work. Moreover, the walls and ceilings are coloured dark grey and the installations are illuminated with white light. By doing so, the discomfort of glare and bloom is avoided in the space, which can create a negative experience for visitors. However, only the installations are highlighted through strong colour contrast (white and black). This prevents the absorption of the colours on any displayed works and visitors can perceive their intrinsic colours.
  - In contrast to the 'white cube' concept, the interplay of light, colour and glass materials appears on displayed glass work only as visual images due to the controlled lighting design and colouration of the surrounding space.
  - It is more suitable for digital displays made in glass, technology-based kaleidoscopic installations, colourless glass works of art and glass work coloured with white and yellow. It is also suitable for presenting particularly opaque and translucent glass work.
  - Through exhibitions, glass is used mostly as a metaphoric medium.

- Taking the approach of using digital displays made with glass, the museum can show glass work and installations made in the same place at the same time as endless possibilities of glass in an exact manner. As for the use of glass in design, the Coordination Asia team argues that many designers often indicate that they had no idea of what the outcome of their work would be because glass is such an unpredictable material (Url 4.46).
- It emphasises exhibited works of arts in space by eliminating and blackening the space itself from the visual field as much as possible.

4.4. Swarovski Kristallwelten

The Swarovski Kristallwelten Museum (Swarovski Crystal Worlds) is a unique museum. It was established by the Swarovski Crystal Business, which is the world's leading cutting-glass manufacturer. In 1995, the museum was opened as a private museum similarly to the Corning Museum of Glass and the Shanghai Museum of Glass.

The Kristallwelten is also known as the Swarovski Museum of Glass; however, it is more similar to an entertainment and multi-dimensional experience centre of crystal glass.[85] In terms of exhibition design and the architecture of the building, it is defined as an innovative communication platform or the key to an imaginary world marked and developed with a unique appeal. The main building is a plastic work of art in and of itself in the form of a 'Giant,' which is comprised of permanent exhibition spaces each designed as a total work of art (Gesamtkunstwerk). In fact, each exhibition room has been designed holistically and is dedicated to representing crystal glass in a special concept of so-called 'Chambers of Wonder.' Accordingly, the Kristallwelten is comprised of seventeen individual Chambers of Wonder, conceptually and spatially separated from each other. In this regard, the Kristallwelten differs from the other two glass museums which house hybrid glass art exhibitions in permanent and temporary glass galleries. As a result, the museum, in its entirety, is a source of artistic inspiration for artists, architects and designers. It can be assumed that the Kristallwelten will lead future glass art museums and inspire them in a new direction in terms of its innovative approaches in design. For these reasons, the Kristallwelten is selected as the third museum for examination in the thesis.

In the thesis, the conceptual, technical and spatial assessment of the architecture of the building itself and some of the selected 'Chambers of Wonders' will be examined.

[85] See Appendix I: Glossary

4.4.1. Regional and Conceptual Context

The Swarovski Kristallwelten was established in the home region of its founder company Swarovski Crystal Business (see Fig. 4.40), near the Swarovski Crystal Business's permanent headquarters in Innsbruck, Wattens, high in the Austrian Alps. The regional conditions of the Wattens had played a role in site selection for Daniel Swarovski to establish a glass cutting manufactory in 1985. Daniel Swarovski is a Bohemian jeweller from Portland and the founder of the Swarovski Crystal Manufactory. Wattens seemed to him to be the ideal location for Swarovski's first cut-crystal production site because of the nearby rivers that provided advantages of local hydroelectricity for the energy intensive grinding process of crystals. In time, the company developed globally. Today, the Swarovski Crystal Group, with its sister companies, is the world's leading provider of precision-cut crystal for jewellery, accessories, fashion, lighting, architecture and interiors (Griffin, 2016, p. 50; Url 4.47; Weiermair et al., 2010, p. 27). While the company was growing, interest in Swarovski crystals also increased in tandem. Since 1895, people would often come from afar to see the home of the Swarovski Crystal company in Wattens, Tyrol. By the end of the 20th century, the company noticed that interest in crystals was greater than ever and decided to open a glass museum on the occasion of the 100th anniversary of the Swarovski Crystal Manufactory. Thus, the Kristallwelten was built in 1995 in the home region of Swarovski Crystal Group, in Wattens, Innsbruck (see Item 1 in Fig. 4.40) (Swarovski Kristallwelten, 2019, p. 3).

In terms of architecture and interior design, the Swarovski Crystal Group is globally known as a master of light and precision and produces varied crystal surfaces for interior and outdoor spaces such as crystalline tiles, etc., which maximises the expressive, emotional, and transformative power of crystal for different concepts in spaces (Langes-Swarovski, 2017; Swarovski Lighting Ltd, 2013; Url 4.48). The Swarovski Crystal Group's aim is to "infuse crystal into daily life" while regarding crystal as an inspirational medium in life. Its indicators are seen in the exhibition design of the Kristallwelten today, which are designed as a 'total work of art' by infusing crystal into to the overall design (Witschen, 2013, p. 98). By means of the establishment of the Swarovski Kristallwelten in 1995, the Swarovski Crystal Group appears to have found a space where it can present all these skills in an artistic manner in the scope of a glass art museum which is equipped with current technology. It is seen that all these innovative and successful design approaches in design of 'crystal glass' are artistically applied in both the design of the architecture of the building and in the design of the exhibition spaces as well as in the design of each exhibited glass works of art.

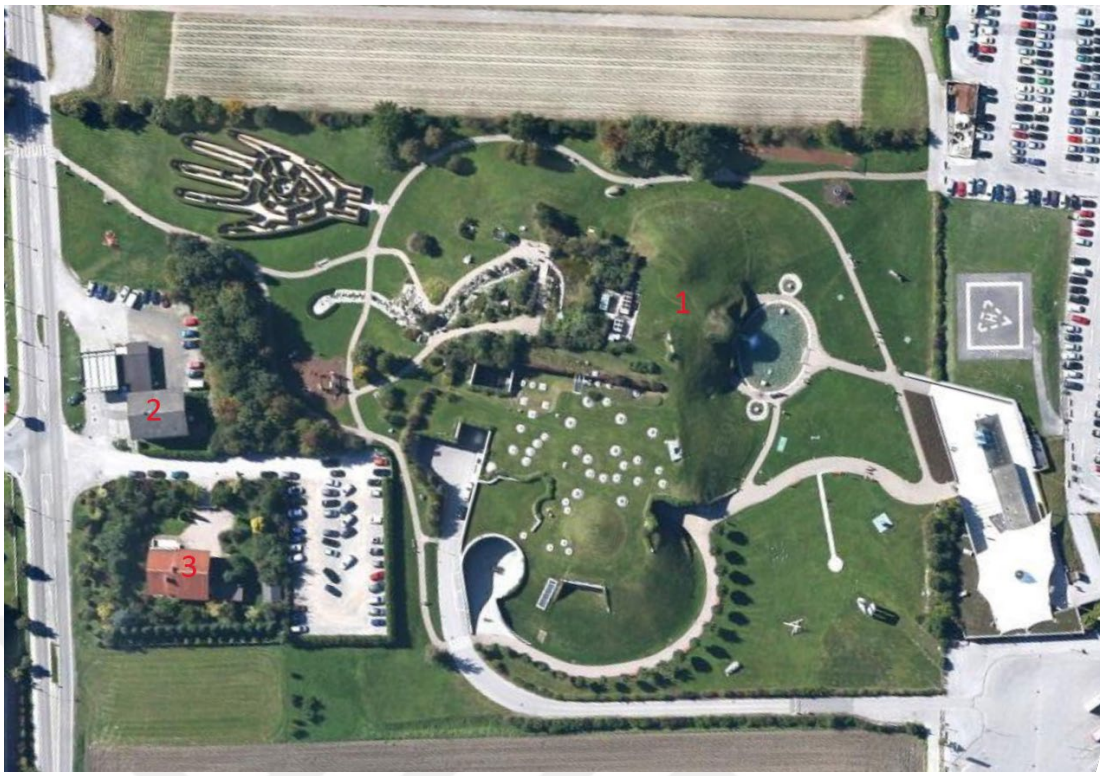


Figure 4.40: Aerial View of the Site Plan of the Swarovski Kristallwelten

1. The Giant (museum building)
2. Playground with a Juxtaposed Play Garden,
3. Daniel's Cafe and Restaurant (photograph from Google Earth)

As a whole concept, the Swarovski Kristallwelten can be defined as a combination of art, culture and entertainment. In the scope of a glass museum, it offers inside the Giant a forum, a store, a VIP lounge, the Crystal Bar, the Crystal Studio and an exclusive venue for events, concerts, and cultural occasions. Moreover, there are seventeen Chambers of Wonder and a glass garden with contemporary art installations (most of which are made with glass), an innovative playground with a juxtaposed play garden for family members of all ages (see Item 2 in Fig. 3.40) and a restaurant in which to relax with special beverages while facing the surrounding landscape (see Item 3 in Fig. 3.40). In addition to all these, it simultaneously serves as a vendor of manufactured crystal glass forms for the Swarovski Crystal Group(Swarovski Kristallwelten, 2019).

In a more detailed perspective, as a glass museum, it has become a centre of active communication. It interprets crystal in new contexts with different approaches and methods of representation and thus, it offers visitors a multi-sensorial experience of glass with the permanent exhibitions in the so-called 'Chambers of Wonder.'

4.4.2. Architecture and Exhibition Design

The Kristallwelten was constructed as a collaborative work of artists, designers and architects from beginning to end. The architecture of the building was designed by the renowned multi-media artist André Heller, who was commissioned by the Swarovski Crystal Business to establish a 'permanent symbol of crystal glass' in an experiential context. In the hands of an artist, the museum has been designed to be a 'three-dimensional plastic work of art' in the shape of a giant (Fig. 4.41).

Figure 4.41: Front View of Swarovski Kristallwelten: the 'Giant'
Tyrol, Austria (Url 4.49)

The uniqueness of the architecture of the building and the architecture of the exhibition spaces are a result of the imaginary world of André Heller. As for the architecture, he was inspired by his childhood memories of giants. As for exhibition spaces, André Heller was inspired by the design of the 'Chamber of Wonder' at Ambras Castle located in Innsbruck, Wattens. This 'Chamber of Wonder' at Ambras Castle is one of the most famous and best-preserved attempts of a 'Chamber of Wonder' that assembles a universal collection of all knowledge at the time.[86] It refers to "the chambers of art and wonder" or "cabinets of curiosities and rarities" which are the predecessors of museums that emerged during the sixteenth century in the Renaissance period. Based on the 'chamber of wonder' concept at Ambras Castle, Heller designed exhibition spaces inside the Giant as a house of multiple 'Chambers of Wonder' with the role of being a 'departure point' while passing through the Swarovski Crystal Worlds inside the Giant. In fact, each exhibition room, a Chamber of Wonder, is seen as a 'site-specific installation made mainly with crystal glass.' (Swarovski Kristallwelten, 2019, pp. 2-4; Url 4.50)

[86] During the sixteenth century in the Renaissance period, the chambers of the royal treasures developed into all-encompassing chambers of art, involving goldsmith works, ivory and woodcut art, clocks and automatons and natural objects in addition to paintings and sculptures. At that time, the cabinets represented the total sum of knowledge about the world, meaning that people attempted to satisfy the longing for new knowledge about the exotic and the foreign. From many of these cabinets, only a few successes occurred through the ages, one of which was the Chamber of Wonder at Ambras Castle.

In 2003, 2007 and 2015, the Kristallwelten had expansion and renovation projects to accommodate new functions. By the third and largest project of the Kristallwelten, realised in 2015, new buildings were constructed in its expanded, new garden, namely Daniels Café & Restaurant (the sun kiss pavilion), the play tower and an adjacent innovative outdoor playground and the Arrivals Building. All these buildings have been uniquely designed with a concept in relation to the concept of the museum building, the Kristallwelten and the characteristics of the region with a variety of facades mostly using material glass as a construction material. The project involved a redesign of the Chambers of Wonder, the complete redesign of the Swarovski Kristallwelten Store and the extension and redesign of the garden. The new expanded garden is a 'glass garden' or even 'an open-air museum of glass' and it has been transformed into an exhibition space of contemporary glass art installations and installations made with other materials. Thus, the museum complex stretches across 75,000 m^2, nearly double in size and it was celebrated with a grand re-opening in 2015 to mark the 120th anniversary of the Swarovski Crystal Company (Swarovski Kristallwelten, 2019; Url 4.51; Url 4.52; Weiermair et al., 2010, p. 28).

More recently in 2019, a new installation made with many pieces of crystal glass, the "Carousel," was installed by the Spanish artist and designer Jaime Hayon with new installations being added in future projects (Url 4.52). However, no new building has been built for exhibition requirements in the museum complex. In fact, only the Giant itself serves as the museum building in terms of glass art exhibitions today, thereby preserving its 'iconic museum image' in people's minds.

In the following section, detailed conceptual, technical and spatial assessments of the Giant and the design of exhibition spaces and the selected Chambers of Wonder in it are presented and examined.

4.4.2.1. The Main Building, the 'Giant' of Kristallwelten

- The Giant, the museum building, was constructed on a 3,500 m^2 site together with its garden. The Giant is the house of seventeen 'Chambers of Wonder' and at the same time, it is the house of a forum, a store, a VIP lounge, the Crystal Bar, the Crystal Studio and an exclusive venue for events, concerts and cultural occasions.
- The main museum building in the shape of a giant is covered with a green roof in harmony with its surrounding landscape, but it is adorned with eye-catching crystals on its face at the focal point for visitors.

- The Giant's mouth was designed as a waterfall and the entrance[87] is located under the mouth, laterally with the waterfall (Url 4.53). The waterfall probably refers to the abundant rivers in the region, which is the reason for Daniel Swarovski having chosen this location to manufacture crystal glass while saving on energy costs (see Fig. 4.41)(Url 4.53).
- Even though the architecture of the Giant and exhibition spaces (Chambers of Wonder) were designed in the beginning by multi-media artist André Heller, all the built environments are constructed as a collaborative work by national and international teams of architects, planners and designers and some of the spaces inside the Giant were redesigned in a 2015 expansion project, including the store. The general planner of the Kristallwelten was the local architecture firm s_o_s architekten Innsbruck, which worked in partnership with the Schlögl-Süß Architekten and Obermoser arch-omo zt gmbh I architektur architecture firms. In the museum, the overall art concept of the entire area, including the seventeen Chambers of Wonder, was supervised by Carla Rumler, the Curator and Creative Director of the Kristallwelten and the Cultural Director of the Swarovski Crystal Company.
- Each Chamber of Wonder was designed with a unique concept by the world's globally renowned artists, designers and architectures or by a team of these under the leadership of the Creative Director Carla Rumler and the general planner s_o_s architekten. Most of the Chambers of Wonder were also designed in collaboration with some other Professions (e.g., musicians, composers, sound designers, etc.) (Swarovski Kristallwelten, 2019, p. 4; Url 4.51; Url 4.54).
- In the design of each Chamber of Wonder and in the design of the architecture of the building itself (the Giant), the artistic principle was based on the inexhaustible interpretation of crystals in new contexts as both a material and as a tool for inspiration. With this aim in mind, the Kristallwelten was designed in a crystalline atmosphere in which crystal glass products of the Swarovski Crystal Company have been widely used for the construction of exhibited works of art/installations, displays units and the space itself. For these reasons, the Giant itself and each Chamber of Wonder act as total works of art in and of themselves and represent the crystals of Swarovski. The museum is therefore named 'Swarovski Crystal Worlds.' (Swarovski Kristallwelten, 2019)

[87] The entrance and exit areas were designed by the local architecture team s_o_s architekten (a collaboration of Obermoser arch-omo zt gmbh I architektur and Schlögl Süß Architekten). The large concrete roof of the new entrance was actually immersed in a birch forest supported by trunks of white trees. Birch wood covers the walls and ceilings and two fully glazed cubes are there to await guests.

- Based on the concept of creating ‘wonder,’ the exhibition spaces have been designed as a venue for surprises and senses to offer visitors ‘a complete and living experience of crystal through multi-senses.’ All the built environments, the so-called Chambers of Wonder, were built as ‘total works of art’ with a holistic approach in a contemporary manner that merges art, design and technology equally (thanks to the use of digital or man-made displays, well-developed lighting systems and other technical systems). Most are designed as ‘interactive spaces.’ In short, separately each of the Chambers of Wonder and the Giant itself are built as a ‘total work of art’ and their spatial designs are handled with the holistic approach, the multidisciplinary approach and the contemporary approach in order to create a space providing a complete experiment of crystals with multi-sensory perception. Thus, a symbiosis is created between the indoor and outdoor, between the day and night, between the monitored and unmonitored, between the broadly sweeping and the densely packed, between holistic and the individual, and between the artificial and the natural (Swarovski Kristallwelten, 2019; Url 4.49; Url 4.55).

With respect to the above information, the conceptual, technical and spatial assessment of the selected Chambers of Wonder inside the Giant, which were designed as total works of art, will be respectively examined in frames to emphasise them as ‘total works of art.’

Chamber of Wonder I: the ‘Blue Hall’

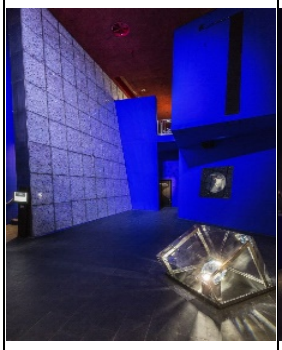


Figure 4.42: Chamber of Wonder I: the ‘Blue Hall

(Url 4.56)

Figure 4.43: Chamber of Wonder I: the ‘Blue Hall’

(Url 4.56)

Figure 4.44: Chamber of Wonder I: the ‘Blue Hall’

(Url 4.56)

Figure 4.45: Chamber of Wonder I: the ‘Blue Hall’

(Url 4.56)

Conceptual, Technical and Spatial Approaches in Design

- This is the first Chamber of Wonder, located at the first part of the crystal journey inside the Giant.
- It was designed with the concept of creating a space that refers to being inside a cave.

- In relation to the cave concept, the space is formed asymmetrically. It was built with asymmetrical matte walls that house asymmetrical niches inside them.
- An 11-meter high 42-meter long Crystal Wall was constructed that leads visitors directly into the Chamber of Wonders and splits the Blue Hall.
- In relation to its cave concept, a variety of exhibited works of art can be selected for exhibition in the space (such as panes, etc.); this refers to excavation and foundlings from the caves. The exhibits are comprised of the masterpieces of famous artists such as Salvador Dalí's "The Persistence of Time", Niki de Saint Phalle's "Crystalbearing Nana" and Andy Warhol's "Gems."
- The displays are specially designed in space. The curved niches inside the walls have been designed as display units with or without crystal glass panel enclosures (Figures 4.43 and 4.45). As seen in Fig. 4.43, some of the display area inside the niches are coloured in black and some are coloured in white. Thus, colour interactions between the exhibited works of art and the space are prevented and the inherent colours of the works of art are allowed to be perceived most accurately.
- Exhibited works of arts are positioned around the centrepiece, 'the Centenar,' and independently from the traditional spatial design concepts (e.g., linear arrangement, labyrinth arrangement, etc.) and are presented on or within the display units inside the niches, on the floor or on the walls, including the Crystal Wall. The Centenar, the black stallion "Chetak," is the largest hand cut crystal in the world at over 310,000 carats (62 kg). Its 100 hand cut facets precisely symbolise the 100th anniversary of Swarovski in 1995 in addition to there being two of the smallest, precision cut crystals of Swarovski: the Xirius Chaton and XERO Chaton, positioned next to its 100 hand cut facets, which creates a size contrast in the arrangement. The second is as large as the tip of a feather in size, which is the latest innovative product from Swarovski. It has especially been designed for the creative requirements of small areas, such as clocks, eyeglasses and jewellery.
- Interior space is characterised with the colour International Klein Blue (Url 4.73) as a whole and the slanted walls of the room are painted with it.
- As for atmosphere, it gives the feeling of a warm and energetic space although Klein Blue is a cold colour.
- Emphasising and highlighting the exhibited items in space is based on design principles such as colour contrast, brightness contrast, contrast of texture, contrast of form and contrast of shape. As a result, the exhibited works of art are highlighted and the crystalline interplay of light and colour is represented.

- To create colour harmony in space, various shades, tones and hues of colour are used in the proper ratios in the space.
- Colour contrast is created mainly by using darker and lighter tones of the Klein Blue in the space. Secondly, the use of golden tones on or within exhibited works of art against the blue background creates a colour contrast and highlights works of art by 'shining on blue.' Thirdly, scattering red onto some parts of the sculptures and using the red on the ceiling creates a colour contrast with the blue.
- According to the figure-ground relationship, contrasts are created between texture, pattern, shape, form and size of each exhibit and of the space itself. Thus, exhibits are highlighted and emphasised in space similarly to the effect of colour contrast. All these contrasts are mostly the result of the differences in the materials used.
- Lighting design is characterised with direct light provided by the artificial spotlights which shine in space. The direction, position and size of the light source depends on the types of exhibits in the space. Some of the spotlights are placed inside the works of art, some are placed inside the display units in the niches and located at the bottom or upper side of the exhibits, and some are placed on the ceilings (see Figures 4.42, 4.43 and 4.45). For example, the three-dimensional horse sculptures inside the niches were illuminated from the bottom with a few spotlights, while the sculpture inside the enclosed display unit was illuminated from the bottom with a few spotlights, as seen in Fig. 4.45. Thus, sparkles emerge on the crystal parts of the sculptures and are highlighted. The two-dimensional wall mounted works of art with or without enclosures and the two-dimensional print works on the Crystal Wall are illuminated from the front and upper sides by the spotlights on the ceilings (see Fig. 4.44). As a result of the combination of key light and fill light, a diffuse illumination is created on the wall mounted flat works of arts and this provides accurate perception of their details (such as their form, colour, pattern, etc.). The Crystal Wall is mainly illuminated by spotlights placed on the corner of the ceilings at the opposite side; thus, sparkles are created inside it thereby highlighting them in the space. As a result, a controlled brightness is provided; the colours of the exhibited works of art are allowed to be viewed accurately. Sparkles emerge on or within the works of art that are made partly or completely of crystal glass. Glare is prevented in the glass enclosures and the exhibited works of art are emphasised and highlighted as a result of providing proper illumination contrast and visual comfort in the space (Swarovski Kristallwelten, 2019, p. 5; Url 4.56; Url 4.57).

