THE REPUBLIC OF TURKEY
BAHÇEŞEHİR UNIVERSITY

BUILDING SKIN: CORPOREAL EXISTENCE OF ARCHITECTURAL SPACE

M.S. Thesis

AYŞEGÜL SEZEGEN

ISTANBUL, 2012

THE REPUBLIC OF TURKEY
BAHÇEŞEHİR UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

BUILDING SKIN: CORPOREAL EXISTENCE OF ARCHITECTURAL SPACE

M.S. Thesis

AYŞEGÜL SEZEGEN

SUPERVISOR: Prof.Dr. Sema Soygeniş

ISTANBUL, 2012

THE REPUBLIC OF TURKEY
BAHÇEŞEHİR UNIVERSITY

THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

MASTER OF ARCHITECTURE

Title of the Master's Thesis : Building Skin: Corporeal Existence of Architectural Space
Name/Last Name of the Student: AYŞEGÜL SEZEGEN
Date of Thesis Defense : 10.09.2012

The thesis has been approved by the Graduate School of Natural and Applied Sciences.

Assoc. Prof. Dr. Tunç Bozbura
Director

I certify that this thesis meets all the requirements as a thesis for the degree of Master of Architecture.

Assoc. Prof. Dr. Özen Eyüce
Program Coordinator

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

Examining Committee Members: Signatures

Thesis Supervisor
Prof. Dr. Sema Soygeniş :

Member
Prof. Dr. Halit Yaşa ERSOY :

Member
Assist. Prof. Dr. İrem Maro KIRIŞ :

ACKNOWLEDGEMENT

This dissertation would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study. First and foremost, I would like to express my appreciation to my advisor Prof. Dr. Sema Soygeniş for valuable guidance and advice. Thanks for her patience and steadfast encouragement to complete this study. Also, thanks to my committee members, Prof.Dr. Halit Yaşa Ersoy and Assist.Prof.Dr. İrem Maro Kırış who offered guidance and support. Special thanks to my friend Jessica Turrin, you always had time to help no matter how busy you were.

The most special thanks goes to my parents for their understanding and endless love. Without your support this thesis would not have been possible.

September, 2012 Ayşegül Sezegen

ABSTRACT

BUILDING SKIN: CORPOREAL EXISTENCE OF ARCHITECTURAL SPACE

Ayşegül Sezegen

Master of Architecture

Supervisor: Prof.Dr. Sema Soygeniş

September 2012, 110 pages

The aim of this thesis is to emphasize the importance of architectural tectonics in the sense of building skin design and search for the relationship between the building skin and two building materials “glass” and “concrete”. Writings on tectonics by Karl Bötticher, Gottfried Semper and Kenneth Frampton provide the conceptual framework for the evaluation of the material qualities of building skin and clarify the importance of the “art of construction” in the design of building skin. The building skin is a transitional element between the interior and the exterior. The skin reflects the design concept of a building that can be perceived from outside. It forms a significant part of our first impression of a building which makes the study of skin increasingly important. The changes in the tectonic features of building skin with respect to the building materials, their application and their reflection on the design of architectural spaces are investigated in this thesis through four different architects from modern and contemporary architectural periods, Mies van der Rohe, Le Corbusier, Herzog & de Meuron and Tadao Ando with an emphasis on their use of building materials and approach to the design of building skin. In this context, this study poses an example in emphasizing the importance of investigating the potentials of new building materials and existing ones to improve the design quality of a building skin in architecture.

Key Words: Building Skin, Facade, Building Material, Concrete, Glass

ÖZET

MİMARİ MEKANIN VAROLUŞUNDA YAPI KABUĞU

Ayşegül Sezegen

Mimarlık Yükseklisans

Danışman: Prof.Dr. Sema Soygeniş

Eylül 2012, 110 sayfa

Bu tez mimari tektoniğin, yapı kabuğu tasarımındaki önemini vurgulamak ve yapı malzemeleri; “cam” ve “beton” ile yapı kabuğu arasındaki ilişkinin araştırılmasını hedeflemektedir. Bötticher, Gottfried Semper ve Kenneth Frampton’un tektonik üzerine çalışmaları, yapı kabuğunun malzemeye dayalı niteliklerini değerlendirmek ve “yapı yapma sanatı” nın yapı kabuğu tasarımındaki önemini açıklamak için kavramsal bir çerçeve oluşturur. Yapı kabuğu iç ve dış arasındaki geçiş elemanıdır. Bu kabuk yapının tasarım konseptini yansıtır. Yapı kabuğu, bir binaya ait ilk izlenimin önemli bir kısmını oluşturduğu için kabuğun incelenmesi önem kazanmaktadır. Bu tezde, bina kabuğunun, yapı malzemeleriyle bağlantılı tektonik özelliklerindeki değişimler, bunların uygulamaları ve mimari mekan tasarımına yansımaları, modern ve çağdaş dönemin dört mimarı Mies van der Rohe, Le Corbusier, Herzog & de Meuron ve Tadao Ando ‘nun cephe malzemelerini kullanımı ve yapı kabuğu tasarımına yaklaşımları üzerinden incelenmiştir. Bu bağlamda, bu çalışma mimaride yapı kabuğu tasarımı için yeni yapı malzemelerinin ve var olan malzemelerin potansiyellerinin araştırılmasının önemini ortaya koymayı amaçlayan bir çalışma örneği oluşturmaktadır.