Chamber of Wonder II: the 'Crystal Dome'

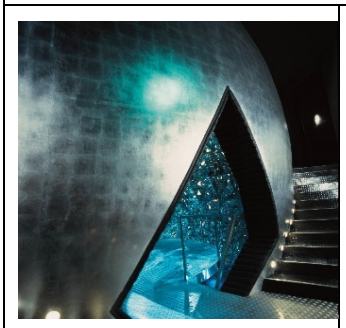


Figure 4.46: Chamber of Wonder II: the 'Crystal Dome'

(Url 4.58)

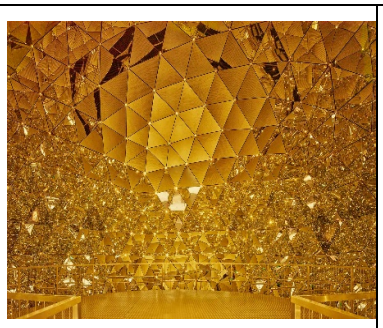


Figure 4.47: Chamber of Wonder II: the 'Crystal Dome'

(Url 4.58)

Figure 4.48: Chamber of Wonder II: the 'Crystal Dome'

(Url 4.58)

Conceptual, Technical and Spatial Approaches in Design

- This chamber has been designed holistically as a combination of art, design and technology to create an overall crystal experience as if one were inside a crystal. For this reason, it is featured as a 'total work of glass art built in the Glass Age.'
- Outside the Chamber is a sphere with a metal surface. In actuality, the metal is a shining material similar to glass. Due to the similarity, the two materials are used harmoniously in the sphere; however, there is actually a difference in the penetration of light owing to the contrast of surfaces. With this information, the metal and glass materials can therefore be intelligently applied inside and outside the sphere.
- Inside the dome, there are 595 triangular mirrors. It is known that mirrors are the most reflective glass products, and they create a special depth effect. Thus, real images of visitors, standing in front of the mirrors become virtual images in the mirrors with the reflected light which comes from the surface of the visitors. Through visual and spatial perception, the visitors can feel as if they were inside a crystal. The complete crystal experience is supported with background music via auditory perception.
- As works of various artists, eight of the mirrors located at the centre of the space are referred to as "spy mirrors" that conceal art objects (see Fig. 4.48). In terms of the spatial design, these eight mirrors contrast with the entrance hole through visual and spatial perception because the entrance in the shape of a crystal is seen as being a flat, black, opaque crystal against the eight, curved, coloured, shining crystals which are positioned upside down and located above the entrance. (Fig. 4.48).
- The interior is not coloured with any colorants. The floor, the exterior surface of the sphere and the juxtaposed staircase in the corridor are made with metal

(see Fig. 4.46). The remainder of the interior space is also colourless as it is made from crystal glass. However, the perceived colours in the space are dynamically achieved using the colours of the light sources.

- The lighting design is firstly characterised by direct light provided by artificial light sources (spotlights). Glimmering spotlights are placed at every corner of each of the 595 triangle crystal glass mirrors (see Fig. 4.47 and 4.48). The spotlights feature coloured lights and are arranged to distribute different colour hues. Due to the coloured lights coming from thousands of points in different directions and splitting from the curved mirrors into many directions, coloured inter-reflections occur in space and sparkles emerge from the corner of the crystals. Thus, a luminous, glimmering space is created which gives the feeling of being inside a sparkling crystal. The lighting design seems as the most important element of the 'total work of art' known as the Crystal Dome. It can be inferred that the lighting design of the Crystal Dome shows the functional benefits of the current lighting technology. Firstly, it appears to visualise that the lighting design is as important as the spatial arrangement. Secondly, it appears to visualise the interdependent relationship between light, colour and glass material through visual and spatial perception and finally, it continues its role as a central element in the perception of a 'whole concept.'
- As a whole, the Crystal Dome can be interpreted as a 'new interpretation of the total work of an art concept in the Glass Age' which was designed firstly by Bruno Taut for his Crystal Pavilion at the Werkbund Exhibition in Cologne in 1914 (see Chapter 2).
- Spatial design is technologically supported with music created by musician Brian Eno and it features as a backdrop to interior installation. By doing so, the 'Crystal Dome' offers a multisensory experience through visual, spatial and auditory perception (Swarovski Kristallwelten, 2019, p. 6; Url 4.57; Url 4.58).

Chamber of Wonder III: the 'Transparent Opacity'

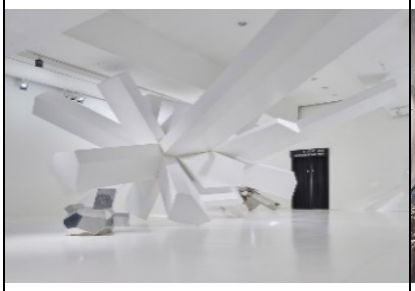


Figure 4.49: Chamber of Wonder III: the 'Transparent Opacity'

(Url 4.59)

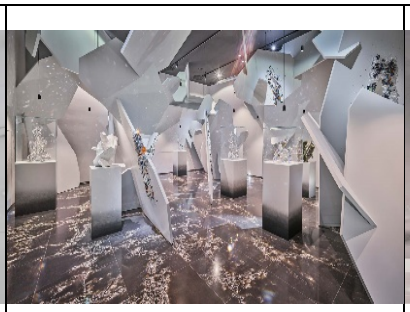


Figure 4.50: Chamber of Wonder III: the 'Transparent Opacity'

(Url 4.59)

Figure 4.51: Chamber of Wonder III: the 'Transparent Opacity'

(Url 4.59)

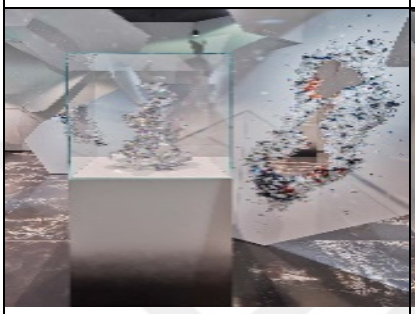


Figure 4.52: Chamber of Wonder III: the 'Transparent Opacity'

(Url 4.59)

Figure 4.53: Chamber of Wonder III: the 'Transparent Opacity'

(Url 4.59)

Figure 4.54: Chamber of Wonder III: the 'Transparent Opacity'

(Url 4.59)

Conceptual, Technical and Spatial Approaches in Design

- "Transparent Opacity" was designed as an homage to the 'diversity of crystal,' which refers to its apparently contradictory aspects, namely its transparency and impenetrability (Fig. 4.51, 4.54).
- It was designed by the artist Arik Levy with support from Compact the Surface Company and Vibia Lighting.
- The entire space is characterised by the 'white cube' phenomenon with walls, ceilings, floors and display units being coloured with white. Moreover, lighting is provided directly by the artificial light sources located in the ceilings. Thus, the intrinsic colours of the crystals and the light emerging from the corners of the crystals are presented properly in space and are perceived as being original (Fig. 4.51).
- According to the figure-background relationship, the sparkling and shining crystals are highlighted in the space which is opaque by means of texture, pattern, shape, form, size, brightness and colour contrasts.

- In the space, both open and closed display units are used, which results in contrasts of the emergence of form, shape and brightness between them. The enclosed display cases were built with crystal glass walls (Fig. 4.52).
- The space is composed of two parts: the entrance room, which was designed following the concept of 'Transparent Opacity' and an annexed space that was designed as a spatial expansion in relation to the same concept known as 'Emotional Formation.'
- The entrance room's 'Transparent Opacity' was designed as both a game of the most diverse array of materials, ranging from glass and marble to steel and synthetic 3D prints. It is also a playful reworking of forms, shapes as well as dimensions and sizes. The shapes of some exhibition pieces are used to invoke the familiar silhouette of the cut crystals and some others are used to reach deep into the abstract realm of natural, archaic crystalline shapes.
- The annexed room, with its 'Emotional Formation,' presents a spatial expansion in relation to Levy's earlier concept of 'Transparent Opacity.' This annexed room is a space where visitors can embark on a journey into themselves as if they were exploring previously undiscovered treasures of their future self when starting to step into this place (Figures 4.50, 4.52 and 4.53). Here, Levy creates an interactive space by using the reflective properties of the glass in order to awaken the spirit of exploration in its visitors. Through this interactive and participatory exhibition, he invites visitors to interact with the space and integrate with it through participation as an involuntary co-creator of the 'total work of art,' referring to the diversity of the crystals. In the "Interactive Arena," this interrelationship becomes completely dynamic such that each and every movement is captured and reflected. A special floor installation was created here which produces a labyrinth like effect wherein the visitor wanders from one section to the next, from one sculpture to the next, discovering new structures and unique perspectives at every turn along the way. In the space, the overall effect in perception is specular and every perspective seems to differ while exhibiting impressive detail in every element. Additionally, each of the six crystal structures is unique, highly faceted and appears as if it had been formed in the wild, mirroring natural growth. The lighting design is arranged to complete the space as a whole, a 'total work of art' by creating a striking interplay of light and shadow and providing visibility of virtual and real forms (Swarovski Kristallwelten, 2019, p. 7; Url 4.59).

Chamber of Wonder IV: 'Eden'

Figure 4.55: Chamber of Wonder IV: 'Eden'

(Url 4.60)

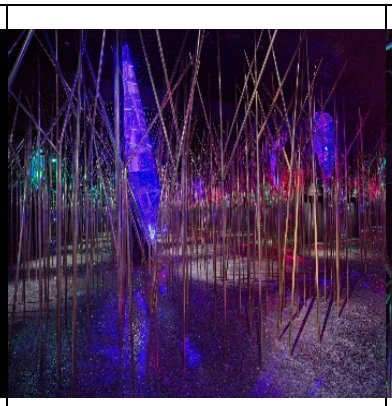


Figure 4.56: Chamber of Wonder IV:'Eden'

(Url 4.60)

Figure 4.57: Chamber of Wonder IV: 'Eden'

(Url 4.60)

Conceptual, Technical and Spatial Approaches in Design

- This chamber was designed by the artistic duo Fredrikson Stallard (Patrick Fredrikson and Ian Stallard).
- The space was designed as an abstract interpretation of a forest; thus, an unordinary forest is created that appears as if it were a 'fantastical and archaic primeval world.' (Url 4.60)
- The space is designed to be able to invite wanderer encounters (visitors) to follow a strange path which meanders through a dense wilderness of simple polished brass structures. By means of the mirrors participating in the spatial arrangement of the space, the path appears to go on to infinity through mirrored walls via spatial perception.
- The spatial design is mainly formed with abstract forms of crystal sculptures and metal branches as if it were a wild forest (Figures 4.56 and 4.57). The crystal sculptures that vary in size (the largest being up to 1.86 meters in height) refers to hidden gems that are produced by the Swarovski Crystal Business.
- Each of the crystal sculptures is illuminated from inside with a different colour of light; however, each colour of light is harmonised with the other colours. Thus, the sparkles are created on or within the crystal sculptures and coloured shadows emerge on the floor and are highlighted in the space in a variety of colours as beacons of light by glimmering in a dark space not unlike strange, exotic birds or reptiles, flowers or fruit that create coloured shadows on the floor. By doing so, the crystal sculptures also symbolise the glory of the surrounding space as a forest and therefore the origins of life (Url 4.60).

- In addition, the shining crystals also act as a direct light source that illuminates the ambience, thereby illuminating the path within the depths of this dark forest and inviting visitors to become involve inside this abstract forest. The interplay of light, colour and glass is presented within the crystals sculptures and completes the entire ambience with coloured shadows. As a result, they create a complete crystal experience in space through visual and spatial perception of real and virtual images.
- A glass wall is placed at the entrance of the room as a digital display and it acts as a diffuse light box (Fig. 4.55). It presents a dynamic representation of a mighty waterfall that was filmed in the surrounding Alps. While the waterfall is cascading down, the roaring sound of the water can be heard in the space and thus, it creates a wall of background sound. By doing so, 'Eden' focuses on a multisensory experience through visual, spatial and auditory perception. Moreover, a relationship is created between the waterfall and the crystal glass. Firstly, the water is transparent like crystal glass. Secondly, the waterfall is seen as the white that is the combination of all colours and each coloured light ray of the white light can be seen within the cut crystal glass work in the manner that artificial white light refracts inside a glass material and becomes distributed as individual coloured lights (Swarovski Kristallwelten, 2019, p. 8; Url 4.57; Url 4.60).

Chamber of Wonder V: 'FAMOS'

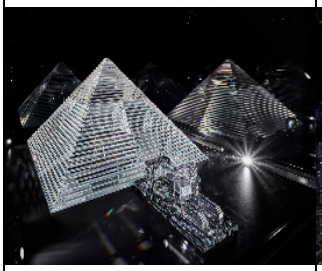


Figure 4.58: Chamber of Wonder V: 'FAMOS'

(Url 4.61)

Figure 4.59: Chamber of Wonder V: 'FAMOS'

(Url 4.61)

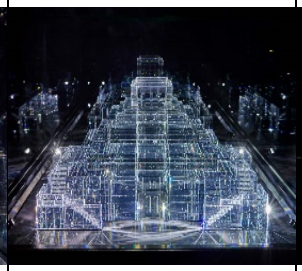


Figure 4.60: Chamber of Wonder V: 'FAMOS'

(Url 4.61)

Figure 4.61: Chamber of Wonder V: 'FAMOS'

(Url 4.61)

Conceptual, Technical and Spatial Approaches in Design

- This was designed by the artistic duo Blue Noses (Viacheslav Mizin and Alexander Shaburov).
- It was designed as performance art and the cutting crystals of Swarovski; thus, the lifeless crystals come to life with an eccentric humour in the form of cryptic short films.

- The space is characterised by the ‘black box’ concept.
- In the space, four of the architectural landmarks were built in a crystalline dimension with the help of crystal experts from the Swarovski Company and are put on display as glass works of art. These include the Taj Mahal in Agra, the Pyramid of Cheops in Giza, the Empire State Building in New York and the Lenin Mausoleum in Moscow. The Pyramid of Cheops alone weighs 105 kilograms and the Empire State Building consists of 386 individual parts (see Figures 4.58, 4.59, 4.60 and 4.61).
- Exhibited works of art are supported with the subtle and humorous home videos that are played inside the exhibition pieces and can only be viewed from above. The crystalline works are placed in opposition to the tongue-in-cheek videos and the Grandeur is cleverly positioned in perspective. In fact, from the bottom only the videos can be perceived separately and from the front only the crystal glass can be perceived separately, but together they create the ambience of a total and holistic work of art.
- As a result of the combination of a virtual installation and real installation, an experimental space seems to be created that inspires the creation of a space of only crystal works of art. Thus, the space has been designed with an interdisciplinary approach and focuses on the whole crystalline experience.
- ‘FAMOS’ shows how the media art is integrated inside glass works and how technological developments are applied in a Glass Age glass art exhibition having the role in equal ratio with the glass work.
- The lighting design is characterised by artificial direct lighting. A few spotlights are placed in the inner areas of the display units and they distribute light from different directions. Thus, sparkles are created on or in the crystal glass work through reflection on the corners and edges of each crystal piece. Moreover, the videos create reflected light on crystal work. As a result, varying colours of light emerge from within the crystal work and the interplay of light, colour and glass effectively appears within the crystal and are thereby highlighted in the dark space (Swarovski Kristallwelten, 2019, p. 8; Url 4.57; Url 4.61).

Chamber of Wonder VI: 'El Sol'

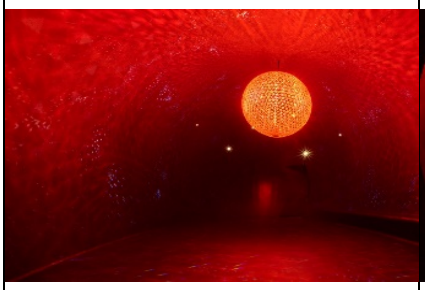


Figure 4.62: Chamber of Wonder VI: 'El Sol'

(Url 4.62)

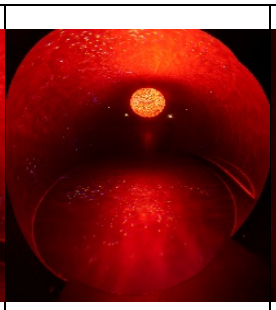


Figure 4.63: Chamber of Wonder VI: 'El Sol'

(Url 4.62)

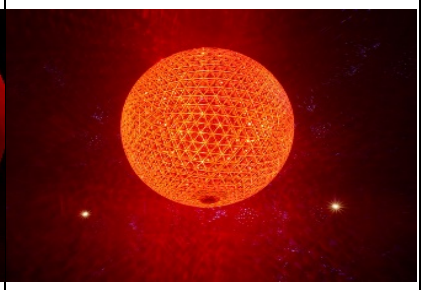


Figure 4.64: Chamber of Wonder VI: 'El Sol'

(Url 4.62)

Conceptual, Technical and Spatial Approaches in Design

- This was designed by architect Fernando Romero based on the concept of an exploration of humans' relationship with the sun, hence the name 'El Sol,' which is Spanish for 'the sun.'
- In the design, the architect was inspired by the geometry of Aztec and Mayan pyramids, so the space was created as a homage of architect's own Mexican cultural heritage.
- In the space is a large glass installation hanging from the middle of a barrel-vaulted ceiling and acting as the 'ball piece' (Figures 4.62 and 4.64). The size of the ball is exactly one-billion times smaller than the sun itself, made with 2,880 custom-made Swarovski crystals (Fig. 4.64).
- The space gives the feeling of being inside the sun because of the physical aspects. It is formed as a tunnel, coloured in red and mainly illuminated from the ball with its orange lights.
- A number of artificial point light sources are placed inside the ball, thus creating sparkles on the crystal glass art pieces. Moreover, a few very small spotlights located on the walls can be seen as sparkling stars around the "sun" at the centre. As a result, size contrast is created between the illuminated sun at the centre and the small spotlights on the walls. Colour contrast is created between the less saturated red (orange) light of the "sun" and the more saturated red of the surrounding space. Between the central sun and the surrounding space, contrasts of texture, pattern and brightness also emerge. Thus, the ball, referred to as the "sun," is highlighted in the space (Swarovski Kristallwelten, 2019, p. 9; Url 4.57; Url 4.62; Url 4.63).

Chamber of Wonder VII: the 'Chandelier of Grief'

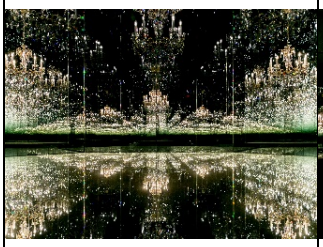


Figure 4.65: Chamber of Wonder VII: the 'Chandelier of Grief'

(Url 4.64)

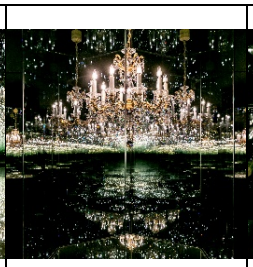


Figure 4.66: Chamber of Wonder VII: the 'Chandelier of Grief'

(Url 4.64)

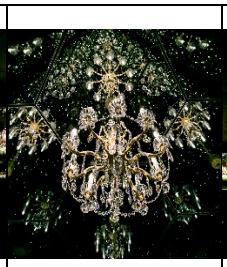


Figure 4.67: Chamber of Wonder VII: the 'Chandelier of Grief'

(Url 4.64)

Figure 4.68: Chamber of Wonder VII: the 'Chandelier of Grief'

(Url 4.64)

Conceptual, Technical and Spatial Approaches in Design

- This was designed by artist Yayoi Kusama as an 'Infinity Mirror' for the seventeenth Chamber of Wonder that was mentioned as being one of the most attractive mirror installations of one of the most renowned contemporary artists (Kusama) in the world. It also features as Kusama's only permanent installation in the world in addition to the installation in her gallery in Tokyo.
- An endless illusion is created in the space through the perception of the spatial depth by benefiting from the reflective feature of the glass mirrors.
- The space is characterised by the 'black box' concept (Figures 4.65, 4.66, 4.67 and 4.68).
- The installation is centred by a rotating chandelier the lustre of which comes to life in a room that is completely lined with mirrors. The chandelier was produced with Swarovski crystals and acts as a centrepiece in the space.
- Illumination is provided by the chandelier as a source of direct light that distributes light multi-directionally. Thus, sparkles are created on the crystal pieces thereby highlighting the centrepiece: the chandelier in a very dark environment.
- It is seen as a site-specific installation made from glass in the Glass Age and reflecting the past and current situation of glass in art, particularly in design (Swarovski Kristallwelten, 2019, p. 7; Url 4.49; Url 4.64).

Chamber of Wonder VIII: 'La Primadonna Assoluta'

Figure 4.69: Chamber of Wonder VIII: 'La Primadonna Assoluta'

(Url 4.65)

Figure 4.70: Chamber of Wonder VIII: 'La Primadonna Assoluta'

(Url 4.65)

Conceptual, Technical and Spatial Approaches in Design

- The space was designed to present moving performances of the renowned soprano Jessye Norman in the displays.
- At the centre of the room, a natural, giant glass crystal from Madagascar is placed on the ground and located in the opposite direction of the virtual show. Whichever visitor touches the mountain crystal will feel its concentrated energy in the form of a subtle warmth as if the song touches them in the form of a subtle warmth. It has the role of completing the experience in the space by reflecting the same emotion in a different manner with a different source. Thus, the room starts to be characterised as an exhibition space rather than being only a presentation room for a digital show.
- The space is characterised by the 'black box' concept (Fig 4.69, 70).
- The space comprises artificial, digital displays and a natural, real crystal sculpture with equal importance in the spatial design. As a result, a contextual contrast is created in the space by positioning the tangible, natural crystal for the exhibition, thereby providing the counterpoint to the intangible man-made art form of music and voice. Moreover, a contrast is created in the space between the archaic, natural form of the glass works and the digital form of virtual work in the current age is presented through a glass screen of technology. Thus, the historical journey of glass art is somehow presented. Additionally, the crystals produce harmony in the space with their colours and lighting that resemble colours in the show, illuminated through light.
- The light can be thought of as the link between the audio-visual show and the crystal which creates the harmony in the space by illuminating the colours of the exhibits

as well as the aesthetic qualities and importance of Swarovski. The remaining space is given up in dark and focuses on exhibits and emphasises their importance in the space.(Swarovski Kristallwelten, 2019, p. 8; Url 4.57; Url 4.63; Url 4.65)

Chamber of Wonder IX: the 'Ice Passage'

Figure 4.71: Chamber of Wonder IX: the 'Ice Passage' (Url 4.66)

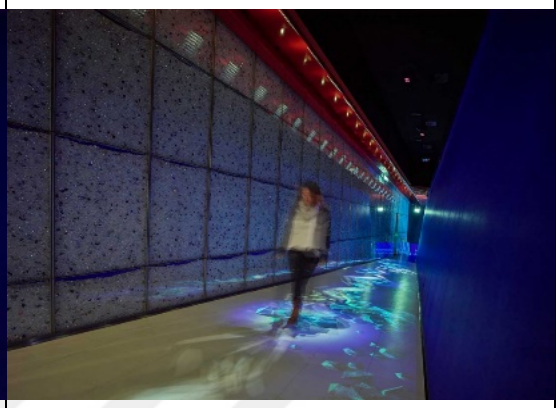


Figure 4.72: Chamber of Wonder IX: the 'Ice Passage' (Url 4.66)

Conceptual, Technical and Spatial Approaches in Design

- This chamber was designed by artist Oliver Irschitz as an interactive corridor to provide an experience as if living on an ice passage.
- As a three-dimensional virtual experience, it focuses on multi-senses which can be perceived through visual, spatial and auditory perception.
- It was designed as an empty corridor that comes to life when visitors start to walk on the floor through the corridor. When they interact with the floor, a series of crystalline tracks start to appear on the floor, thus revealing their way as an ice passage. Simultaneously, the light spontaneously follows the images and traces this track, so it allows visitors to have sporadic views into the surrounding world of the glistening ice. When more visitors participate and walk through the corridor, the intensity of the light increases and the tracks appear denser on the floor. Moreover, mysterious and sometimes alarming creaking and crackling sounds accompany each step as if walking on a frozen surface. These cause small fissures in the ice with each step.
- The space is designed with a blue opaque wall and an opposing glossy mosaic wall consisting of crystal glass pieces some of which are coloured blue (Fig. 4.71, Fig. 4.72). In this manner, visual contrast is created between the two walls due to differences in their textures and patterns. As for colour, a light-dark contrast is created between lighter value of the glass wall and darker value of the opaque wall.

- The bright floor against a dark ceiling is used to create images of the ice. Red lighting is used on the ceiling in a linear form.
- The lighting is designed with an installation of spotlights at the edge of the ceiling and arranged to be active when somebody walks in the corridor and to be passive when no one enters. The light sources provide a complement spatial perception of the walking experience through an ice passage. The mosaic wall reflects the lighting in space as a secondary light source (see Fig. 4.71, Fig. 472) (Swarovski Kristallwelten, 2019, p. 7; Url 4.57; Url 4.66).

All the selected Chambers of Wonder are located inside the Giant and each feature as a total work of art. Additionally, the Crystal Cloud and Mirror Pool also features as a 'total work of art' outside. It features as an outdoor, site-specific installation illuminated by daylight during the day and with artificial light during the night. Due to its unique characteristics, a detailed assessment of the Crystal Cloud and Mirror Pool is made in the scope of the thesis.

Site-Specific Glass Installation in the Garden: the 'Crystal Cloud and Mirror Pool'

Figure 4.73: Site-Specific Glass Art Installation in the Garden: the 'Crystal Cloud and Mirror Pool'

(Url 4.67)

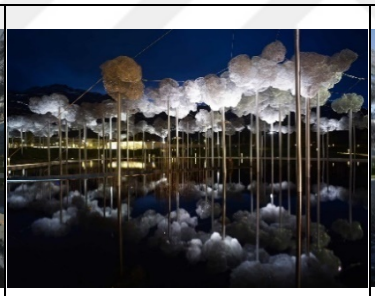


Figure 4.74: Site-Specific Glass Art Installation in the Garden: the 'Crystal Cloud and Mirror Pool'

(Url 4.67)

Figure 4.75: Site-Specific Glass Art Installation in the Garden: the 'Crystal Cloud and Mirror Pool'

(Url 4.67)

Conceptual, Technical and Spatial Approaches in Design

- This was designed as a monumental glass art installation and a park and it appears as a natural phenomenon of crystals (Url 4.67).
- It was designed under the leadership of Andy Cao and Xavier Perrot by a team from Cao|Perrot Studio and PLACE studio with its partners Peter Heppel Associates, Theatre Machine and ATT. Architecture: Snøhetta, s_o_s Architekten (Swarovski Kristallwelten, 2019; Url 4.54; Url 4.67; Url 4.68; Url 4.69; Url 4.70; Url 4.71).
- It has a surface area of approximately 1,400 m^2 and consists of about 800,000 hand-mounted Swarovski crystals. It is the largest of its kind in the world.
- The Crystal Clouds stand above the Mirror Pool against its reflected shadows on the pool (Figures 4.73 and 4.74) (Url 4.51; Url 4.72). The pool is coloured in black,

thus it acts as a black crystal glass panel and a relationship emerges in between the Crystal Cloud Installation and the Mirror Pool via transparency.

- By lighting with spotlights at night, sparkles emerge on the Crystal Clouds and the image of it appears in the Mirror Pool as shadows (Fig. 4.74). Thus, a complete crystal experience is created and it becomes a total work of art. By using daylight during the day, the same effect is achieved (Fig. 4.73).
- In the surrounding landscape, thousands of fireflies are present naturally creating magical light around the pool, which helps to complete the crystalline experience in the space as a total work of art (Fig. 4.75) (Url 4.67).
- The site-specific installation Crystal Cloud and Mirror Pool is presented with a sound installation hidden in the Crystal Cloud. The sound installation is specifically designed with natural sounds such as soft bird song and rain drops by musician and sound designer Emil Berliner in order to create an almost spiritual atmosphere in the garden and complete the crystal experience in terms of an entire perception through multi-senses.
- As a result, the Crystal Cloud and Mirror Pool installation is accompanied with the sound installation creating a total work of art in an open display in an outdoor space (Swarovski Kristallwelten, 2019; Url 4.67; Url 4.68; Url 4.69; Url 4.70; Url 4.71).

4.4.3. Summary

The Swarovski Kristallwelten is a unique glass museum that is a technology-based Art, Design and Entertainment Centre integrating the fields of art, architecture and technology in equal importance in the scope of a glass museum. Even the Kristallwelten does not present itself as a glass museum but rather presents itself as a ‘glass art, culture and entertainment centre’ mostly known as the Swarovski Museum of Glass.

In design of the architecture of the building and in the design of the exhibition spaces, the Kristallwelten benefits from holistic and multi-disciplinary approaches to achieve a total work of art concept with respect to the contemporary era and the Glass Age. In fact, its uniqueness comes from its exhibition design ‘total work of art’ concept, which is designed holistically by multi-discipline professions (e.g., artists, architects, designers, etc.) and offers a multi-sensory perception of glass. Based on the conceptual, technical and spatial assessment of the architecture of the building and exhibition design within it, the following results can be inferred:

- **As a ‘whole,’** the museum can be thought of as an indication of the interdisciplinary approach in Glass Museums of the Glass Age or even an indication of visitor centred glass

exhibitions in the Glass Age. As a glass museum in the Glass Age, the Kristallwelten presents an evolution of the total work of art concept perceived by multi-senses, which was applied one-hundred years ago in the design of the Crystal Pavilion by architect Bruno Taut. The "Chambers of Wonder" concept also has a historical reference. It recalls "cabinets of curiosities", that are predecessors of museums.

- **Solely in terms of the architecture of the main building,** the "Giant" reflects a thematic centrepiece built as an iconic architecture in an expressionist manner. It acts as a landmark and a cultural icon in Innsbruck, Wattens in the home of its founder company.
- **In terms of the exhibition design in the scope of 'total work of art' concept**, the following statements can be inferred from the overall research:

  - "Chambers of Wonder" can be mentioned as 'glass art exhibition prototypes of the Glass Age' owing to the fact that each of them merges art, architecture and technology holistically following an interdisciplinary method in a contemporary manner in order to offer a complete crystal experience. By doing so, it appears as a role-model for future glass museums. Such future glass museums can take inspiration from the Kristallwelten's technologically evolved total 'work of art' concept.
  - Each Chamber of Wonder is designed being informed by a unique concept with unique representation methods as a multi-disciplinary work of art that revolts against traditional spatial organisation and lighting design techniques applied in museums and galleries. By doing so, the Kristallwelten visualises the transformation from site-specific installations into 'total work of art' concepts in the Glass Age, which may be a sophisticated combination of various types of installation (such as sound installations, glass installations, etc.).
  - The 'total work of art' concept makes use of both the 'black box' and 'white box' concepts in interior design.
  - The Kristallwelten is specialised only to exhibit crystal glass both in virtual and in physical displays. The versatility of glass is emphasised through the use of glass in different constructions, such as works of art, display units, screens of digital displays and the space itself.
  - It is seen that the virtual works of art (digital art installations) take up more space than physical glass artworks in the Chambers of Wonder.
  - In each Chamber of Wonder, colour selection both in exhibits and in the space is based on the overall concept of each Chamber of Wonder and is arranged by applying the approaches of harmony, balance and contrast with respect to the concept of the total work of art.

- In each Chamber of Wonder, for the lighting design, both the 'direct light' as a key-light on displays and the 'diffuse light' as a fill-light in Chambers of Wonder are applied. Crystal made artworks and installations are highlighted in the space thanks to proper arrangements of the direction, position, colour, intensity and amount of direct light. In the same manner, sparkles are achieved in particular crystal artworks on the displays, while the occurrence of glare and veiling reflections on the displays are avoided.

4.5. Assessment of Case Studies and Concepts of Exhibition Design: 'White Cube,' 'Black Box' and 'Total Work of Art'

In the scope of the regional and conceptual context, the three museums have a number of similarities in terms of the conceptual background with other glass factory-based glass art museums. These include the following:

- They are established in the homeland of their respective founder companies;
- They all have commercial aims, promote their own glass products by using them in the design of the museum building itself and in the design of the exhibition spaces, and directly in exhibited artworks and installations;
- They can all be classified as *type 2 museums* which have spaces for entertainment, communication, food and drink and shopping;
- They all have touristic aims for their respective regions; therefore, the relationship with glass history in the region and the glass of today in the region is reflected as much as possible in the design of museums and some of their permanent exhibitions in a manner that highlights the glass-making history of the respective museums' founder companies.

In the scope of the architecture and exhibition design, in reality, the three museums (CMOG, SHMOG and Kristallwelten) have modern and contemporary built environments and they benefit from both the 'black box' and 'white cube concepts in the designs of their different exhibition spaces. However, each of them is dominantly specialised in one of the three exhibition design concepts of the 'white cube,' 'black box' and 'total work of art' concepts.

In this thesis, and with the aim of assessing the conceptual, technical and spatial approaches of the three concepts applied to the exhibition design of glass museums in the Glass Age, the Contemporary Art and Design Wing of CMOG was selected to be examined with the 'white box' concept, the main building of SHMOG was selected with the 'black box' concept and the main building of the Kristallwelten, the "Giant," was selected with the 'total work of art' concept.

The following table below comparatively presents the similarities and differences between these three concepts over the three glass museums examined in this thesis. Table 6 also covers investigation of permanent exhibitions and installations of contemporary glass art exhibited in other glass gallery and museums.

Table 6: The Comparison of the Three Concepts in terms of Exhibition Design and Spaces of the Three Museum Buildings: Contemporary Art and Design Wing of CMOG (the 'white cube'), Main Building of SHMOG(the 'black box') and Main Building of the Kristallwelten – the "Giant" (the 'total work of art')[88]

	Contemporary Art and Design Wing of CMOG	Main Building of SHMOG	Main Building of Kristallwelten – the "Giant"
Exhibition Design Concept	**White Cube**	**Black Box**	**Total Work of Art**
General ambience in relation to light, colour and material surfaces (mostly made with glass)	Light-filled space using diffuse, white light, light colours and highly reflective finishes	High-contrast space via direct, white light, dark colours and low-reflection finishes (coloured light is also rarely used in a space)	Varies in each of the Chambers of Wonder depending on the desired concept
Method of Representation	Highlighting exhibited glass works and/or installations in displays by simplifying the exhibition space in the visual field. (The exhibition space here assumes the role of being a background that reflects all the intrinsic colours of exhibits and reveals structural details in their forms and surfaces while emphasising the material properties of glass.)	Highlighting exhibits and/or installations on display by eliminating the exhibition space in the visual field. (The exhibition space here assumes the role of being a background that offers the occurrence of sparkles and highlights on glass artworks, thereby revealing structural details in their forms and surfaces while emphasising the material properties of glass.)	Highlighting both the space itself and the elements in the space (including crystal glass display units and exhibited glass artworks and/or installations in the displays) by creating a 'total work of art' in the visual field. (The exhibition space here assumes the role of being both a 'work of art' by itself and a background to the displayed artworks, which might offer perceptions of intrinsic colours in the artworks and the space itself. This reveals structural details in the forms and surfaces in the space and the space itself.)
Style and Form of Exhibited Glass Artworks	Contemporary glass artworks and glass art installations	Contemporary glass artworks and installations are made with glass and site-specific installations	Contemporary glass artworks and installations are made with glass
Content of Exhibits	Mostly single glass artworks	Mixed media works including glass, light installations and single glass artworks	Mixed media works including glass, light installations, displays as virtual glass spaces and single glass artworks
Physical Properties of Glass Artworks	Mostly coloured and translucent glass artworks	Mostly colourless and transparent or translucent glass	Various types of artworks which might be virtual works of art and/or physical works of art

[88] The table visualises the information in a comparative manner, which was interpreted by the author as a general evaluation of this chapter.

		artworks or opaque glass installations that may be virtual works of art. Physical works of art may be partly or completely produced with glass	which might be partly or completely made of glass in or might and/or other materials or technology
Type of Exhibition	Object-oriented, systematic and thematic exhibitions and/or installations	Object-oriented, thematic, responsive, interactive, dynamic, participatory exhibitions and/or installations	Object-oriented, thematic, responsive, interactive, dynamic, participatory exhibitions and/or installations
Displays	Display cases and open displays	Display cases, display units, open displays, digital display screens and/or installed displays	Smart display technologies, projections, installed displays or open displays, display units
Colour of Surrounding Surfaces (space and the other elements in space)	Stark white	Mainly black velvet and far less often dark grey	May be composed of various colours or tones and shades of a single colour; this would depend on the overall concept of an exhibition
Lighting	Daylight is used as a key light and artificial lighting is used as a fill light to support and complete the daylight and it is provided by the light sources. White, glossy surfaces also act as secondary light sources that distribute reflected diffuse light. All the exhibited works and installations are presented with similar properties thanks to the use of diffuse light. Glare and veiling reflections are prevented on the display cases and on the exhibited works and glass installations thanks to the use of fill light. The texture of the light is mainly characterised by diffuse lighting. The colour of the light is mainly characterised by white. The intensity of the light increases in comparison to the black box concept Light is used for ambience in the space and it is used for accenting on displays as well as on or in exhibited works and/or	Artificial lighting is used as both a key light and as a fill light that are provided by light sources and digital displays. Light-art installations and/or illuminated glass artworks also act as light sources. Sparkles and highlights on exhibits and installations are achieved thanks to the use of direct light. Glare and the veiling of reflections are prevented on display cases, exhibits and installations made with glass thanks to the use of fill light. The texture of the light is mainly characterised by direct lighting. The colour of the light is mainly characterised by white. The intensity of the light is lower in comparison with the white cube concept. Light is used only to accent displays and on or in exhibits and/or	Artificial lighting is used as both a key light and fill light provided by light sources, projections or digital display screens. Light art installations and/or illuminated glass artworks also act as light source. White, glossy surfaces act as secondary light sources distributing reflected diffuse light. Sparkles and highlights are achieved on exhibits and/or installations thanks to the use of direct light. Glare and veiling reflections are prevented on display cases, exhibits and installations made with glass thanks to the use of fill light. Depending on the overall concept in each Chambers of Wonder, the texture of the light might be diffuse and/or direct and/or diffuse-direct. The colour of the light might be a single colour or combination of colours in a Chamber of Wonder. The intensity of light depends on the desired concept. It might be used as ambient light in a space and/or it might be used as an accent light on or in an

	installations made from glass.	installations made with glass.	exhibit and/or installation made with glass.
Perception of Exhibited Glass Artworks, Art Installations or Installations made with Glass	Essentially visual and spatial perception	Essentially visual and spatial perception; Rarely auditory perception or haptic perception	Multi-sensory perception
Spatial Organisation	Visible; partly depending on traditional spatial design concepts	Invisible; independent from traditional spatial design concepts	Visible or invisible; independent from traditional spatial design concepts

CHAPTER 5
CONCLUSION

In this thesis, a comprehensive study has been made in the context of *exhibition design and spaces for contemporary glass art in glass museums in the so-called 'Glass Age.'* Based on the studies discussed in Chapters 2, 3 and 4, the following inferences can be made:

a. As a result of the literature study in Chapter 2, the following statements can be inferred:

- Parallel to the developments in science and technology of glass production, glass has always been used, at one and the same time, as a medium of art and design since it was first discovered around 3500 BC.

- The 21st century is credited as being the "Glass Age" and it stands as a milestone in the history of glass, glass art and glass art exhibitions due to the rapid scientific and technological developments in glass having occurred in the first decade of the 21st century. In this respect, the two former milestones were the Industrial Revolution (occurring between the late 1700s and early 1800s in Great Britain) and the Studio Glass Movement (1962 in the U.S.A.). However, the Glass Age also simultaneously acts as a milestone in the history of architecture and interior architecture (Url 5.1). As a result:

- Glass stands as the most versatile medium of art, design and technology today due to possibilities of glass provided by new techniques and methods of glass-making and glass production and the abilities of glass provided by the developed properties of glass (e.g., information transmission, flexibility, etc.), which are provided by current scientific studies in glass. Accordingly, with regard to material preferences, it is placed among other materials in a prominent position. In addition, glass has been changing the world and transforming present society toward digitalization as glass is used widely in everyday surfaces.

- Absolute glass works of art have mostly transformed into mixed-media works of art and contemporary glass art installations have mostly transformed into interactive media installations, digital media installations and/or a mixture of the both. In some cases, contemporary glass art installations have also transformed into architecturally involved works of art or site-specific installations made with glass.

- The concept of the 'total work of art' has evolved as a concept in exhibition design for contemporary glass art in glass museums today. Traces of this evolution can be seen especially in the design of Expressionist architect Bruno Taut's Glass Pavilion for the Deutscher Werkbund's Industrial Art and Architecture Exhibition held in Cologne, Germany in 1914. The 'total work of art' concept has transformed from being a concept of modern glass installation into being a concept of exhibition design for contemporary glass art by the Swarovski Kristallwelten located in Wattens in Austria opened in 1995. More recently, the concept of 'total work of art' has been applied as being both as concept of contemporary glass art installation and as a concept of exhibition design for contemporary glass art at the same time by the opening of Chihuly Garden and Glass, a permanent exhibition of contemporary glass art in Seattle, U.S.A. in 2012 (Bletter, 1981, pp. 20-43; Url 5.2; Url 5.3; Url 5.4).

- A new revival of the age-old crystal metaphor emerged today in art and architecture, which had also experienced a revival at the beginning of the 20th century. Its current revival has transformed glass architecture into a technologically evolved glass architecture. Thus, the transparency of glass architecture, which exposes structural details of buildings, has been transformed into a 'reflectivity of today's glass architecture,' where façades appear as display screens and reflect their surroundings. Some even benefit from smart technology in glass.

- Interior spaces have begun to be partly transformed from physical spaces into virtual spaces informed by the concept of *smart home technology*. In this respect, digital displays have started to be embedded into interior elements such as the walls, doors etc. They have also begun to be embedded in white goods and furniture (e.g., cupboards). This has caused a merging of digital and physical spaces in the same room thanks to the versatile use of material glass, which is most obviously seen in exhibition spaces of glass museums dedicated to contemporary glass art and built particularly in the Glass Age.

o The three evolving concepts, the 'white cube', 'black box' and 'total work of art,' are dominantly applied in exhibition design and spaces of glass museums today in the Glass Age. In this regard:

- The ‘white cube’ concept evolved with the influence of *modernism* and it has begun to be applied in art museums starting with the Museum of Modern Art (MoMa) thanks to modern approaches in exhibition and architectural design. Traces of the penetration of the ‘white cube’ concept into the spaces of glass museums as a concept of exhibition design is still continuing and the ‘white cube’ concept is still applied today as one of the three dominant exhibition design concepts of glass museums, particularly in the world’s leading glass museum, the Corning Museum of Glass.

- The ‘black box’ concept, together other with multi-sensory methods, has evolved under the influence of the penetration of *New Media* (refers to digital media and related with New Media Age) into daily life and it has begun being applied in art museums thanks to contemporary approaches in exhibition design. In fact, the penetration of the ‘black box’ concept into glass museum spaces as a concept of exhibition design is quite fresh and it is increasingly being applied in exhibition designs and glass museum spaces.

- The ‘total work of art’ concept has very freshly evolved under the effects of *multi-sensory approaches* in art museums and *interdisciplinary approaches* in exhibition design in addition to the influence of the Glass Age. It has already begun to be applied in glass museum spaces as an exhibition design concept as exemplified in the Swarovski Kristallwelten. Solely in terms of exhibition design, the ‘total work of art’ concept might take the advantage of either the ‘white cube’ or ‘black box’ concept. In this regard, it can be said that the ‘total work of art’ is a rather more complementary concept than the ‘white cube’ or the ‘black box’. It seems that this new approach will lead exhibition design and spaces for glass art and even the future architecture of glass museums

b. As a result of the literature and theoretical study in Chapter 3 (Exhibiting Glass Art: Perceptual and Technical Assessment), the following statements can be inferred:

- Exhibition design for contemporary glass art in a general sense primarily depends on the optical and physical properties of the displayed work in addition to its form and surface structure. In this regard, it can be inferred that the more transparent, smooth and simple the form the piece is, the more it interacts with its surroundings and vice versa.[89]

- The light-colour duality plays the most determinant role in the visual and spatial perception of an exhibition atmosphere owing to the fact that the other physical

[89] The statement is inferred by the author based on the overall research throughout the thesis.

properties of the space (e.g., texture, patterns on surfaces, forms of the space itself, etc.) are for the most part simplified or eliminated from the visual field in order for the space to function as a background to the exhibits.[90] Accordingly, light and colour are often used to manipulate the visual and spatial perception of exhibitions in general and glass exhibitions in particular.

- The light-colour duality simultaneously plays the most determinant role in the visual and spatial perception of displayed glass exhibits for three important reasons:
  - *They are both able to interact with material glass with regard to transparency.*
  - *They both play a role in the emergence of an indispensable relationship between light, colour and material glass as regards to colour transparency.*
  - *Glass in and of itself is a carrier of light and a multiplier of colour as Expressionist Paul Scheerbart has stated in his Glass Architecture (Miller, 2015).*
- The properties of light and colour correspond with each other as seen in the following items and this situation is more obviously seen in the investigation of glass art works in relation to colour transparency.
  - *the saturation of a colour corresponds to the intensity of the light;*
  - *the value of a colour corresponds to the texture of the light; and*
  - *the hue of a colour corresponds to the colour of the light.*
- White and black are the most proper colour phenomena used in spaces for glass art exhibitions in order to prevent colour interactions between exhibits and the space itself, and by doing so, white or black provides an accurate perception of intrinsic colours of exhibits since material glass is able to interact with surrounding colours with regard to transparency. Between them (white and black), the proper colour preference for surrounding surfaces should depend on the colour of the displayed glass exhibits. In this regard:

[90] For additional factors playing a role in the perception of the displayed glass exhibits (e.g., design and material components of the exhibits, etc.), see 3.2.2.2. Factors Effecting Visual and Spatial Perception of Glass Works of Art on Display.

"The whiter the surrounding surfaces, the more light they reflect; proper for glass works of arts in darker value."[91]

"The blacker the surrounding surfaces, the more light they absorb; proper for glass works of arts in lighter value."[92]

- Lighting design requires more attention for the modelling of glass exhibits than for other types of exhibits for the following reasons:

  - Unlike other materials, glass transmits, scatters, reflects and absorbs light at the same time. Any alteration in the arrangement of light on a display may alter the perception of the glass exhibit with regard to its perceived colour, form and surface details.

  - Glass is insensitive material to light damage in contrast with most other materials that are in fact sensitive to light damage. A glass work of art on display shows unique effects by virtue of its colour transparency and the use of other light sources (such as UV light) for its modelling and display, which are generally not used in museums due to the fact that works of arts made with other materials (such as paper, textile, etc.) would be damaged.

  - Exhibits can be illuminated with coloured lights on displays and by doing so, it offers a special interplay of light, colour and glass by virtue of its interaction with light in terms of transparency or translucency.

  - Exhibits can permit the falling of coloured cast shadows on surroundings with regards to transparency, particularly on white or black surfaces.

  - Since glass is a highly reflective material, high amounts of light may cause disturbing glare and veiling reflections on exhibits, which in turn would prevent the perception of an exhibit as being real.

  - With the exception of some special cases, sparkles are aimed to achieve on three-dimensional glass exhibits as a general rule in lighting design.

- Accent lighting for glass art exhibitions reveals the form and surface details of exhibits and presents their intrinsic colour in order to provide an accurate perception of them, in addition to emphasising them and providing them with attention. To provide these results:

[91] The statement is inferred by the author, based on the overall research throughout the thesis.

[92] The statement is inferred by the author, based on the overall research throughout the thesis.

- A small number of small lights sources may be used to illuminate a glass exhibit instead of one large light source. Small light sources should be positioned in different directions with a proper spatial distance in order to prevent higher intensity contrast on the exhibit.

- Showcase exhibits for glass art can be illuminated with ambient light or with diffuse light provided from above or below or from behind of an opaque glass wall.

- Glass exhibits are mainly illuminated with white light as are all other exhibits; however, it also allows for the use of coloured light sources if desired to achieve a special ambience on the displays.

- Since glossy surfaces (including glass enclosures of display cases) are able to reflect light, they increase the perceived brightness of exhibits placed in glass enclosure display cases. By the same reason, glass pieces should be positioned in the space with sufficient distance between each other. If possible, open displays and matte surfaces are preferred.

- Since glass art works are very sensitive to light differences and every change of light with regard to transparency, artificial light sources are preferred to illuminate glass exhibits. However, if there is a desire to create a dynamic atmosphere, natural daylight might also be used for illumination.

c. As a result of the case studies in Chapter 4 (Case Studies: A Comparative Analysis of Architecture and Exhibition Design of Glass Museums in the Glass Age), the following inferences with regard to the literature and theoretical studies cited in this thesis can be made:

- For the comparative analyses of Architecture and Exhibition Design of Glass Museums in the Glass Age, one building each from three of the world's foremost glass museums is selected, of which the architectural and exhibition spaces were specially designed to house contemporary glass art exhibitions. In this regard:

  - The Contemporary Art and Design Wing of the Corning Museum of Glass was selected to exemplify the 'white cube' concept in exhibition design and its conceptual, spatial and technical assessments were made in terms of architectural and exhibition design.

  - The Main Building of the Shanghai Museum of Glass was selected to exemplify the 'black box' concept in exhibition design and its conceptual, spatial and technical assessments were made in terms of architectural and exhibition design.

- The Main Building of the Swarovski Kristallwelten, the so-called 'Giant,' was selected to exemplify the 'total work of art' concept in exhibition design and its conceptual, spatial and technical assessments were made in terms of architectural and exhibition design.

- As a result of the detailed assessment of one selected building from each of the three glass museums, the three concepts of exhibition design are already compared in a table at the end of Chapter 4 (Case Studies: A Comparative Analysis of Architecture and Exhibition Design of Glass Museums in the Glass Age" (see Table 6). The same table can be used for the design of exhibitions of contemporary glass art in other glass museums or glass galleries by benefiting from the following inferences:

  a. The 'white cube' concept is especially convenient when applied in spaces where hybrid glass art exhibitions, be they modern or contemporary, are exhibited and might include colourful glass art works made with various types of glass, made with mixed media or created with different glass-making techniques and methods in different concepts by a variety of artists, except for the achromatic glass-made works of art and the others lighter in colour value. Based on the following reasons:

     - It creates a vast and spacious sense of space and offers visitors a comfortable, safe feeling throughout the journey through the exhibition.
     - It allows perceptions of all the colours of each work of art equally in importance presented in the visual field and makes the space a background by simplifying it.
     - It bears the traces of modernism and is still used in modern glass museums. However, at the same time, it is used in glass museum spaces today where contemporary glass art is exhibited and which is developed as an 'overall white cube' thanks to contemporary approaches in architecture and exhibition design.

  b. The 'black box' concept is especially convenient when applied in spaces where contemporary glass art exhibitions are made with mixed media and glow in darkness are exhibited. They are comprised solely of digital art installations and/or physical works of art/installations that present the interplay of light, colour and material glass (e.g., light and space art installations, neon glass work of arts, plasma glass work of arts etc.). It is also quite convenient for exhibitions comprised of achromatic glass works of art and performance arts presented in virtual and physical spaces using technological devices (e.g., digital displays, projections etc.) or performed by artists, such as in hot glass blowing shows as glass blowers require darkness to see properly the liquid state (appearing radiant and reddish) and frozen state (appearing relatively

pale and in its intrinsic colour) of glass during their working process. Based on the following reasons:

- It creates an infinite, mysterious, and even lively, dynamic sense of space and it offers visitors an adventurous, curious and perhaps a somewhat suspicious feeling throughout the journey through an exhibition.
- It allows the perception of only the glass works and installations, except from the space itself.
- As much as they are presented in the field of vision, it provides a focused attention on solely the exhibits and makes the space a background by eliminating it from the visible field of vision.
- It allows the use of physical display cases/units or digital displays or a mix of both in the same place.
- It bears the traces of the contemporary approaches of postmodernism and the effects of New Media in exhibition design. It is widely used in glass museum spaces today where contemporary glass art is exhibited.

c. The 'total work of art' concept is especially convenient when applied in spaces where the architecturally involved glass art installations will be exhibited either with modern or with contemporary approaches (e.g., space experience installations, site-specific installations etc.), based on the following reasons:

- It creates a complementary sense of space and offers visitors a lively experience of exhibitions through multi-sensory perception.
- It allows the perception of the exhibition as a *whole* offering perception of displayed glass works and installations as well as perception of the space itself at an equal rate.
- It is designed holistically in an interdisciplinary approach of a team comprising various professions (e.g. artists, designers, interior architects, architects, etc.).
- It bears the traces of a previous revival of the old-age crystal metaphor at the beginning of the 20th century and it bears at the same time the traces of the current revival of the crystal glass metaphor that has already arisen in the Glass Age during the contemporary era.

Consequently, Chapter 2 of the thesis has given the theoretical background, Chapter 3 has provided information about the techniques in exhibition design (particularly in terms of lighting design and colour preference of the space) and perception that will benefit everyone in practice, from the artist who deals with glass to the architect who designs the space. Chapter 4 examined the information obtained in Chapter 3 by examining the concepts applied

in glass museums spaces and in the exhibition design of contemporary glass art comparatively over the cases. With this content as a whole, the thesis will be an important reference for designers, interior designers and architects in a general sense.

In addition, some further suggestions for further study for the practicing designer, interior architect and architect are outlined below:

- A further study is suggested for a comparison of the properties of light and colour.
- Due to the Glass Age giving glass art, design in glass and glass architecture equal importance, the study on glass science and technology is suggested so as to be able to design innovative spaces with smart technology in glass.
- Due to the number of glass museums rapidly increasing from the 1990s onwards and the beginnings of the exploration of innovative approaches in exhibition design and iconic architectural design, (interior) architects should research contemporary glass art more so than ever previously and be aware of the idea that 'transparency tells more than it presents.'[93]
- Evolutions in concepts of exhibition design and glass museum spaces show that physical glass exhibits started to be replaced slowly with digital works of arts, and so, the exhibition spaces started to be replaced slowly with virtual spaces. Therefore, in the design of the future's glass galleries, there might be designed an empty, visitor-centred, interactive, holistic white cube gallery with white, opaque, touch-operated smart glass walls thanks to the development of smart technology. By doing so, a more participatory, visitor-centred exhibition design can be achieved instead of today's object-centred, visually and spatially perceived representation techniques because the future of such museums lays in a multi-sensory perception of living exhibition experiences. Therefore, studying the topic of perception is advisable for those wishing to be exhibition designers or museum architects.

[93] The statement is inferred by the author based on the overall research throughout the study of the thesis.

REFERENCES

Aalto-Setälä, L. (2018). Functional Glasses for Glass Art. The Glass Path 47th Annual Conference, Murano, Italy.

Abu Dhabi City Municipality. (2014). *Abu Dhabi Public Realm & Street Lighting Handbook*. Abu Dhabi: Abu Dhabi City Municipality.

Ağatekin, M. (1998). Endüstriyel Ürün Tasarımında Fantezi. *Anadolu Sanat, 8*, 1-2.

Ağatekin, M. (2008). Cam Sanatında Işık Etkileri Ve Stanislav Libensky'nin Çalışmaları. *Anadolu Sanat, 19*, 8.

Ajmat, R., Sandoval, J., Arana Sema, F., O'donell, B., Gor, S., & Alonso, H. (2011). Lighting Design in Museums: Exhibition Vs. Preservation. *WIT Transactions on The Built Environment, 118*, 195-206.

Albers, J. (2013). *Interaction of Color* (50th Anniversary ed.). New Haven, Connecticut: Yale University Press.

Altıparmakoğlu Sakarya, G., & Mutlu Tunca, G. The "Order of Things" in Media Cube: Transparency as a Design Tool in Ntv News Studio. *Gazi University Journal of Science Part B: Art Humanities Design and Planning, 7*(2), 223-237.

Amheim, R. (1974). *Art and Visual Perception : Psychology of the Creative Eye*: CA: The University of California Press.

Anderson, B. L. (2011). Visual Perception of Materials and Surfaces. *Current Biology, 21*(24), R978-R983.

Andıç, L. (2000). *Turkish Glass Culture and Its Relationship with Contemporary Glass and Education* [PhD Dissertation, The University of Edinburgh]. Edinburgh, Scotland, UK. http://hdl.handle.net/1842/26119

Arup. (2019). Rethinking Lighting in Museums and Galleries. In. London, UK: Arup Lighting Design.

Atalayer, F. (2008). Cam Gizeminin Kavramsal Değerleri. *Anadolu Sanat, 19*, 25.

Aydın, M. (2008). Camın Tarihsel Sürecinde Pate De Verre Tekniği. *Anadolu Sanat, 19*, 29.

Aydın, M., & Ağatekin, M. (2010). Plastik Sanatlarda Cam Ve Tarihsel Gelişimi. CAMGERAN 2010 Uluslararası Katılımlı Uygulamalı Cam Sempozyumu, Eskişehir, Turkey.

Aydınlı, S. (1986). *Mekansal Değerlendirmede Algısal Yargılara Dayalı Bir Model* [PhD Dissertation, İstanbul Teknik Üniversitesi]. İstanbul, Turkey.

Balik, D. (2017). Ephemeral Transparency: Glass as a Reflective Screen and Opaque Veil in the New National Gallery. *Dearq. Revista de Arquitectura*(21), 146-153.

Ballato, J., & Dragic, P. (2016). Glass: The Carrier of Light-a Brief History of Optical Fiber. *International Journal of Applied Glass Science, 7*(4), 413-422.

Basirico, L. A. (1983). *Glass Consciousness: Social Organization and Social Interaction in the Stained Glass World* [PhD Dissertation, State University of New York at Stony Brook]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/303227678

Bayazıt, N. (2008). *Tasarımı Anlamak*. İstanbul, Turkey: İdeal Kültür.

Belcher, M. (1991). *Exhibitions in Museums*. Leicester, UK: Leicester University Press.

Benli, T. (2008). İçmekan Ve Donatılarının Çağdaşlaşma Sürecinde, Cam Malzemenin Yeri. *Anadolu Sanat, 19*, 43-44.

Berger, J. (2017). *Görme Biçimleri* [Ways of Seeing] (Y. Salman, Trans.). İstanbul, Turkey: Metis Yayınları.

Bird, M. (2016). *Sanatı Değiştiren 100 Fikir* [100 Ideas That Changed Art] (D. Öztok, Trans.). İstanbul, Turkey: Literatür Yayıncılık.

Birren, F. (1999). *Light, Color & Environment* (Rev ed.). US: Schiffer Publishing Ltd.

Bletter, R. H. (1981). The Interpretation of the Glass Dream-Expressionist Architecture and the History of the Crystal Metaphor. *Journal of the Society of Architectural Historians, 40*(1), 20-43. https://doi.org/10.2307/989612

Blitzer, W. F. (2003). Light in Design – an Application Guide. *Illuminating Engineering Society Consumer Publication CP-2-10*. (Illuminating Engineering Society)

Bonomo, M. (2015). *Important 20th Century Art Glass: The Untold Story of the Sturdy-Lange Company* [M.A., Sotheby's Institute of Art - New York]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/1728065224

Bridge, N. (2017). *Mimari Üsluplar, Önemli Yapılar Ve Ünlü Mimarlar Hakkında Bilmeniz Gereken Her Şey* [Architecture 101: From Frank Gehry to Ziggurats, an Essential Guide to Building Styles and Materials] (F. Sezer, Trans.). İstanbul, Turkey: Say Yayınları.

Brooker, G., & Stone, S. (2012). *İç Mimarlıkta: Bağlam + Çevre* [Form and Structure : The Organisation of Interior Space] (C. Uçar, Trans.; Vol. 02). İstanbul, Turkey: Literatür Yayıncılık.

Brown, M., & Brown, A. (2008). *Color Vision: One of Nature's Wonders*. Retrieved 05.10.2018 from http://www.clivemaxfield.com/diycalculator/sp-cvision.shtml

Brusatin, M. (1992). *A History of Colors*: Shambhala Publications Inc.

Bugler, C., Kramer, A., Weeks, M., Whatley, M., & Zaczek, I. (2017). *Sanat Kitabı* [The Art Book] (A. Fethi, Trans.). İstanbul, Turkey: Alfa Yayıncılık.

Butterfield, J., Machugh, J., Irwin, R., Turrell, J., Nordman, M., Wheeler, D., Nauman, B., Orr, E., Bell, L., & Valentine, D. (1993). *The Art of Light+ Space*. New York: Abbeville Press.

Ching, F. D., & Binggeli, C. (2012). *Interior Design Illustrated* (3 ed.). New Jersey, USA: John Wiley & Sons.

Coirier, L. (2013). *Glass Is Tomorrow*: Pro Materia asbl /New TLmag.

Coles, J., & House, N. (2012). *İç Mimarlığın Temelleri* [The Fundamentals of Interior Architecture] (Z. Vaizoğlu & M. Yıldırım, Trans.). İstanbul, Turkey: Literatür Yayıncılık.

Corning Museum of Glass. (1959). *Glass 1959 : A Special Exhibition of International Contemporary Glass*. Corning, New York, USA: Corning Museum of Glass.

Cosgrove, R. E. (1936). *An Investigation of the Influences of Certain Twentieth Century Techniques on Design in Glass* [Master Thesis, University of Southern California]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/1627114403

Cummings, K. (2011). *Çağdaş Cam Sanatı Fırın Teknikleri Ve Uygulamalar* (M. Ağatekin, Trans.). İzmir, Turkey: Karakalem Kitabevi Yayınları.

Da Vinci, L. (2012). *The Notebooks of Leonardo Da Vinci* (Vol. 1). Dover, UK: Courier Corporation.

David Pye, L. (2016). Arrival of the Glass Age Affirmed. *International Journal of Applied Glass Science, 7*(4), 407-408.

Demirörs, Ç. (1994). *Perception and Evaluation of Spaciousness in Interior Spaces* [Master Thesis, Bilkent University]. Ankara, Turkey. http://hdl.handle.net/11693/17564

Dodsworth, S., & Anderson, S. (2018). *İç Mekan Tasarımının Temelleri* [The Fundamentals of Interior Design] (N. Işık, Trans.; Vol. 02). İstanbul, Turkey: Literatür Yayıncılık.

Duan, B. Q. (2011). *On the Combination and Development of Crafts of Glass and the Installation Art* [Master Thesis, Tsinghua University (People's Republic of China)]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/1874428247

Edwards, B. (2004). *Color by Betty Edwards: A Course in Mastering the Art of Mixing Colors*. New York, USA: TarcherPerigee.

Elhawary, S. (2014). *Lighting System in Interior Design for Modern Administration Buildings*. Riga, Latvia: Lap Lambert Academic Publishing.

Erdemir, E. (1993). *Culture-Space Relationship: Japanese Traditional Residential Interiors* [Master Thesis, Bilkent University]. Ankara, Turkey.

Eskilson, S. (2018). *The Age of Glass: A Cultural History of Glass in Modern and Contemporary Architecture*. London, UK: Bloomsbury Publishing.

Fielder, W. J., & Jones, F. H. (2001). *The Lit Interior*. Cornwall, Great Britain: Routledge.

Fies, T., & Mathers, M. (2009). *The Basics of Efficient Lighting: A Reference Manual for Training in Efficient Lighting Principles*. Australia: National Framework for Energy Efficiency.

Forrest, R. (2015). *Design Factors in the Museum Visitor Experience* [PhD Dissertation, The University of Queensland]. Queensland, Australia.

Fu, L. J. (2011). *The Strange and Supernatural Element in the Glass Art* [Master Thesis, Shanghai University (People's Republic of China)]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/1873856887

Gagg, R. (2013). *İç Mimarlıkta; Doku + Malzeme* [Basics interior architecture 05: Texture+ materials] (C. Uçar, Trans.; Vol. 5). İstanbul, Turkey: Literatür Yayıncılık.

Ganslandt, R., & Hofmann, H. (1992). *Handbook of Lighting Design*. Germany: ERCO Leuchten GmbH.

Gordon, G. (2003). *Interior Lighting for Designers* (4 ed.). New Jersey, USA: John Wiley & Sons.

Grey, C. (2004). *Master Lighting Guide for Portrait Photographers*. New York, USA: Amherst Media.

Griffin, M. (2016). Crystal Clear: An Analysis of Swarovski Crystals' Human Resource Management Strategy and the Influence of Generation Y. *Best Business Research Papers, 9*, 50.

Grzymkowski, E. (2017). *Sanat 101 (Leonardo Da Vinci'den Andy Warhol'a Sanat Hakkında Bilmeniz Gereken Her Şey)* [Art 101: From Vincent van Gogh to Andy Warhol, Key People, Ideas, and Moments in the History of Art] (O. Düz, Trans.). İstanbul, Turkey: Say Yayınları.

Hall, C. M., & Page, S. J. (2014). *The Geography of Tourism and Recreation: Environment, Place and Space*. UK: Routledge.

Holtzschue, L. (2009). *Rengi Anlamak-Tasarımcılar İçin Kılavuz Kitap* [Understanding color: an introduction for designers] (F. Akdenizli, Trans.). İzmir, Turkey: Duvar Yayınları.

Hong, Y. (2006). *A Research on Exhibition and Installing Form of Contemporary Glass Art* [Master Thesis, National Changhua University of Education]. Changhua, Taiwan. https://hdl.handle.net/11296/4c82kb

Hurlbert, A., & Ling, Y. (2017). Understanding Colour Perception and Preference. In *Colour Design* (pp. 169-192). Amsterdam, Netherlands: Elsevier.

Itten, J. (1970). *Itten: The Elements of Color* (E. V. Hagen, Trans.; F. Birren, Ed.). New Jersey, USA: John Wiley & Sons.

Japee, S. A., & Schiler, M. E. (1997). Interior Illuminance, Daylight Controls and Occupant Response. *Vital Signs Curriculum Materials Project*.

Karcher, A., Krautter, M., Kuntzsch, D., Schielke, T., Steinke, C., & Takagi, M. (2010). *Light Perspectives*. Lüdenscheid, Germany: ERCO Press Office.

Karlen, M., Spangler, C., & Benya, J. R. (2017). *Lighting Design Basics*. New Jersey, USA: John Wiley & Sons.

King, C. S. (1996). *Designing with Glass: The Creative Touch*: PBC International.

Kleiner, F. S., & Mamiya, C. J. (2009). *Gardner's Art through the Ages: The Western Perspective* (Vol. 2). Belmont, California, USA: Wadsworth Publishing.

Kocabağ, D. (2002). *Cam: Kimyası, Özellikleri, Uygulaması*: Birsen Yayınevi.

Kula, E. (2014). *Recycled Foam from Glass and Its Usage in Artistic Glass Art*. http://www.turkser.org.tr/seres14/docs/bildiri_ozetleri/art/AR-23.pdf

Kula, E. (2018). Pate De Verre Ve Krİstal Şeker Görünümlü Tasarimlar. *İdil Sanat ve Dil Dergisi, 7*(48), 1043-1049.

Kuo, C.-Y. (2010). *The Relations of Boys' and Girls' Interest with Their Mothers' Art and Science Talk: The Case of Visiting the Chihuly's Firework of Glass Exhibit* [PhD Dissertation, Indiana University]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/750052607

Kurtay, C., Aybar, U., Başkaya, A., & Aksulu, I. (2003). Müzelerde Algılama Ve Aydınlatma Kriterlerinin Analizi: Ankara-Anadolu Medeniyetleri Müzesi Orta Holü. *Gazi Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi, 18*(2), 95-113.

Küçükerman, Ö. (1985). *Art of Glass and Traditional Turkish Glassware*. İstanbul, Turkey: Türkiye İş Bankası Kültür Yayınları.

Langes-Swarovski, M. (2017). *Architecture Collection*. Wattens, Austria: D. Swarovski Distribution GmbH.

Licht, F. G. (2000). Good Lighting for Museums, Galleries and Exhibitions 18.

Locker, P. (2017). *Basics Interior Design 02: Exhibition Design*. London, UK: Bloomsbury Publishing.

Lorente, J. P. (2016). *Çağdaş Sanat Müzeleri* (Ş. Öztürk, Trans.). İstanbul, Turkey: Koç Üniversitesi Yayınları.

Lynn, M. D. (2000). *Challenging Boundaries: The History and Reception of American Studio Glass 1960 to 1990* [PhD Dissertation, University of Southern California]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/304624785

Macdowell, B. A. (1986). *American Women Stained Glass Artists, 1870s to 1930s: Their World and Their Windows* [PhD Dissertation, Michigan State University]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/303500349

Melvin, J. (2006). *İzmler Mimarlığı Anlamak* (M. Şahin, Trans.). İstanbul, Turkey: YEM Yayınevi.

Merleau-Ponty, M. (1981). *Phenomenology of Perception* (C. Smith, Trans.). UK: Routledge and Kegan Paul.

Mesher, L. (2013). *İç Mekan Tasarımında Mağaza Tasarımı* [Basics Interior Design 01: Retail Design]. İstanbul, Turkey: Literatür Yayınları.

Miller, T. (2015). Paul Scheerbart and the Utopia of Glass. *Serbian Architectural Journal*, 88. (University of California)

Moholy-Nagy, L. (1930). *Light and Glass Abstraction*. Dezeen. Retrieved 08.04.2018 from https://www.wright20.com/auctions/2018/06/important-design/106

Morse, D. L., & Evenson, J. W. (2016). Welcome to the Glass Age. *International Journal of Applied Glass Science, 7*(4), 409-412.

Mulder, K. L. (2007). *New Rationales for Neues Glas: Architectonic Considerations in Postwar German Glass Installations* [PhD Dissertation, University of Virginia]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/304806553

Naredi-Rainer, P., & Hilger, O. (2004). *Museum Buildings: A Design Manual*. Hudson, New York, USA: Princeton Architectural Press.

Neufert, E., & Neufert, P. (2012). *Architects' Data* (4th ed.). New Jersey, USA: John Wiley & Sons.

O'doherty, B. (2010). *Beyaz Küpün İçinde, Galeri Mekânının İdeolojisi* [Inside the White Cube: The Ideology of the Gallery Space] (A. Antmen, Trans.). İstanbul, Turkey: Sel Yayıncılık.

Ocvirk, O. G., Stinson, R. E., Wigg, P. R., Bone, R. O., & Cayton, D. L. (2015). *Sanatın Temelleri Teori Ve Uygulama* [Art Fundamentals: Theory and Practice] (N. B. Kuru, Trans.). İzmir, Turkey: Karakalem Kitabevi Yayınları.

Olcay, B. Y. (1998). Cam Sanatı Tarihi İçinde Bizans Döneminin Yeri. *Anadolu Sanat, 8*, 146.

Oldknow, T. (2011). *Contemporary Czech Sculpture*. The Corning Museum of Glass. Retrieved 05.10.2018 from https://www.cmog.org/article/contemporary-czech-sculpture

Olla, A. (2014). *The Impact of Perceptions on Built Form: A Proposed Transport Interchange for Durban* [Master Thesis, University of KwaZulu-Natal]. KwaZulu-Natal, South Africa.

Pepperell, R. (2012). The Perception of Art and the Science of Perception. Human vision and electronic imaging XVII,

Per, M. (2012). Renk Teorilerine Tarihsel Bir Bakış. *İzmir: Yedi: Sanat, Tasarım ve Bilim Dergisi*(8), 17-26.

Petru, S. (2010). The Power of Colour. *L 'art pléistocène dans le monde/Pleistocene art of the world/Arte pleistoceno en el mundo, Actes du Congrès IFRAO, Tarascon-sur-Ariège*.

Petty, M. M. (2007). Illuminating the Glass Box: The Lighting Designs of Richard Kelly. *Journal of the Society of Architectural Historians, 66*(2), 194-219.

Phillips, D. (2000). *Lighting Modern Buildings*. UK: Routledge.

Plümacher, M., & Holz, P. (2007). *Speaking of Colors and Odors* (Vol. 8): John Benjamins Publishing.

Ramsey, C. G., Sleeper, H. R., & Packard, R. T. (1981). *Ramsey/Sleeper Architectural Graphic Standards*. New Jersey, USA: John Wiley & Sons.

Raynham, P., & Boyce, P. (2009). *The Sll Lighting Handbook*. London, UK: The Society ofLight and Lighting.

Richard, J. T. (2004). Understanding Solids: The Science of Materials. In. New Jersey, USA: John Wiley & Sons.

Rowe, C., & Slutzky, R. (1997). *Transparency : With a Commentary by Bernhard Hoesli and an Introduction by Werner Oechslin*. Boston, USA: Birkhäuser Architecture.

Russell, S. (2012). *The Architecture of Light - Architectural Lighting Design Concepts and Techniques*. California, USA: Conceptnine Print Media.

Ryder, M. (2013). *Forming a New Art in the Pacific Northwest: Studio Glass in the Puget Sound Region, 1970–2003* [PhD Dissertation, Portland State University]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/1426829037

Safavi, S. (2013). *Effects of Design Principles on Visitors' Perception in Museum Spaces* [Master Thesis, Eastern Mediterranean University (EMU)-Doğu Akdeniz Üniversitesi (DAÜ)]. Gazimağusa.

Shepard, M. B. (1990). *The Thirteenth Century Stained Glass from the Parisian Abbey of Saint-Germain-Des-Pres* [PhD Dissertation, Columbia University]. ProQuest Dissertations & Theses Global. Ann Arbor, Michigan, USA. https://search.proquest.com/docview/303839594

Shishegar, N., & Boubekri, M. (2016). Natural Light and Productivity: Analyzing the Impacts of Daylighting on Students' and Workers' Health and Alertness. Proceedings of the International Conference on "Health, Biological and Life Science"(HBLS-16), İstanbul, Turkey.

Singh, I. (2012). *Color, Facture, Art and Design: Artistic Technique and the Precisions of Human Perception*. Winchester, UK: John Hunt Publishing.

Soliman, O. (2013). Perception of Building Materials in Architecture. *Journal of Engineering and Applied Science, 60*(6), 1-23.

Solso, R. L. (2003). *The Psychology of Art and the Evolution of the Conscious Brain*. Cambridge, Massachusetts, USA: MIT Press.

Sotheby's. (2018). *Glass Art through the Ages*. Sotheby's Museum Network. Retrieved 13.05.2019 from https://museumnetwork.sothebys.com/en/articles/glass-art-through-the-ages

Spankle, R. (2012). *İç Mekan Çizimi Ve Sunumu* [Drawing Out the Interior] (Z. Vaizoğlu, Trans.; Vol. 03). İstanbul, Turkey: Literatür Yayınları.

Stacher, S. (2018). *Sublime Visions: Architecture in the Alps*. Basel, Switzerland: Birkhäuser.

Stejskalová, J. (2016). Whether and How the Gallery Space and Exhibited Artworks Affect Each Other? In. Porto, Portugal: Universidade do Porto.

Steuben Glass, I. (1983). *How to Display Steuben Glass*. New York, USA: Steuben Glass.

Styhre, A. (2008). *Perception and Organization: Art, Music, Media*. Basingstoke, UK: Palgrave Macmillan.

Swarovski Kristallwelten. (2019). *Press Information*. Wattens, Tyrol, Austria: D. Swarovski Tourism Services GmbH.

Swarovski Lighting Ltd. (2013). *Swarovski Architectural Solutions Brochure*. Wattens, Austria: Swarovski Lighting, Ltd. .

Sylvania, F. (2015). *Lighting for Museums and Galleries*: Havells Sylvania Europe Ltd.

The Corning Museum of Glass. (2014). *Fact Sheet*. The Corning Museum of Glass. Retrieved 10.10.2019 from http://www.cmog.org/sites/default/files/2014_Corning_Museum_of_Glass_Fact_Sheet.rtf

Tilley, R. J. (2011). *Colour and the Optical Properties of Materials*. New Jersey, USA: John Wiley & Sons.

Tregenza, P., & Loe, D. (2013). *The Design of Lighting*. UK: Routledge.

Weiermair, K., Keller, P., Pechlaner, H., & Go, F. M. (2010). *Innovation and Entrepreneurship: Strategies and Processes for Success in Tourism*. Berlin, Germany: Erich Schmidt Verlag GmbH & Co KG.

Wilkinson, P. (2010). *Gerçekten Bilmeniz Gereken 50 Mimarlık Fikri* [50 Architecture Ideas You Really Need To Know] (V. Atmaca, Trans.). İstanbul, Turkey: Domingo Yayınevi.

Wingler, H. M. (1969). *The Bauhaus: Weimar, Dessau, Berlin, Chicago* (W. Jabs & B. Gilbert, Trans.; J. Stein, Ed.). Cambridge, Massachusetts, USA: MIT Press.

Witschen, J. (2013). Swarovski: Analysis and Recommendations. *How They Could Impact the Largest Swiss Watch Company, Swatch Group*, 98.

Wördenweber, B., Boyce, P., Hoffman, D. D., & Wallaschek, J. (2007). *Automotive Lighting and Human Vision* (Vol. 1): Springer.

Yılmaz Yatır, S. (2015). *Towards Freedom*. Höhr-Grenzhausen, Germany.

Zeytinoglu, A. (2011). *Geometry of Light: The Architecture of Arkan Zeytinoglu*. Vienna, Austria: Springer Vienna Architecture.

Internet Sources:

Url 2.1. *Vase in "Acanthus Leaf" Pattern*. The Corning Museum of Glass. Retrieved 07.02.2018 from https://www.cmog.org/artwork/vase-acanthus-leaf-pattern

Url 2.2. *Automobile Mascot, Vitesse (Speed)*. The Corning Museum of Glass. Retrieved 07.02.2018 from https://www.cmog.org/press-release/corning-museum-glass-organizes-exhibition-dedicated-glass-ren-lalique

Url 2.3. *Favrile Vase with Peacock Feather Plique À Jour Mount*. The Corning Museum of Glass. Retrieved 10.02.2018 from https://www.cmog.org/artwork/vase-peacock-feather-plique-jour-mount

Url 2.4. *Timeline of Glass History*. The Corning Museum of Glass. Retrieved 10.02.2018 from https://www.cmog.org/visit/schools-groups-and-scouts/school-tours/resources/timeline-glass-history

Url 2.5. *Tiffany Glass*. Antique-Marks. Retrieved 13.02.2018 from https://antique-marks.com/tiffany.html

Url 2.6. *Deutscher Werkbund*. Encyclopaedia Britannica. Retrieved 13.02.2018 from https://www.britannica.com/topic/Deutscher-Werkbund

Url 2.7. *Mies Van Der Rohe: The Modernist Architect Who Led the Bauhaus to Its End*. Dezeen. Retrieved 16.02.2018 from https://www.dezeen.com/2018/11/19/mies-van-der-rohe-modernist-architect-third-director-bauhaus-100

Url 2.8. *Glass: New Glass and Studio Glass*. European Museum of Modern Glass. Retrieved 16.02.2018 from https://glasmuseum.kunstsammlungen-coburg.de/en/collections/glass

Url 2.9. *Sybren Valkema, the Nestor of Vrij Glas 'Free Glass' in Europe*. Vrij Glas Foundation. Retrieved 21.02.2018 from http://www.vrijglas.org/detail.php?id=18

Url 2.10. *The Glass Age*. Corning Incorporated. Retrieved 22.02.2018 from https://www.corning.com/worldwide/en/innovation/the-glass-age.html

Url 2.11. *Mustafa Ağatekin Portfolio*. Mustafa Ağatekin. Retrieved 08.03.2018 from http://mustafagatekin.com/index.php/2005-2

Url 2.12. *Ekrem Kula Portfolio*. Ekrem Kula. Retrieved 08.03.2018 from https://i1.rgstatic.net/ii/profile.image/858333313499137-1581654017764_Q512/Ekrem_Kula.jpg

Url 2.13. *Hide-and-Seek*. Fatma Çiftçi. Retrieved 11.03.2018 from https://www.fatmaciftci.com.tr/2019?lightbox=dataItem%20jykhlgir

Url 2.14. *White Cube*. Larry Bell. Retrieved 11.03.2018 from http://digicult.it/news/white-cube-larry-bell-6x6-an-improvisation

Url 2.15. *The Elliptical Glass*. James Turrell. Retrieved 12.03.2018 from https://haeusler-contemporary.com/james-turrell-the-elliptical-glass_en

Url 2.16. *Vulkaneifel*. Judith Röder. Retrieved 12.13.2018 from https://judithroeder.myportfolio.com/vulkaneifel

Url 2.17. *Kursk III*. Jens Gussek. Retrieved 15.03.2018 from http://www.jens-gussek.de/en/works+%232/KURSK+III+.+2012%0Aglass%2C+iron%2C+latex+.+12.html?view=l&n=1153;1379&lang=en&

Url 2.18. *A Part of You*. Verena Schatz. Retrieved 16.03.2018 from http://www.verenaschatz.com/a-part-of-you-2012111

Url 2.19. *Transmission*. Verena Schatz. Retrieved 17.03.2018 from http://www.verenaschatz.com/transmission-20122111

Url 2.23. *The Crystal Palace*. Wikimedia Foundation, Inc. Retrieved 22.03.2018 from https://en.wikipedia.org/wiki/The_Crystal_Palace

Url 2.24. *The Great Exhibition at the Crystal Palace*. Magic Lantern World. Retrieved 22.03.2018 from https://magiclanternist.com/2017/08/05/magic-lantern-slide-crystal-palace

Url 2.25. *The Crystal Palace Exhibition*. The Victorian-Era. Retrieved 25.03.2018 from http://victorian-era.org/crystal-palace-exhibition.html

Url 2.26. *Glass Pavilion*. Architectuul. Retrieved 23.03.2018 from http://architectuul.com/architecture/glass-pavilion

Url 2.27. *Bruno Taut*. Architectuul. Retrieved 26.03.2018 from http://architectuul.com/architect/bruno-taut

Url 2.28. *Werkbund Exhibition (1914)*. Wikimedia Foundation, Inc. Retrieved 24.03.2018 from https://en.wikipedia.org/wiki/Werkbund_Exhibition_(1914)

Url 2.29. *International Exhibition of Modern Decorative and Industrial Arts*. Wikimedia Foundation, Inc. Retrieved 29.03.2018 from https://en.wikipedia.org/wiki/International_Exhibition_of_Modern_Decorative_and_Industrial_Arts

Url 2.30. *René Lalique*. The Corning Museum of Glass. Retrieved 29.03.2018 from https://www.cmog.org/article/lalique

Url 2.31. *Dale Chihuly*. Chihuly Garden and Glass. Retrieved 01.04.2018 from https://www.chihulygardenandglass.com/about/dale-chihuly

Url 2.32. *Exhibition*. Chihuly Garden and Glass. Retrieved 01.04.2018 from https://www.chihulygardenandglass.com/about/exhibition

Url 2.33. *Story*. Chihuly Garden and Glass. Retrieved 02.04.2018 from https://www.chihulygardenandglass.com/about/story

Url 2.34. *Photo Tour: Chihuly at Biltmore*. Explore Asheville. Retrieved 04.04.2018 from https://www.exploreasheville.com/blog/post/photo-tour-chihuly-at-biltmore

Url 2.35. *Chihuly Garden and Glass*. Chihuly, Inc. Retrieved 04.04.2018 from https://www.chihuly.com/exhibitions/chihuly-garden-and-glass/chihuly-garden-and-glass

Url 2.36. *Chihuly by Samantha Shipley*. Tes Global Ltd. Retrieved 04.04.2018 from https://www.tes.com/lessons/EGU8QikZORf_eQ/chihuly

Url 2.37. *The Story of the World's First Public Museum*. The Ashmolean Museum. Retrieved 05.04.2018 from https://www.ashmolean.org/article/the-story-of-the-worlds-first-public-museum

Url 2.39. *Art Term: White Cube*. TATE. Retrieved 06.04.2018 from https://www.tate.org.uk/art/art-terms/w/white-cube

Url 2.40. *The Renovated Moma*. Travel + Leisure Group. Retrieved 06.04.2018 from https://www.travelandleisure.com/attractions/museums-galleries/moma-renovation-closing

Url 2.41. *Moma: Expanded and Refreshed*. Los Angeles Review of Books. Retrieved 08.04.2018 from https://lareviewofbooks.org/article/moma-expanded-refreshed

Url 2.42. *Art Term: Black Box*. TATE. Retrieved 08.04.2018 from https://www.tate.org.uk/art/art-terms/b/black-box

Url 2.43. *Corning Museum of Glass - Iwan Baan*. Thomas Phifer and Partners. Retrieved 09.04.2018 from https://www.thomasphifer.com/projects/corning-museum-of-glass-iwan-baan

Url 2.44. *World's First 'Digital-Only Art Museum' Set to Wow in Tokyo*. Clad Global. Retrieved 09.04.2018 from https://www.cladglobal.com/CLADnews/architecture_design/teamLab-Digital-Art-Museum-Mori-Building-Company-Borderless-Toshiyuki-Inoko/338010

Url 2.45. *Shanghai Museum of Glass Opens*. Senatus Pte Ltd. Retrieved 11.04.2018 from https://senatus.net/article/shanghai-museum-glass-opens

Url 2.46. *Toyama Glass Art Museum: Contemporary Glass Art Exhibitions*. Matcha, Inc. Retrieved 11.04.2018 from https://matcha-jp.com/en/1585

Url 2.47. *Gesamtkunstwerk: Definition & Examples*. Study.com. Retrieved 13.04.2018 from https://study.com/academy/lesson/gesamtkunstwerk-definition-examples.html

Url 2.49. *The Giant*. Swarovski Group. Retrieved 15.04.2018 from https://kristallwelten.swarovski.com/Content.Node/wattens/Chamber_Of_Wonder_Exhibition_Swarovski_Kristallwelten.en.html

Url 2.50. *Transparent Opacity*. Swarovski Group. Retrieved 15.04.2018 from https://kristallwelten.swarovski.com/Content.Node/wattens/Arik_Levy_Exhibition.en.html

Url 2.51. *Chandelier of Grief*. Swarovski Group. Retrieved 15.04.2018 from https://kristallwelten.swarovski.com/Content.Node/wattens/Chandelier_of_Grief.en.html

Url 3.1. *Electromagnetic Spectrum*. Sapling Learning. Retrieved 20.05.2018 from https://sites.google.com/site/chempendix/em-spectrum

Url 3.2. *Meaning of Glass in English*. Lexico Powered by Oxford. Retrieved 20.05.2018 from https://www.lexico.com/definition/glass

Url 3.3. *Chemistry of Glass*. The Corning Museum of Glass. Retrieved 20.05.2018 from https://www.cmog.org/article/chemistry-glass

Url 3.4. *What Is Glass?* The Corning Museum of Glass. Retrieved 21.05.2018 from https://www.cmog.org/article/what-is-glass

Url 3.5. *Exhibition Tapio Wirkkala*. Fondazione Musei Civici di Venezia. Retrieved 21.05.2018 from https://museovetro.visitmuve.it/en/mostre-en/archivio-mostre-en/exhibition-tapio-wirkkala/2019/03/18305/exhibition-2/

Url 3.6. *Vestment Ii 1997 Stanislav Libensky Czech*. The Metropolitan Museum of Art. Retrieved 22.05.2018 from https://www.metmuseum.org/art/collection/search/490742

Url 3.7. *Glasgow Museums Display Guidelines*. Glasgow City Council. Retrieved 22.05.2018 from https://www.britishcouncil.in/sites/default/files/guidelines_for_museum_display.pdf

Url 3.8. *Apple Store 5th Avenue Ny*. ScoopNest. Retrieved 23.05.2018 from https://www.scoopnest.com/user/thecoolhunter/1171757021084864512-apple-store-5th-avenue-ny-covered-in-iridescent-tape

Url 3.9. *Apple Store 5th Avenue Ny*. ArchDaily. Retrieved 23.05.2018 from https://www.archdaily.com/925305/apple-store-fifth-avenue-foster-plus-partners

Url 3.10. *Tiffany Glass*. Wikipedia. Retrieved 23.05.2018 from https://en.wikipedia.org/wiki/Tiffany_glass

Url 3.11. *Ancient and Modern Glass from the Permanent Collection*. Tampa Museum of Art. Retrieved 24.05.2018 from https://tampamuseum.org/exhibition/ancient-and-modern-glass-from-the-collection-ancient-glass-a-closer-look/

Url 3.12. *Photochromism Glass*. The Corning Museum of Glass. Retrieved 24.02.2018 from https://www.corning.com/worldwide/en/products/advanced-optics/product-materials/specialty-glass-and-glass-ceramics/ophthalmic-glass/photochromism.html

Url 3.13. *Photochromic Lenses*. Essilor India Private Ltd. Retrieved 24.05.2018 from https://www.essilorindia.com/products/adaptive-photochromic-lenses

Url 3.14. *Photochromic Windows*. Efficient Windows Collaborative. Retrieved 25.05.2018 from https://www.commercialwindows.org/photochromic.php

Url 3.15. *Photochromic Lenses: Transitions and Other Light-Adaptive Lenses*. AAV Media, LLC. Retrieved 25.05.2018 from https://www.allaboutvision.com/lenses/photochromic.htm

Url 3.16. *Conversation: Kim Harty, the Curator of the Streetkraft Exhibition at Habatat, on the Genesis of This Atypical Gallery Exhibition*. UrbanGlass. Retrieved 27.05.2018 from https://urbanglass.org/glass/detail/conversation-kim-harty-the-curator-of-the-streetkraft-exhbition-at-habatat-on-the-genesis-of-this-atypical-gallery-exhibition

Url 3.17. *Chihuly Collection*. The Morean Arts Center. Retrieved 27.05.2018 from https://www.moreanartscenter.org/chihuly/

Url 3.18. *Alena Matějka - Czech Republic*. European Glass Festival. Retrieved 27.05.2018 from https://www.facebook.com/pg/EuropeanGlassFestival/photos/?tab=album&album_id=2330761166969609

Url 3.19. *Piotr Ostrowski*. Stained Glass Museum. Retrieved 28.05.2018 from https://muzeumwitrazu.pl/temporary-exhibitions/

Url 3.20. *Tobias Møhl*. Heller Gallery. Retrieved 28.05.2018 from http://www.hellergallery.com/tobias-mohl

Url 3.21. *Ekrem Kula*. European Glass Festival. Retrieved 29.05.2018 from http://www.europeanglassfestival.com/en/node/120

Url 3.22. *Exhibition: Mireille Perron's "Glass Menagerie" Explores Decorative Glass, Museology, and the Natural World*. UrbanGlass. Retrieved 29.05.2018 from https://urbanglass.org/glass/detail/exhibition-mireille-perrons-glass-menagerie

Url 3.23. *Member Spotlight: Masahiro Sasaki*. Glass Art Society. Retrieved 30.05.2018 from https://www.glassart.org/masahiro-sasaki/

Url 3.24. *Glass Art Changing in 21st Century, 47th International Exhibition*. The Oakland Press. Retrieved 30.05.2018 from https://www.theoaklandpress.com/entertainment/glass-art-changing-in-st-century-th-international-exhibition/article_5ec2bfa2-6d1a-11e9-9b2f-effc02fe5042.html

Url 3.25. *Light Charmer: Neon and Plasma in Action*. Houston Center for Contemporary Craft. Retrieved 01.06.2018 from https://www.crafthouston.org/exhibition/light-charmer/

Url 3.26. *Rui Sasaki Chosen for the 33rd Corning Museum of Glass Rakow Commission*. UrbanGlass. Retrieved 01.06.2018 from https://urbanglass.org/glass/detail/corning-reveals-the-work-of-rui-sasaki-the-creator-of-the-33rd-rakow-commission

Url 3.27. *Empoli Glass*. Google Arts & Culture. Retrieved 02.06.2018 from https://artsandculture.google.com/exhibit/gQEMcuoK

Url 3.28. *Chihuly Garden and Glass*. Chihuly, Inc. Retrieved 02.06.2018 from https://www.chihuly.com/exhibitions/chihuly-garden-and-glass/chihuly-garden-and-glass

Url 3.29. *Beautiful Blown Glass by the Late*. Habatat Galleries. Retrieved 04.06.2018 from https://www.facebook.com/habatatgalleriesfl/photos/a.1293943263976893/2847194721985065/

Url 3.30. *Glass Experience Museum*. ZIBA Prague. Retrieved 04.06.2018 from https://www.youtube.com/watch?v=FWB7nv6rjWk

Url 3.31. *Self*. Verena Schatz. Retrieved 07.06.2018 from http://www.verenaschatz.com/self

Url 3.32. *Mustafa Ağatekin Cam Sergisi*. Nurol Sanat Galerisi. Retrieved 07.06.2018 from https://www.nurolsanat.com/mustafa-agatekin-cam-sergisi.html

Url 3.33. *Listen to Me*. Jens Gussek. Retrieved 07.06.2018 from https://www.mutualart.com/Artwork/Listen-to-me/3D00EAA7399C44A7

Url 3.34. *Green Eye of the Pyramid*. Libensky, S & Brychtova, J. Retrieved 08.06.2018 from https://www.bidsquare.com/online-auctions/rago/libensky-brychtova-green-eye-of-the-pyramid-697952

Url 3.35. *Hektor by Jon Kuhn*. Habatat Galleries. Retrieved 10.06.2018 from https://www.facebook.com/habatatgalleriesfl/photos/a.209392582431972/2785710418133496/

Url 3.36. *Traps I-V*. Jesse Magee. Retrieved 11.06.2018 from http://www.jessemagee.net/show.html?work=traps

Url 3.37. *Vierzehn X 0*. Lena Feldmann. Retrieved 13.06.2018 from http://lena-feldmann.com/vierzehn-x-0/

Url 4.1. *The Corning Museum of Glass Is Getting Bigger and Better*. Steuben County Conference & Visitors Bureau. Retrieved 10.07.2018 from https://www.corningfingerlakes.com/steuben-stories/post/corning-museum-glass-getting-bigger-and-better

Url 4.2. *About Us*. The Corning Museum of Glass. Retrieved 10.07.2018 from https://www.cmog.org/about

Url 4.3. *Corning Museum of Glass in New York Unveils North Wing Expansion Design*. Compelo Ltd. Retrieved 10.07.2018 from http://www.designcurial.com/news/corning-museum-of-glass-in-new-york-unveils-north-wing-expansion-design

Url 4.4. *Innovation Center*. The Corning Museum of Glass. Retrieved 10.10.2018 from https://www.cmog.org/collection/innovation-center

Url 4.5. *A Collection of Modern Glass Architecture*. The Corning Museum of Glass. Retrieved 11.10.2018 from https://www.cmog.org/about/architecture

Url 4.6. *Corning Museum of Glass Has a New Reflective Wing*. Shaping Beauty. Retrieved 15.10.2018 from http://www.shapingbeauty.net/item/325-corning-museum-of-glass-has-a-new-reflective-wing.html

Url 4.7. *Corning Museum of Glass / Thomas Phifer and Partners*. ArchDaily. Retrieved 20.10.2018 from https://www.archdaily.com/611498/corning-museum-of-glass-thomas-phifer-and-partners/550b2a84e58ece1511000106-corning_museum_tpp_0275-jpg

Url 4.8. *New Glass Now*. The Corning Museum of Glass. Retrieved 09.11.2018 from https://www.cmog.org/collection/exhibitions/new-glass-now

Url 4.9. *World's Largest Space for Contemporary Glass Art Lets in the Light*. Hyperallergic Media Inc. Retrieved 21.11.2018 from https://hyperallergic.com/191723/worlds-largest-space-for-contemporary-glass-art-lets-in-the-light

Url 4.10. *Corning Museum of Glass Thomas Phifer and Partners 013*. Arch2o.com. Retrieved 23.11.2018 from https://www.arch2o.com/corning-museum-of-glass-thomas-phifer/arch2o-corning-museum-of-glass-thomas-phifer-and-partners-013/

Url 4.11. *Corning Museum of Glass / Thomas Phifer and Partners*. ArchDaily. Retrieved 25.11.2018 from https://www.archdaily.com/611498/corning-museum-of-glass-thomas-phifer-and-partners/56a7944fe58ecef0b100031c-corning-museum-of-glass-thomas-phifer-and-partners-photo

Url 4.12. *Corning Museum of Glass / Thomas Phifer and Partners*. ArchDaily. Retrieved 05.12.2018 from https://www.archdaily.com/611498/corning-museum-of-glass-thomas-phifer-and-partners/550b4b57e58ece1511000113-corning_museum_tpp_0679-jpg

Url 4.13. *Corning Museum of Glass / Thomas Phifer and Partners*. ArchDaily. Retrieved 11.12.2018 from https://www.archdaily.com/611498/corning-museum-of-glass-thomas-phifer-and-partners/550b2f36e58ece151100010c-corning_museum_tpp_1348-jpg

Url 4.14. *The Contemporary Art + Design Wing Celebrates Leed Certification*. The Corning Museum of Glass. Retrieved 15.12.2018 from https://blog.cmog.org/2016/06/30/the-contemporary-art-design-wing-celebrates-leed-certification

Url 4.15. *Genesis the 1st. Day*. Péter Borkovies. Retrieved 20.12.2018 from https://cmog.tumblr.com/post/189975690570/artists-and-designers-only-a-week-remains-to

Url 4.16. *Largest Contemporary Glass Museum to Open in Upstate Ny*. Hyperallergic Media Inc. Retrieved 10.01.2019 from https://hyperallergic.com/52558/corning-museum-of-glass-thomas-phifer-and-partners-expansion

Url 4.17. *Environmental Design Elements*. The Corning Museum of Glass. Retrieved 10.01.2019 from https://www.cmog.org/about/architecture/contemporary/green

Url 4.18. *Corning Museum of Glass / Thomas Phifer and Partners*. ArchDaily. Retrieved 10.01.2019 from https://www.archdaily.com/611498/corning-museum-of-glass-thomas-phifer-and-partners

Url 4.19. *Thomas Phifer and Partners Unveils Design for Corning Museum of Glass*. ArchDaily. Retrieved 10.01.2019 from https://www.archdaily.com/242055/thomas-phifer-and-partners-unveils-design-for-corning-museum-of-glass

Url 4.20. *New Contemporary Art + Design Wing to Open at the Corning Museum of Glass*. Vocus PRW Holdings, LLC. Retrieved 10.02.2019 from https://www.prweb.com/releases/2015/03/prweb12587120.htm

Url 4.21. *Continuing Education: Corning Museum of Glass, New York*. BNP Media. Retrieved 10.02.2019 from https://www.architecturalrecord.com/articles/5907-continuing-education-corning-museum-of-glass-new-york

Url 4.22. *Architecture*. The Corning Museum of Glass. Retrieved 10.02.2019 from https://www.cmog.org/sites/default/files/Architecture%20Fact%20Sheet_0.pdf

Url 4.23. *Corning Museum of Glass / Thomas Phifer and Partners*. ArchDaily. Retrieved 10.02.2019 from https://www.archdaily.com/611498/corning-museum-of-glass-thomas-phifer-and-partners/56a79337e58ecef0b100031a-corning-museum-of-glass-thomas-phifer-and-partners-section

Url 4.24. *An Innovative Approach to Protecting Artwork*. The Corning Museum of Glass. Retrieved 10.02.2019 from https://blog.cmog.org/2015/04/10/an-innovative-approach-to-protecting-artwork

Url 4.25. *Shanghai Museum of Glass / Logon | Urban.Architecture.Design*. ArchDaily. Retrieved 10.03.2019 from https://www.archdaily.com/144236/shanghai-museum-of-glass-logon-architecture

Url 4.26. *Shanghai Museum of Glass*. Architizer, Inc. Retrieved 10.03.2019 from https://architizer.com/projects/shanghai-museum-of-glass

Url 4.27. *Shanghai Museum of Glass*. SmartShanghai.com. Retrieved 10.03.2019 from http://www.smartshanghai.com/venue/6318/Shanghai_Museum_of_Glass

Url 4.28. *Shanghai Museum of Glass*. Museums of the World. Retrieved 10.03.2019 from http://museu.ms/museum/details/15846/shanghai-museum-of-glass

Url 4.29. *Shanghai Museum of Glass*. Smart Destinations, Inc. Retrieved 10.03.2019 from https://www.smartdestinations.com/shanghai/museum-of-glass/_ptattr_Shg_Att_Shanghai_Museum_of_Glass.html

Url 4.30. *Shanghai Museum of Glass*. Time Out Group Ltd. Retrieved 10.03.2019 from http://www.timeoutshanghai.com/venue/Around_Town-Museums/5496/Shanghai-Museum-of-Glass.html

Url 4.31. *Logon Architecture | Shanghai Museum of Glass*. arthitectural.com. Retrieved 10.03.2019 from https://www.arthitectural.com/logon-architecture-shanghai-museum-of-glass

Url 4.32. *Shanghai Museum of Glass*. thecoolist.com. Retrieved 10.04.2019 from https://www.thecoolist.com/shanghai-museum-of-glass

Url 4.33. *Shanghai Museum of Glass Unveils New Design Wing by Coordination Asia*. Designboom Srl. Retrieved 10.04.2019 from https://www.designboom.com/design/shanghai-museum-of-glass-coordination-asia-design-wing-china-05-23-2016

Url 4.34. *Shanghai Museum of Glass Park*. Frame Publishers. Retrieved 10.04.2019 from https://frameawards.com/project/3935265-shanghai-museum-of-glass-park

Url 4.35. *Kids Museum of Glass / Coordination Asia*. ArchDaily. Retrieved 10.04.2019 from https://www.archdaily.com/597411/kids-museum-of-glass-coordination-asia

Url 4.36. *The Coolest Place to Get Smart*. The Kids Museum Of Glass. Retrieved 10.04.2019 from http://www.kmog.org

Url 4.37. *About: Shanghai Museum of Glass*. Shanghai Museum of Glass. Retrieved 10.04.2019 from http://www.shmog.org/about

Url 4.38. *Shanghai Museum of Glass Park / Coordination Asia*. ArchDaily. Retrieved 10.04.2019 from https://www.archdaily.com/921573/shanghai-museum-of-glass-park-coordination-asia

Url 4.39. *Shanghai Museum of Glass*. Indesign Media Asia Pacific. Retrieved 10.04.2019 from https://www.indesignlive.sg/articles/shanghai-museum-of-glass

Url 4.40. *Coordination Asia*. Architizer, Inc. Retrieved 10.04.2019 from https://architizer.com/firms/coordination-asia

Url 4.41. *Logon.Design*. Architizer, Inc. Retrieved 10.05.2019 from https://architizer.com/firms/logon

Url 4.42. *Shanghai Museum of Glass Park / Coordination Asia*. ArchDaily. Retrieved 10.05.2019 from https://www.archdaily.com/921573/shanghai-museum-of-glass-park-coordination-asia/5d358a3b284dd1710e0001ca-shanghai-museum-of-glass-park-coordination-asia-image

Url 4.43. *Shanghai Museum of Glass Park / Coordination Asia*. ArchDaily. Retrieved 10.05.2019 from https://www.archdaily.com/921573/shanghai-museum-of-glass-park-coordination-asia/5d358ce1284dd148020000a6-shanghai-museum-of-glass-park-coordination-asia-image

Url 4.44. *Shanghai Museum of Glass Park / Coordination Asia*. ArchDaily. Retrieved 10.05.2019 from https://www.archdaily.com/921573/shanghai-museum-of-glass-park-coordination-asia/5d358cc6284dd148020000a5-shanghai-museum-of-glass-park-coordination-asia-image

Url 4.45. *Shanghai Museum of Glass Park / Coordination Asia*. ArchDaily. Retrieved 10.05.2019 from https://www.archdaily.com/921573/shanghai-museum-of-glass-park-coordination-asia/5d358ca9284dd1710e0001dc-shanghai-museum-of-glass-park-coordination-asia-image

Url 4.46. *Di Gregorio Associati's Cinematic Pergola Frames a Rural Italian Home*. TI Media Limited. Retrieved 10.05.2019 from https://www.wallpaper.com/architecture/monticello-house-di-gregorio-associati-italy

Url 4.47. *Corporate News*. Swarovski Group. Retrieved 10.05.2019 from https://www.swarovskigroup.com/S/news/Corporate_News.en.html

Url 4.48. *About Swarovski*. Swarovski Group. Retrieved 10.06.2019 from https://kristallwelten.swarovski.com/Content.Node/wien/About_Swarovski.en.html

Url 4.49. *Swarovski Crystal Worlds*. austria.info. Retrieved 10.06.2019 from https://www.austria.info/in/swarovski-kristallwelten

Url 4.50. *The Giant*. Swarovski Group. Retrieved 10.06.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Chamber_Of_Wonder_Exhibition_Swarovski_Kristallwelten.en.html

Url 4.51. *Swarovski Kristallwelten / Wattens S_O_S Architekten*. Obermoser Arch-omo ZT GmbH. Retrieved 10.06.2019 from http://www.arch-omo.at/index.php/portfolio_page/308

Url 4.52. *Indian Couple Breaks through the Magic Number of Visitors at Swarovski Crystal World*. National Herald News. Retrieved 10.06.2019 from http://nationalheraldnews.com/indian-couple-breaks-through-the-magic-number-of-visitors-at-swarovski-crystal-world

Url 4.53. *Swarovski Kristallwelten a Wattens (Innsbruck) – Snøhetta, S_O_S Architekten, Cao Perrot*. New Business Media Srl. Retrieved 10.06.2019 from https://www.arketipomagazine.it/swarovski-kristallwelten-a-wattens-innsbruck-snohetta-s_o_s-architekten-cao-perrot

Url 4.54. *Swarovski Kristallwelten*. Snøhetta. Retrieved 10.06.2019 from https://snohetta.com/project/229-swarovski-kristallwelten

Url 4.55. *André Heller*. Swarovski Group. Retrieved 10.06.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Andre_Heller_Swarovski.en.html

Url 4.56. *Blue Hall*. Swarovski Group. Retrieved 10.07.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Swarovski_Exhibition2.en.html

Url 4.57. *Svarovski Crystal Worlds – the Sparkle of Innsbruck*. National Herald News. Retrieved 10.07.2019 from http://nationalheraldnews.com/svarovski-crystal-worlds-the-sparkle-of-innsbruck

Url 4.58. *Crystal Dome*. Swarovski Group. Retrieved 10.07.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Swarovski_Exhibition.en.html

Url 4.59. *Transparent Opacity*. Swarovski Group. Retrieved 10.07.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Arik_Levy_Exhibition.en.html

Url 4.60. *Eden*. Swarovski Group. Retrieved 10.07.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Fredrikson_Stallard_Exhibition.en.html

Url 4.61. *Famos*. Swarovski Group. Retrieved 10.07.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Blue_Noses_Exhibition.en.html

Url 4.62. *El Sol*. Swarovski Group. Retrieved 10.08.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Fernando_Romero_Exhibition.en.html

Url 4.63. *New Chambers of Wonder at the Swarovski Crystal Worlds in Wattens*. blog.tirol. Retrieved 10.08.2019 from https://www.blog.tirol/en/2017/12/new-chambers-of-wonder-at-the-swarovski-crystal-worlds-in-wattens/

Url 4.64. *Chandelier of Grief*. Swarovski Group. Retrieved 10.08.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Chandelier_of_Grief.en.html

Url 4.65. *La Primadonna Assoluta*. Swarovski Group. Retrieved 10.08.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Swarovski_Exhibiton3.en.html

Url 4.66. *Ice Passage*. Swarovski Group. Retrieved 10.08.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Oliver_Irschitz_Exhibition.en.html

Url 4.67. *Crystal Cloud & Mirror Pool*. Swarovski Group. Retrieved 10.08.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Pool_Crystal_Cloud.en.html

Url 4.68. *Cao Perrot*. Swarovski Group. Retrieved 10.08.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Cao_Perrot_Swarovski.en.html

Url 4.69. *Interview: Cao Perrot Studio*. The Architectural League. Retrieved 10.08.2019 from https://archleague.org/article/cao-i-perrot-studio/

Url 4.70. *About: Cao Perrot*. Cao Perrot Studio. Retrieved 10.09.2019 from https://www.caoperrotstudio.com/EN_about.html

Url 4.71. *Swarovski Crystal Worlds*. Tirol Info. Retrieved 10.09.2019 from https://www.tyrol.com/things-to-do/attractions/all-attractions/a-swarovski-kristallwelten-crystal-worlds

Url 4.72. *Works: Parks & Gardens*. Cao Perrot Studio. Retrieved 10.02.2019 from http://www.caoperrotstudio.com/EN_work_parksgardens.html

Url 4.73. *International Klein Blue*. Lexico Powered by Oxford. Retrieved 10.09.2019 from https://www.lexico.com/en/definition/international_klein_blue

Url 5.1. *Industrial Revolution*. Investopedia. Retrieved 13.09.2019 from https://www.investopedia.com/terms/i/industrial-revolution.asp

Url 5.2. *Chihuly Garden and Glass*. Chihuly, Inc. Retrieved 13.09.2019 from https://www.chihuly.com/exhibitions/chihuly-garden-and-glass/chihuly-garden-and-glass

Url 5.3. *The Giant*. Swarovski Group. Retrieved 10.10.2019 from https://kristallwelten.swarovski.com/Content.Node/wattens/Chamber_Of_Wonder_Exhibition_Swarovski_Kristallwelten.en.html

Url 5.4. *Rediscovering Paul Scheerbart's Glass-Inspired Modernism*. Hanley Wood Media, Inc. Retrieved 13.10.2019 from https://www.architectmagazine.com/design/rediscovering-paul-scheerbarts-glass-inspired-modernism_o

Url a.1. *Timeline of Glass History*. The Corning Museum of Glass. Retrieved 10.10.2019 from https://www.cmog.org/visit/schools-groups-and-scouts/school-tours/resources/timeline-glass-history

APPENDICES

Appendix I:
Glossary

adaptive reuse: Referring to the process of reusing an existing building for new purposes other than for what it had originally been built or designed. A building having undergone such a process is known as an *adaptive reuse building*.

auditory perception: the perception of sounds as a meaningful phenomenon through the auditory sense.

cast-glass: a technique of glass-making that includes preparation of a glass batch from powdered glass and colorant oxides followed by filling of the glass batch in a fire-proof mould and finally firing the glass inside the mould in a furnace to melt it and cool it after being shaped.

clear glass: achromatic, transparent glass without any visible additives or tints.

concept of exhibit: the concept of a work of art refers to five general concepts of exhibited glass works, namely historical glass artefacts (may be mentioned as 'glass craft'), industrial glass (artistic manufacture, architectural glass, etc.), scientific glass products (e.g., optical devices), modern glass works of art and contemporary glass works of art (including glass-art installations).

crystal glass: a clear, achromatic, transparent, high reflective index glass usually including lead oxide.

curator: a person who researches, manages and organises collections and exhibitions.

cut-glass: glass that is produced in a process of glass-cutting including pressing of the completed glass works of art against a rotating wheel made of stone or iron.

dichroic glass: glass that appears in one colour in reflected light and appears in another colour under transmitted light due to some of its components; e.g., colloidal gold.

etched glass: glassware with decorative designs put on the surface with an acid etching method.

exhibition design: a complex profession in which a diversity of media in exhibition spaces is organised requiring a wide range of knowledge and skills (e.g., technical knowledge, design skills, marketing, pedagogy, ergonomic, etc.).

fiberglass: a glass composite made with pressed or woven glass filaments; the moulded and/or strengthened fiberglass can include additional plastic resins.

flat glass: a plane of glass produced when molten glass is spread on a metal plane in sheets.

haptic perception: the interpreted and understood knowledge obtained from the outer world using the sense of touch and *proprioception.*

installation: an art form developed in the late 1950s involving sensory experiences or the creation of an aesthetic enveloping in a particular environment usually inviting active engagement of the spectator.

light and space art: an artistic expression that focuses on sensory perception rather than the media and ideas of traditional fine arts; emerged as an art movement in the 20th century.

mixed media: an art work in which different materials, media and forms are used in an integrated manner.

New Media Age (also Digital Age or Computer Age): period starting around 1970 characterized by shifting away from traditional industry and noted for abundant consumption, manipulation and publication of information, especially by computers.

site-specific installation: a works of art *in situ* which has an interrelationship with its location and was specially designed for its particular location.

spatial design concepts: traditional spatial organisation concepts based on visitors' circulation in space, as given in Appendix IV.

type-two museum: Type-two museums differ from type-one museums which are located in downtown areas and are easily accessed by public transportation. Type-two museums are multi-functional with workshops, lectures, demonstrations, interactive facilities in addition to permanent and temporary exhibitions. In addition, they have restaurants, coffees, shops, public spaces, etc.

Appendix II:
Glass Museums Around the World

Table A.1: Glass Museums in the World[94]

No	Name of Museum	Type of Museum	Location	Foundation Date	Collection Highlights
1	Sandwich Glass Museum	Glass Museum	Massachusetts, U.S.A.	1825	Wide range of glass that involves glass produced at the local Boston & Sandwich Glass Factory produced between 1825 and 1888
2	Museuo del Vetro (Murano Glass Museum)	Glass Museum	Venice, Italy	1861	Local Murano glass collections and contemporary glass art work
3	Musée Ariana/ Musée suisse de la céramique et du verre (Swiss Museum of Ceramics and Glass)	Glass and Ceramics Museum	Geneva, Switzerland	1884, Reopened 1993	Extensive collection of historical, technological and contemporary glass work
4	Smålands Museum	Glass Museum	Vaxjo, Sweden	1885, Reopened 1996	Comprehensive historic Swedish glass collection beginning from Neolithic settlement up to modern times; also an extensive international collection of historic tools for glassmaking
5	Museum of Glass in Novy Bor	Glass Museum	Novy Bor, Czech Republic	1893	Glass artworks from the 17th century to the present, particularly paintings and engravings involving old models of glasswork
6	Museum für Glaskunst Lauscha	Glass Museum	Lauscha, Germany	1903, (Modern redesign 2014)	Glass Christmas decorations, lamp glasses, historic and modern eyeglasses and studio glass collections pertaining to Lauscha and Thüringer Wald
7	Muzeum Witrażu w Krakowie (Stained Glass Workshop and Museum)	Glass Museum	Kraków, Poland	1907	Stained-glass artwork produced in Krakow for many years
8	Optical Museum Jena (Foundation German Optical Museum)	Scientific and Technological Museum	Jena, Germany	1922	Technological and historic optical instruments from eight centuries due to the development of the city as the centre of optics productions

[94] The table was compiled by the author as a result of research on websites of each museum.

9	Museum of Glass in Kamenicky Senov	Glass Museum	Kamenický Šenov, Czech Republic	1923	Variety of glassworks made with different glass art techniques from the 17th century to the present, particularly unique double-walled cups and goblets, engravings and local historic production
10	Turner Museum of Glass	Glass Museum	Sheffield, England	1943	Most comprehensive international glass collections in England made in the 19th and 20th centuries and contemporary glasses
11	Corning Museum of Glass	Glass Museum	New York, U.S.A	1951	World's most comprehensive collection of glass
12	Nationaal Glasmuseum Leerdam	Glass Museum	Leerdam, Netherlands	1953	Modern and contemporary Netherlands glass artworks and craftworks of the Leerdam Glass Factory; also a collection of glass packings and a few crystal glasses made by different producers
13	Bergstrom-Mahler Museum of Glass, Neenah	Glass Museum	Wisconsin, U.S.A.	1959	Paperweights, German glass, art glass and contemporary glass collections
14	Finnish Glass Museum	Glass Museum	Riihimäki, Finland	1961	Mostly Finnish household, design and art glass from the 18th to the 21st century
15	Le Musée-Atelier départemental du Verre de Sars-Poteries	Glass Museum and Atelier	Sars-Poteries, France	1967	Most significant glass collections in France that involves international contemporary glass artwork
16	Glasmuseum Reinbach	Glass Museum	Reinbach, Germany	1968	One of the most comprehensive Bohemian glass collections
17	Greentown Glass Museum	Glass Museum	Greentown, Indiana	1970	Extensive collection made by the Indian Tumbler and Goblet Company
18	The Stained-Glass Museum	Glass Museum	Cambridgeshire, England	1972	Stained glass and painted glass artworks from all parts of the British Isles starting from the 13th century to the present day
19	Museum of American Glass, Wheaton Arts and Cultural Center	Glass Museum	New Jersey, U.S.A.	1973	Comprehensive historic and contemporary collection of American made glass
20	The Glass Museum of Charleroi (Musée du Verre de Charleroi)	Glass Museum	Charleroi, Belgium	1973, Reopened 2007	International glass works of art created in Belgium
21	National Heisey Glass Museum	Glass Museum	Ohio, U.S.A.	1974	Significant collection of Heisey glass, own colours, patterns, techniques

22	Glasmuseum Frauenau	Glass Museum	Frauenau, Germany	1975, Reopened 2005	Collections of snuff bottles from Bavaria, Bohemian glass jewellery made in the 1920s and 1930s and paintings on glass from Spain to China
23	Glasmuseum Wertheim	Glass Museum	Wertheim, Germany	1976	Extensive collection that involves historic and industrial glass
24	Historical Glass Museum (and future Contemporary American and European Glass Museum)	Glass Museum	California, U.S.A.	1976	Largest collection of American-made glass
25	Yelverton Paperweight Centre	Glass Museum	Devon, United Kingdom	1978	Bernard Broughton's antique and modern paperweight glass collection
26	National Bottle Museum	Glass Museum	New York, U.S.A.	1978	Manufactured antique bottles that were mostly produced in the 1800s.
27	Heritage Glass Museum	Glass Museum	New Jersey, U.S.A.	1979	Extensive collection of historic glass, bottles, animal figurines and other related glass art
28	Broadfield House Glass Museum	Glass Museum	Kingswinford, West Midlands, England	1980; Closed 2015	One of the finest glass collections made in the 18th, 19th and 20th centuries involving cameo glasses and special glasses of the Stourbridge Factories
29	Fundacion Centro Nacional del Vidrio	Glass Technology Museum	Segovia, Spain	1982	Extensive European glass collection from the 16th century to the 19th century; regional La Granja crystal glass collection, stained-glass and contemporary glass collections
30	Glasmuseum Passau	Glass Museum	Passau, Germany	1985	Most extensive European glass collection in the world with, Bohemian, Bavarian, Austrian and Silezian glass production examples
31	Kunstsammlung Landstieg	Glass and Ceramics Museum	Oberwangen, Switzerland	1985	Studio glass and contemporary glass art collections
32	Glasmuseum Ebeltoft	Glass Museum	Ebeltoft, Denmark	1986	One of the most unique collections of glass in Europe; also international contemporary glass artworks
33	Galerie-Musée Baccarat	Galerie-Museum	Paris, France	1988	Baccarat crystal glasses
34	Dorflinger-Suydam Glass Museum	Glass Museum	Pennsylvania, U.S.A.	1988	Extensive collection of the Dorflinger glass company
35	Glasmuseum Hentrich	Glass Museum	Düsseldorf, Germany	1990	Historic and Art Nouveau eyeglasses collections, medieval glass, Middle Eastern glass and contemporary European glass collections

36	Barcelona Glass Centre	Glass Library; Documentation and Searching and Art Centre	Barcelona, Spain	1990	Temporary exhibitions made with different glass art techniques
37	Museum Jan van der Togt	Glass and Visual Art Museum	Amstelveen, Netherlands	1991	(Mostly sculptural) contemporary glass art collections and contemporary visual art collections
38	Museo del Vidrio	Glass Museum	Monterrey, Mexico	1992	Mexican pulquero glass collections; Byzantium and Persian crystals made ca. 12th century; Venice and Catalan glasses made ca. 15th-17th centuries; Phoenician, Roman and Medieval glasses
39	The Museum of Oglebay Institute	Glass Museum	West Virginia, U.S.A.	1992	Historic glass, China made Wheeling glass made from 1829 to 1939 including the largest piece cut lead crystal glasses, Victorian art glass, peachblow glass, pattern and depression glass, Northwood's carnival glass, and many other glass examples showcasing Ohio Valley history
40	The Museum of American Glass	Glass Museum	West Virginia, U.S.A.	1993	Industrial glass made in West Virginia, U.S.A. and manufactured elsewhere
41	The Museum of Connecticut Glass	Glass Museum	Coventry, England	1994	Historic glassworks of Connecticut
42	Swarovski Crystal Worlds (Swarovski Kristallwelten)	Glass Museum	Watterns, Austria	1995	Glass works of the Swarovski Crystal Company; exhibits of contemporary crystal glass art
43	National Imperial Glass Museum	Glass Museum	Ohio, U.S.A.	1995	Glassware collection of the Imperial Company created between 1904 and 1984
44	Ernsting Stiftung Glasmuseum	Glass Museum	Coesfeld-Lette, Germany	1996	One of the best contemporary European glass collections since the 1970s
45	Glassworks Museum of the Ore Mountains	Glass Museum	Neuhausen, Germany	1996	Local glass works and historic glass works from the 1600s
46	Hakone no Mori Venetian Glass Museum (Hakone Glass Forest Museum)	Glass Museum	Hakone, Japan	1996	Historic and modern Venetian glasses in Japan
47	Deutsches Glasmalerei-Museum (German Stained-Glass Museum	Stained-Glass Museum	Linnich, Germany	1997	The only historic and contemporary stained-glass collection in Germany
48	Nijima Glass Art Museum	Glass Museum	Nijima, Japan	1997	Artworks of the pioneer Studio Glass Artists' (modern glasses) and contemporary glass art collections by renowned world glass artists

49	Norsk Glassmuseum	Glass Museum	Hokksund, Norway	1997	Norwegian industrial glass collections developed after 1741 in Norway
50	Contemporary Glass Art Museum of Alcorcón (MAVA)	Contemporary Glass Art Museum	Alcorcón, Spain	1997	International contemporary glass art work made completely or partially from glass material with different techniques
51	National Glass Centre	Contemporary Glass Education	Sunderland, England	1998	Glass collections showing the properties of glass, as well as exhibits of historic, modern and contemporary glass artworks especially created at the University of Sunderland Ceramic and Glass Department
52	Glass Museum of Hsinchu City	Glass Museum	Hsinchu, Taiwan	1999	Glass artworks made in Hsinchu City
53	Tittot Glass Art Museum	Glass Museum	Taipei, Taiwan	1999	Historic and contemporary glass artworks produced in China and the Western world as well as glass art works of the Tittott Company which is the first Chinese glass museum
54	World of Glass St. Helens	Glass Museum and Art Center	St Helens, England	2000	Historic glass collections from Ancient Egypt to the present day; also temporary exhibitions of modern and contemporary art
55	Smith Museum of Stained-Glass Windows	Glass Museum	Chicago, U.S.A.	2000, Closed 2014	Stained-glass windows of the Chicago Tiffany Glass Works
56	Museo del Cristallo di Colle Val d'Elsa	Glass Museum	Colle Val d'Elsa, Italy	2001	Historical crystal glass production covering pre-industrial production and glass finds dating back to the 14th and 15th centuries; glassworks produced in the furnace of this building from 1823 until crystal production in 1963 and later crystal examples
57	Red House Glass Cone	Glass Museum	West Midlands, England	2002	Exhibits of contemporary glass artwork including industrial glass produced by Stourbridge Glass Manufactures
58	Museum of Glass	Glass Museum	Tacoma, U.S.A.	2002	Contemporary glass artworks and studio glass works that are an international contemporary glass art
59	Glass Art Museum	Glass Museum	Harrania Village, Egypt	2004	Glass artworks made with various glass art techniques
60	Lalique Museum Hakone	Glass Museum	Hakone, Japan	2005	Artworks of French glass artist Rene Lalique, such as perfume bottles, jewellery and flower vases that were made in the late 19th and early 20th centuries

61	New Bedford Museum of Glass	Glass Museum	Massachusetts, U.S.A.	2005	Art glass made in New Bedford by the Mt. Washington and Pair Point factories; glass from the Midwest and other regions of the country; English and continental glass; ancient glass; historic glass; Tiffany and Steuben paperweights; studio glass and much more
62	Ohio Glass Museum and Glass Blowing Studio	Glass Museum	Ohio, U.S.A.	2006	Glass collections of the local (produced in the Lancaster and Fairfield County), surrounding areas, and sometimes out-of-state that are mostly no longer producing at these companies
63	Het Glazen Huis	Glass Museum	Lommel, Belgium	2007	Focus on contemporary glass, including industrial and historic glass
64	Contemporary Glass Art Museum	Glass Museum	Eskişehir, Turkey	2007	International contemporary glass art collection
65	European Museum of Modern Glass	Glass Museum	Coburg, Germany	2008	Studio glass collections from the 1960s to the present including ceramics collection since 2012
66	Glass Museum-Piegaro (Museo del Vetro di Piegaro)	Glass Museum	Piegaro, Italy	2009	Historic glassworks in Piegaro from the Middle Ages to the 20th century
67	Museo del Vitrariro (Empoli Glass Museum)	Glass Museum	Empoli, Italy	2010	Empoli's historic industrial artistic and green glass works such as the classic green "fiaschi" (demijohns, recipients and table utensils, etc. mostly dating back to the 13th-15th centuries
68	Shanghai Museum of Glass	Glass Museum	Shanghai Shi, China	2011	Contemporary glass works of art and design collections
69	Musée Lalique	Glass Museum	Wingen-sur-Moder, France	2011	Rene Lalique's Art Neuveau jewelry, Art Deco glass and contemporary crystal collections
70	ZEISS Museum der Optik	Scientific and Technological Museum	Oberkochen, Germany	2014	Optical instruments such as lenses, microscopes, etc. produced by the ZEISS company
71	ZIBA Prague Glass Experience Museum	Glass Museum	Prague, Czech Republic	2016	Modern and contemporary glass artworks

Appendix III:
Literature Review

In Chapter 1 (Introduction), written theses and dissertations of the fine arts, interior architecture and architecture faculties since the 1950s have already been grouped under the main headings. In this part, most of these theses will be listed below under the main subheadings, which will also act as samples of the other remaining theses.

1. Theses in relation to changing states of glass generally in the 20th century

a. A Master Thesis from the Institute of Art Education at the National Changhua University of Education titled 'A Study on Exhibition and Installing Form of Contemporary Glass Art,' which examines the formation of installation art in the context of contemporary glass art touching on semiology (Hong, 2006).

b. A doctoral dissertation from the Philosophy in Urban Studies faculty at the Portland State University titled 'Forming a New Art in the Pacific Northwest: Studio Glass in the Puget Sound Region, 1970-2003,' which examines the emergence and influences of the studio glass movement by taking into account the factors affecting the development of a new art form in the Puget Sound Region between 1970 and 2003 (Ryder, 2013).

c. A doctoral dissertation on Art History from the University of Southern California titled 'Challenging boundaries: The history and reception of American studio glass 1960 to 1990,' which examines the relationship between the worlds of craft and high art while explaining the changes of perception of glass from factory craft glass after the studio glass movement from the 1960s to the 1990 as well as the relationship between 'Artists and Glass: A History of International Studio Glass (Sculpture).' The thesis also includes a section detailing how studio glass entered The Museum of Modern Art and the marketing of studio glass. Glass material as an art medium is examined, which is directly germane to our thesis topic 'Glass Art on Display.' (Lynn, 2000)

d. A master's thesis by Richard Almond Cosgrove from the Department of Fine Arts at the University of Southern California titled 'An investigation of the influences of certain twentieth century techniques on design in glass,' which examines the influences of twentieth-century techniques on design in glass by describing the natural features of twentieth-century glass as a material and as a design element. It analyses how 'design defines material' and 'material defines design,' which is an important topic while working on glass because of technical limits of glass during the working process (Cosgrove, 1936).

In addition, there are a number of theses analysing glass art from traditional glass art to contemporary glass art in relation to changing situations and developments of glass as an art medium by considering the physical and material properties of glass, namely:

- 'Process in glass art: A study of some technical and conceptual issues' by Doreen Gail Hemp at the University of South Africa (South Africa) in 1996.

2. Theses in relation to glass art techniques

a. A master's thesis at the Department of Fine Arts by Bao Qi Duan at Tsinghua University (People's Republic of China) titled 'On the combination and development of crafts of glass and installation art,' which examines glass and installation art that may combine due to the limited technical problems of the glass. In relation to our thesis, it expounds on the present situation of glass art coming together with installation art, in other words, changing the expression of how glass as an art medium affects exhibition spaces for glass art. Therefore, the exhibition space seems to be specific to the requirements for glass art in the near future (Duan, 2011).

b. A doctoral dissertation from the College of Arts and Letters at Michigan State University titled 'American Women Stained Glass Artists, 1870s to 1930s: Their World and Their Windows,' which examines American women stained glass artists and their artwork from the 1870s to the 1930s to determine the cultural and other influential factors in their work while examining the social, professional, religious and artistic situations around them. The thesis also focuses on the professional contributions of female stained-glass artists to American life from the 1870s to 1930s and mentions the idea that 'decorative arts are more suitable for the women in the late nineteenth century.' (Macdowell, 1986)

c. A doctoral dissertation on the Sociology by Laurence Albert Basirico at the State University of New York at Stony Brook titled 'Glass Consciousness: Social Organization and Social Interaction in The Stained Glass,' examines the social evolution and social structure of stained glass in the arts and craft world while focusing on the revival of artists and craftsmen from the history of twentieth-century stained glass in architecture. It also explains art movements such as Art Nouveau, Bauhaus, Neo-Gothicism in relation to the use of stained glass in architecture. Our thesis also covers this relation (Basirico, 1983).

d. A doctoral dissertation on the Arts and Sciences by Mary Bradley Shepard at Columbia University titled 'The thirteenth century stained glass from the Parisian abbey of Saint-Germain-des-Pres,' which examines the historical background of Saint-Germain-des-

Pres Lady Chapel in relation to its stained glass and the dispersion of its stained glass windows during the French Revolution (Shepard, 1990).

Similarly, other theses in relation to stained glass include:

- 'The Stained Glass of Saint-Pere de Chartres' by Meredith Parsons Lillich at Colombia University in 1969.
- 'The Stained-Glass Decades: A Study of Louis Comfort Tiffany (1848-1933) and The Art Nouveau in America' by Robert Koch at Yale University in 1957.
- 'The spectacle of stained glass in modern France and medieval Chartres: A history of practices and perceptions' by Anne F. Harris at the University of Chicago in 1999.
- 'The Early Stained Glass of Troyes Cathedral: The Ambulatory Chapel Glazing, C. 1200-1240 (France)' by Elizabeth Carson Paston at Brown University in 1986.

3. Theses in relation to pioneer glass artists

a. A doctoral dissertation on counselling and educational psychology from Indiana University titled 'The relations of boys' and girls' interest with their mothers' art and science talk: The case of visiting the Chihuly Firework of Glass exhibit' examined children's interest in art in relationship with their parents' interest in art while visiting the glasswork exhibition of Dale Chihuly's in comparing between children's gender (Kuo, 2010).

Other theses in relation to pioneer glass blower Dale Chihuly include:

- 'Dripping with Expression: The American Evolution of Self-Representation as Communicated Between Abstract Expressionism and Dale Chihuly' by Jaqueline Karrick Beck at Sotheby's Institute of Art, New York in 2012; and
- 'Objectively Art? An Examination of the Critical Reception of Dale Chihuly's Work' by Caitlin Laura Clay at Texas Christian University in 2018.

4. Thesis in relation to pioneer glass companies

a. A master's thesis on American fine and decorative art by Michelle Bonomo at Sotheby's Institute of Art titled 'Important 20th Century Art Glass: The Untold Story of the Sturdy-Lange Company' which examined the production of glass art designed by Greene and Greene in the early twentieth century at the Sturdy-Lange Company in the manner of glass design and construction information there to bring to light of the paucity of information written on it (Bonomo, 2015).

- Another thesis in relation to glass companies or industries:
- 'The Wistarburg Glassworks of Colonial New Jersey' by Arlene Mary Palmer at the University of Delaware (Winterthur Program) in 1973.

5. Theses in relation to developments and interactions in the glass art during a selected period and in selected countries or regions

a. A doctoral dissertation in architectural history from the University of Virginia titled 'New rationales for Neues Glas: Architectonic considerations in post-war German glass installations' examines a gap in glass window installations since 1945. The thesis is based on the conceptual dissemination of glass design in windows as an architectural element that was produced in post-war Germany because of German post-war glass artists having disparaged traditional stained glass and proposing new glass window concepts (Mulder, 2007).

b. A doctoral dissertation from the glass department of the School of Design and Applied Arts by Lale Andıç at Heriot-Watt University Edinburgh College of Arts titled 'Turkish glass culture and its relationship with contemporary glass and education' examined the connections and interactions between traditional Turkish glassmaking and contemporary glass and its education with gathered information from the U.S.A., England and Turkey. The thesis explains the development of glass art in Turkey from traditional to contemporary in terms of interactions (Andıç, 2000).

Another thesis in relation to a selected period, region, countries, etc.:

- 'Gold-glass vessels of the late Roman Empire: Production, context, and function' by Stephanie Leigh Smith at the State University of New Jersey, New Brunswick in 2000.

5. Theses in relation to material identity of glass art as being an art medium

a. A master's thesis in communication and the arts by Li Jun Fu at Shanghai University (People's Republic of China) titled 'The strange and supernatural element in the glass art' examining glass as a strange and supernatural element in relation to religion and mythical themes and the use of glass as an important contemporary art language by the artist and its aspects of being a strange and supernatural material according to the interpretation of Li Jun Fu (Fu, 2011).

In the following thesis, the value of glass was analysed throughout history based on the question of how glass had come to the contemporary art field from being an ancient material by considering the challenges and opportunities affecting its progress.

- ‘The research of the application value of glass artistic products’ by Zhi Ming Xiao at the Wuhan University of Technology (People’s Republic of China) in 2009.

6. Theses in relation to the present situation of glass in terms of its interaction and combination with the other materials

a. A master’s thesis in the fine arts by Biao Fu Li at Tsinghau University (People’s Republic of China) in 2010 titled ‘Fusion and Innovation-Practical knowledge of Glass Art’ examining glass art in relation to glass materials, glass technology and glass art with examples specific glass art pieces and supporting the idea of glass having its own language in artistic creation. The thesis is based on modern glass art combining with the other materials as a result of being aware of the outside world.

Other theses written about the modern language of glass while exploring the meaning of its craft language and art language in research on plate glass include:

- ‘Research on the Graphic Language of Modern Glass Art’ by Yan Xiao Guo at Tsinghua University (People’s Republic of China) in 2005.

- ‘Graphic glass: development of creative approaches to expressions of ethnicity’ by Jeffrey R. Sarmiento at the University of Sunderland (United Kingdom) in 2011.

After further detailed research into international and national theses, it is observed that Turkey also has an influential role in the development of contemporary glass art in the academic art programmes of the world. Similarly, because of the freshness of glass art in fine art faculties, glass art is also very fresh in fine arts faculties in Turkey. It was first combined in the ceramic arts departments at Marmara University and Mimar Sinan University under the name of ‘ceramic and glass.’ Then, a glass art department opened for the first time at Anadolu University. Because of the lack of knowledge in the Turkish language, written theses aimed at mostly closing this gap. Therefore, theses would usually begin by searching the history of glass followed usually by the techniques of glass art. Some of the theses have focused on the historical development of glass art and analysing the present situation of glass. Some other theses focus on the interactions of glass with ceramics and others are about the material properties of glass as an art medium. There are, moreover, theses expounding upon the material of glass in relation to architecture. Some theses from the Turkish literature include:

a. ‘Glass education on a global scale and developments in this area’ by Ayşenur Ceren Asmaz at Anadolu University in 2013.

b. ‘Refractory mould mixes used in kiln forming glass methods and their effects on glass in glass art’ by Mehmet Aydın at Anadolu University in 2016.

c. ‘Artistic glass applications in contemporary architecture’ by Emre Çelikkol at Anadolu University in 2015.

d. ‘Expressions of colour, light and texture in contemporary glass art’ by Fatma Çiftçi at Anadolu University in 2017.

e. ‘Glass sculptures in public spaces’ by Gizem Doğanay at Mimar Sinan Fine Arts University in 2015.

f. ‘The use of glass and ceramic materials in forming surfaces and coatings in the 21st century’ by Ferda Tazeoğlu at Anadolu University in 2016.

g. ‘Education in glass on a global scale and developments in this area’ by Ayşe Eryılmaz at Marmara University in 2007.

h. ‘A long journey in glass working art’ by İzzet Umut Çalik at Marmara University in 2009.

i. ‘Glass furnaces through the ages’ by Serra Kanyak at Marmara University in 2009.

j. ‘Stained Glass’ by Hakan Esmer at Anadolu University in 1996.

k. ‘Studio glass technology’ by Duygu Faga at Mimar Sinan Fine Arts University in 2012.

l. ‘Glass art sculptures from 1950 to the present’ by Feruha Aslı Karslıoğlu at Dokuz Eylül University in 2007.

m. ‘Research and an application study on the subject of pate de verre glass forming techniques’ by Sema Okan at Dokuz Eylül University in 2008.

n. ‘The state of glass art in educational institutions’ by Gülşen Aslan at Gazi University in 2007.

o. ‘The aesthetic and visual participation of glass in sculpture’ by Rahmi Atalay at Anadolu University in 2006.

p. ‘Applications of glass as a material in the plastic arts’ by Nazlı Gülgün Elitez at Mimar Sinan Fine Arts University in 2003.

q. ‘A study of glass as an art material in the post-studio glass movement’ by Naciye Danış at Dokuz Eylül University in 2012.

Through overall research in the literature review of national and international sources, it was demonstrated that there is a gap in the literature regarding the exhibition design[95] of glass art or the curation of glass art exhibitions or installations, even in the Glass Age. For this reason, this thesis has focused on the topic of *Glass Museums: Exhibition Design and Spaces for Contemporary Glass Art in the Glass Age*.

The reason for this gap may be linked to the fact that glass is the newest programme in the field of plastic arts, which emerged after 1960s. Even if in the 1990s an increased interest can be seen in the glass material by the glass artists and artists from the other fields, the interest in glass in the academic field had begun at the beginning of the twenty-first century, in the first decade of which glass was mostly studied in terms of glass-making techniques, glass art programs and courses, glass raw materials, historical glass artefacts, etc. in the field of fine arts during the same period. In the second decade of the twenty-first century, there was a rapid increase in the number of written theses on glass, particularly in the other fine arts fields such as graphics, visual arts, etc. This rapid increase in the investigation of glass art in theses is especially seen in the art faculties of China. Although they have been late in starting glass art education programmes, they seem to have rapidly caught up with the present situation in glass art and are even at the forefront in research on the current state of glass art and by doing so, integrating it into other art fields.

In many theses, they handled the use of glass in combination with other materials in the artistic field of glass due to the technical limitations or challenges of glass for designed artworks. In fact, regarding glass as a material, it can be said that glass art occurs if the glass allows design, in another words, in the context of many designs being created; however, glass allows only a few of them to be possible due to its material features and technical limitations. Moreover, glass occasionally produces compelling changes in design; however, the use of glass has been increasingly preferred in various art fields in the twenty-first century despite all these factors. Therefore, it can be asserted that in the twenty-first century, glass art has been taking first place among other plastic art branches in the world's art as the most popular art branch.

Moreover, through the developments of glass in not only the art field but also in technology and architecture, glass has begun to be accepted as a strong tool in all fields since the beginning of the present century. At the end of the second decade of the twenty-first century, mentions have been made about this century being the Glass Age in the speeches and presentations made by the Corning Museum of Glass. In some articles, particularly in Corning Museum of Glass journals, there have been cursory mentions about this new situation about glass. In parallel

[95] See Appendix I: Glossary

with these developments, a book *The Age of Glass: A Cultural History of Glass in Modern and Contemporary Architecture* was published by Stephen Eskilson on February 8, 2018 and thus, this century has gained a certain identity and naming as "the Glass Age." This may be the first literary work that precisely documents this century as the Glass Age. The best part of this work is the existence of a glass age that is exactly as acknowledged in architecture although there has been no publication or thesis written yet in terms of exhibition design of glass art and in turn the design of glass art museums and other exhibition spaces in the architectural field. Since especially 2019, the Corning Museum of Glass has produced movies and demonstrations, increased publishing on this topic to announce this century as the Glass Age and has drawn attention to this new term in the current agenda of history.

Consequently, the perceptible necessity of this thesis, which deals with the exhibition design of glass art, can be summarised under two main statements:

1. The current situation of contemporary glass art, which has started to be integrated with other media and digital environments more so than ever in the twenty-first century in the hands of various professions in various fields and requires to preserve its own place by having broader knowledge on glass art and design, perceptual theories and about related art movements (particularly conceptualism) etc.

2. The Glass Age, the current century made to gain a new identity in glass in both the art and architectural fields and making it the most versatile medium of metaphor and source of inspiration in design, that requires to be special attention on lighting and display design of glass exhibits based on perceptual phenomena.

Appendix IV:
Evolution of Glass Throughout History

Table A.2: Evolution of Glass Throughout History

(Url a.1)[96]

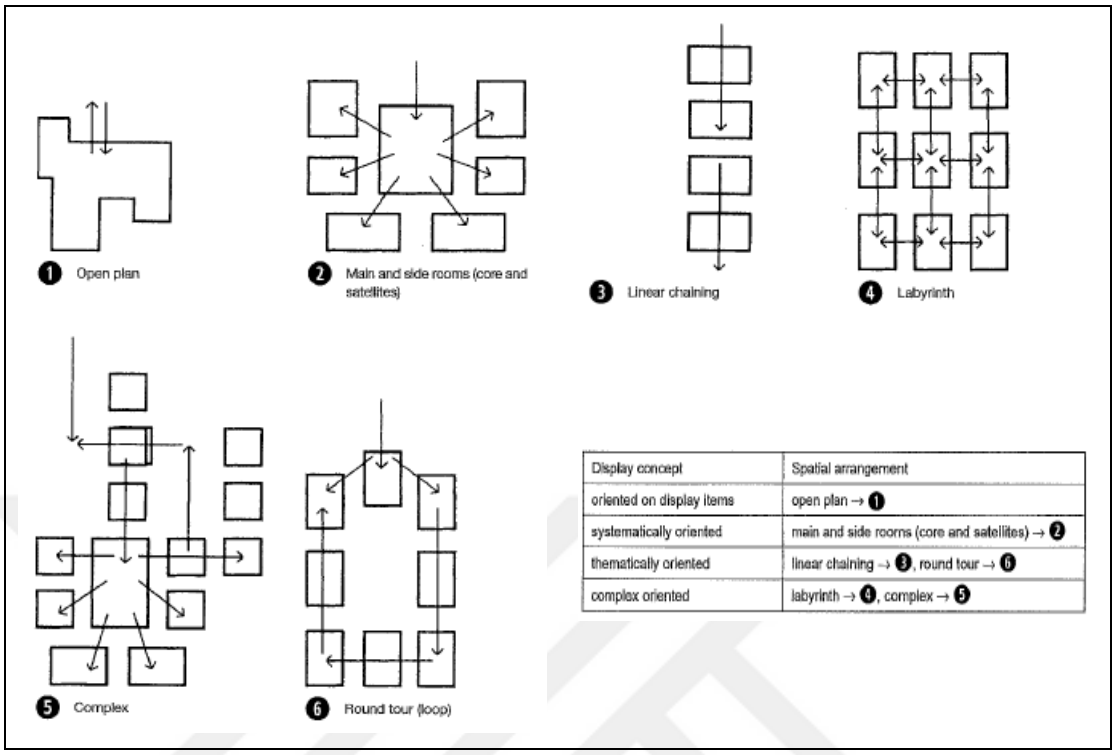
Periods		Developments
Early Glass-Making (2000 BC-500 AD)	Before 2000 BC	For the first time, human beings manufactured man-made glass objects and used mould casting techniques and simple tools to form glass inside a mould. During this period, glass-making was labour-intensive and expensive.
	16th century BC	For the first time, hollow vessels were created by craftsmen wherein molten glass was shaped by gathering it around a temporary core.
	ca. 50 BC	Glass makers living on the Syro-Palestinian coast, a part of the Roman Empire, had discovered inflating a gob of melted glass using a hollow tube. Thus, glass products could now be produced more easily and more affordably thereby causing rapidly increasing production of glass objects. Moreover, in these times, the Romans developed glass-making prescriptions, discovered cut-glass, engraving and enamelling techniques and produced some of the most lavish luxury glass items ever made.
Medieval and Islamic Glass (500-1450)	After 476 AD	Due to the collapse of the Roman Empire, there were no appearances of glass-making by the Romans after 476 AD. For the first time, glass furnaces were used by the Frankish, who performed the most sophisticated techniques at the kiln which survived into the Middle Ages.
	Beginning of 7th century AD	Glass-making flourished throughout the region extending from central Europe to Spain after the Muslim conquest. As a result, Roman techniques were revived and developed by Muslims producing new forms and types of ornaments.
	15th-16th centuries (Renaissance period)	Luxury glass-making had flourished in Italy. By the mid-15th century, 'cristallo,' a colourless, thin glass, resembling rock crystal, was made by Venetian glassblowers of the island of Murano. By the 16th century, glass products were exported for the first time. Highly skilled Venetian glassmakers produced elaborate glass wares and exported them throughout Europe and the Islamic East. As a result, the knowledge of the glassmaking techniques of the Venetian glassmakers had spread and their objects came to be identified as Venetian or falcon de Venice.
Early European Glass (1450-1700)	Last quarter 17th century	Two technological breakthroughs were realised in glass-making. Firstly, the English and Bohemian glassmakers had produced the most brilliant man-made glass than previously. To achieve this result, the English added lead oxide (PbO) to the glass batch and the Bohemians added chalk ($CaCO_3$). Secondly, the first time coloured, deep red glass was produced by the chemist Johann Kunckel in Potsdam by adding gold chloride to the batch.

[96] The table is adopted and extended from the information achieved by the website (Url A.1) of CMOG.

Early European Glass (1450-1700)	Mid-19th century	In these periods, due to the growth of industrialization and the middle class, the demand for elegant, high quality consumer goods including glass objects had increased in Europe and America. With the increased demand for glass, glass had been developed by various skilled glass masters such as glass decorators, cutters, engravers and painters and their craftsmanship had become as important as glassblowers. Although there were only a few successful glass factories in America, industrial growth and developments had occurred by the mid-19th century. The production of tableware increased threefold and prices fell, making tableware available for the public to buy. In 1851, glass objects were exhibited for the first time in history. The most elaborate and largest works of European and American glass companies were displayed at world fairs by their own efforts. The first of these fairs, the 1851 Great Exhibition at London's Crystal Palace, which was in itself an architectural glass wonder, had more than six million visitors. Within the context of the 1851 Exhibition, glass material was exhibited as both an artistic production on display and as a design element in the architecture of the building. Additionally, through this exhibition, glass products as artistic works became part of the 'high arts' in academies.
European and American Glass (1700-1890)		Modernism that developed in decorative arts included glass as part of the legacy of Art Nouveau. Modernism in glass from 1900 onward is characterised by clean lines, defined colours and the absence or judicious use of surface decoration.
Modern Glass (1890-1960)	1800s-1918 (until World War I)	Art Nouveau (New Art) refers to many different artistic styles including arts and crafts, the Aesthetic movement, and Japonisme. It emerged in the 1880s, reached its peak in 1900 and ended with the onset of the First World War (1914). The glass works of the period reflected two distinct design styles, one of which had been inspired by nature and emphasised asymmetry and sinuous lines, while the other focused on restrained forms and geometric patterns.
	1918-1945 (between the two world wars)	With inspiration from many sources including the geometric aspects of Art Nouveau, Cubism, and tribal art, the Art Deco style dominated design between the two world wars. It emphasised symmetry, angularity as well as the use of new luxury materials such as glass.
	After 1945	An increasing tendency is seen in the design of artists and architects wishing to emphasise modern ideals of beauty, utility and affordability and design of daily-use objects.
	After the 1960s	Art glass dramatically changes after 1960. Harvey K. Littleton and Dominick Labino organise experimental workshops with a glass furnace in a studio setting and invite artists to show and explain the possibility of glass-making using a small furnace in a studio setting. This small glass furnace was designed by Dominick Labino, who made it possible for artists to work with molten glass outside factories. Following these workshops, the artists begin working with hot glass in studio conditions leading to a rapid development of glass art.

Studio Glass (1960-21st century)	21st century	Glass is one of the most used materials in art, architecture, science, technology and communication. It is handled as a versatile medium in all fields owing to its wide range of properties. In terms of contemporary art and architecture, glass has transformed to become a material of metaphor and it has almost shifted from being a material of function. Glass is used as a communication medium for expressionism and conceptualism, a metaphoric medium of art and design and a medium for inspiration. Today, glass, a versatile medium with which artists can express a range of ideas, has transformed to become a material of metaphor shifting from being a material of function.
The Glass Age (21st century)	21st century	Recently, glass has become one of the most used materials in art, architecture, science, technology and communication. It is used as a versatile medium in all fields owing to its wide range of properties. In terms of contemporary art and architecture, glass has been transformed into a material of metaphor and has almost shifted from being a material of function. Glass is used as a communication medium of expressionism and conceptualism, a metaphoric medium of art and design and as a medium for inspiration.

Appendix V:
Spatial Organization in Space



Display concept	Spatial arrangement
oriented on display items	open plan → 1
systematically oriented	main and side rooms (core and satellites) → 2
thematically oriented	linear chaining → 3, round tour → 6
complex oriented	labyrinth → 4, complex → 5

Figure A.1: Spatial Organisation in the Space with regard to Circulation of Visitors in the Space

(Neufert & Neufert, 2012, p. 208)

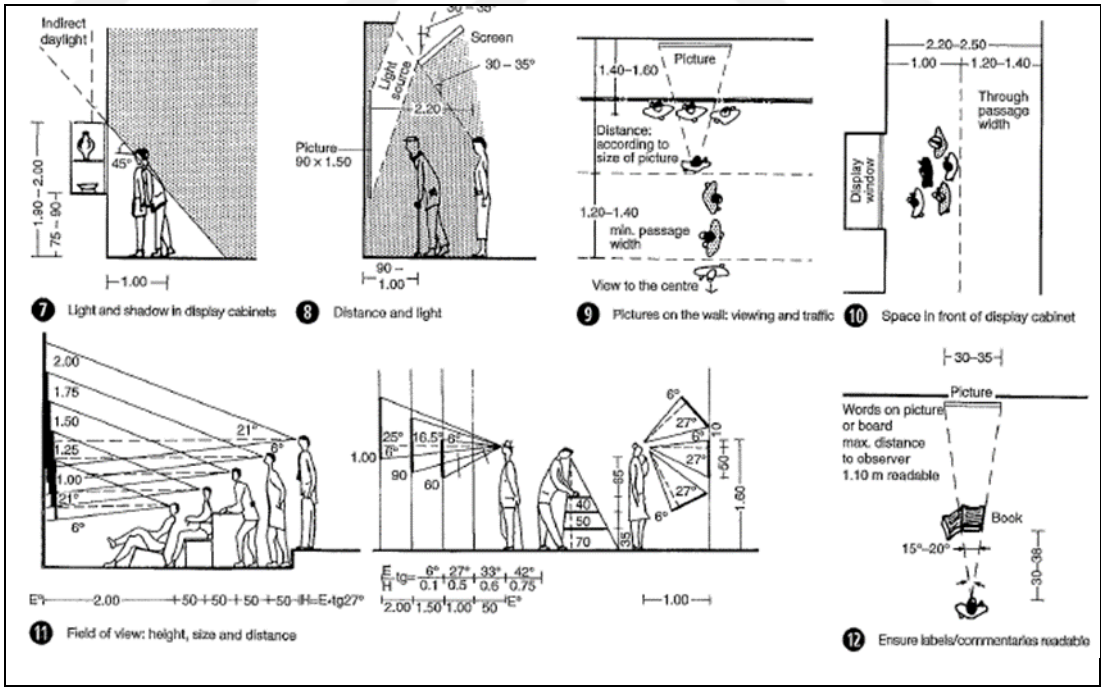


Figure A.2: Spatial Organisation of the Works of Art on Display with regard to Suggested Distance of the Visitors

(Neufert & Neufert, 2012, p. 208)

Appendix VI:
Daylighting in Museums and Galleries

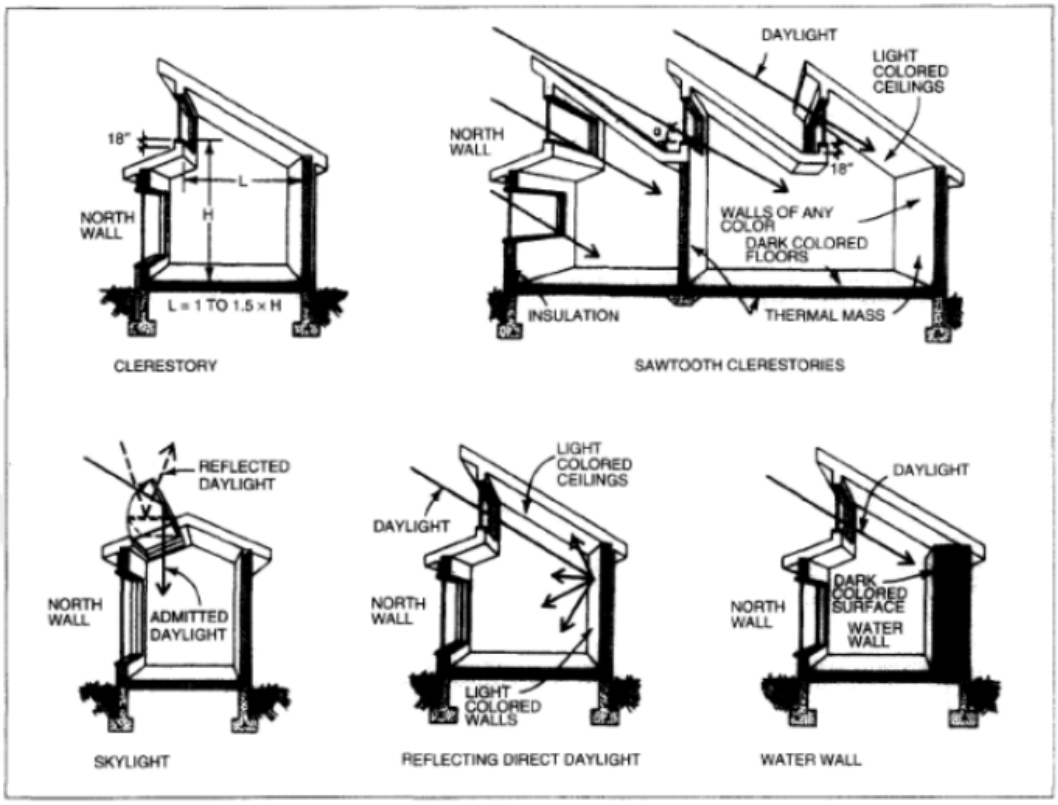


Figure A.3: Multiple Design Alternatives in the Architecture of a Building to Admit Daylighting into Exhibition Spaces

(Ramsey et al., 1981, p. 721)

Table A.3: Comparison of Daylight and Artificial Light Used in Museums and Galleries

(Arup, 2019)

Benefits of Daylight	Benefits of Artificial Light
Energy savings	Significant energy savings
Cost savings in terms of energy reduction and reduction in ongoing maintenance costs	Reduction in size of luminaries
Provides improved visitor experience	Reduction in re-lamping costs
Enables visitors to link with the outside world, thus providing them with an opportunity to rest their eyes and relax their concentration	Enhanced flexibility
Improved well-being to staff and lower absenteeism	Enhanced control where lighting can be linked to presence (potentially reducing illumination exposure as well as energy use)
Variability in lighting conditions and alters the ambience of gallery interiors so there are subtle differences on each occasion when a visitor walks around	Ability to tune lighting according to visitor and curator preference (colour temperature, illuminance level, etc.) Recording and logging of illumination exposure
	Customised lighting spectrum turned to objects being illuminated

Appendix VII:
Most Used Display Lighting Techniques in Exhibition Spaces

Table A.4: A Selection of the Most Used Display Lighting Techniques in Exhibition Spaces

(Tregenza & Loe, 2013, pp. 105-107)

Techniques	Definition
Cast shadow	The shape of objects being revealed by shadows cast on other objects or onto a background surface.
Enhancement of solid form	A light beam positioned approximately at 45° in azimuth and elevation from the direction of the point of view providing large brightness variations across the surfaces of three-dimensional objects. For example, the fresh appearance of food may fail to reveal the three-dimensional form of a matt surface.
Enhancement of texture	A light beam positioned at a glancing angle of incidence accentuates surface roughness or shallow carvings
Flattening of texture or form	Light beam positioned close to the viewing direction or a large diffusing source reducing the perception of shapes so that other characteristics such as surface pattern and colour can be appreciated. For example, lighting that emphasises surface variation in low-relief sculpture that can reduce the visibility of applied paintwork.
Halo	A light beam from above and behind a display shines towards the viewer and creates bright edges.
Lamps within display	Light sources that form part of the display itself; widely used to illuminate glass art work.
Lighting from unusual directions	As an example, a light beam positioned from below reveals unexpected aspects of an object normally seen in daylight, thereby enabling it to be viewed from different points of view.
Silhouette	The outline shape of the displayed object is seen darker against a bright background
Sparkle	Minute points of light are reflected by shiny surfaces revealing the shape of the surface and degree of polish. For example, small beams of light can enhance the sparkle of jewellery.
Transmission	Lighting through translucent materials revealing the form of crystalline objects (Fig.A.4). In relation to this thesis topic, glass art needs to be highlighted as explained in Chapter 3. As seen in Fig. A.4, a crystalline glass work gains dramatic effects when exhibited with a dark background and illuminated properly as in the figure. (Tregenza & Loe, 2013, p. 107)

Figure A.4: 'Crystalline glass work', illuminated with light transmission

(Tregenza & Loe, 2013, p. 104)