Anahtar Kelimeler: Yapı Kabuğu, Cephe, Yapı Malzemesi, Beton, Cam

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure 4.11: Pantheon in Rome ... 58
Figure 4.12: Rue Franklin Apartments by Auguste Perret ... 59
Figure 4.13: Louis Kahn's Jonas Salk Institute at La Jolla ... 60
Figure 4.14: Yale Art Gallery ... 61
Figure 4.15: The pilgrimage church in Neviges ... 61
Figure 4.16: Wire reinforcements placed before the pouring of concrete ... 63
Figure 4.17: A precast concrete walled in construction ... 64
Figure 4.18: A modern block plant in operation and its application in site ... 65
Figure 4.19: Autoclaved aerated concrete block with a sawn surface ... 65

1. INTRODUCTION

1.1 PROBLEM STATEMENT

Advancements in construction techniques, along with the usage of new technologies have allowed architects to design more effective building skin. New material applications and reinterpretation of existing ones have also been closely related to the evolution of building skin design. Understanding the design process, the role of building materials, and significance of building skin have become an extensive field of research in the context of the twenty-first century. Through this thesis, the development of “building skin” as a notion in historic and modern practice will be investigated specifically through two different building materials glass and concrete to evaluate the meaning and materiality of building skin and its role in the design of buildings.

1.2 THE SCOPE OF THE STUDY

Investigating the development of the building elements that have been formed through various techniques in history of architecture opens new ways in design arena. In this process, the role of each building element and the changing material usage in combination of the building elements are essential fields of research.

Since the primitive times, there has been an innate requirement for space to protect human beings from the threats of nature. Primitive architecture, based on the human/nature relationship, has made a great progress with the aid of developing factors, such as the development of different materials, their use and application techniques. From the times that materials take part in the installation of a space as it appears in nature to today’s concept, the variety of the possibilities is really important which includes the substance of the material as well as the technique of how it is used. Together, the terms “technique” and “material” create the term “tectonic” – an important field of study to understand the substance of building skin design.

In this regard, a discussion about the meaning of the term “tectonic” in architectural literature requires attention. Writings on tectonic by Kenneth Frampton, Gottfried Semper, and Karl Bötticher will provide the conceptual framework to evaluate the material quality of building skin in this study.

Kenneth Frampton reinterpreted architecture of the past in his book, “Studies in Tectonic Culture: The Poetics of Construction in nineteenth and twentieth Century Architecture” (1995). He investigated the work of modern architects according to material usage instead of classifying them by their stylistic approach as previously done. As Mallgrave explains, Frampton was interested in “architecture’s tangible materiality, which must be distinguished from cruder efforts at artistic materialism” (Mallgrave 1996). He strongly believes that tectonics have an important influence on the development of the architectural forms. Investigating his studies on tectonic culture is important in order to understand the origins of tectonics in terms of building materials and construction techniques.

Nineteenth century German theorist and architect Gottfried Semper, classified the primary elements of a primordial dwelling based on a Caribbean hut that he saw in the Great Exhibition of 1851, in his book titled, “Four Elements of Architecture,” as; the earthwork, the hearth, the framework / roof, the lightweight enclosing membrane (Frampton 1995). Through these four elements Semper was able to identify the “enclosure”. The term “enclosure” gains its architectural meaning by creating a space isolated from the outside elements, defining the hearth of the enclosure by surrounding it, and separating the interior space from exterior. Depending on the classification, Semper assigns different techniques to each element or motive. Through acts of stringing, binding, covering, protecting, or isolating, textile art is assigned to define the enclosure (Semper 1989) Semper is focused on allowing the material to transform itself into a dressing, which follows his theory of progressing from simple enclosure to complex ones.

Not only Gottfried Semper but other architects are also concerned about the structure, cladding, skin and dressing. In his essay, “Principles of Cladding,” well-known architect

Adolf Loos, with the authority of Gottfried Semper, claimed that the first task of architecture was cladding. He (Loos 1898, p.37) states that;

> *"The architect's general task is to provide a warm and livable space. Carpets are warm and livable. He decides for his reason to spread out one carpet on the floor and to hang up four to form the four walls. But you cannot build a house out of carpets. Both the carpet on the floor and tapestry on the wall require a structural frame to hold them in the correct place. To invent this frame is the architect's second task. This is the correct and logical path to be followed in architecture. It was in this sequence that mankind learned how to build. In the beginning was cladding. Man sought shelter from inclement weather and protection and warmth while he slept. He sought to cover himself. The covering is the oldest architectural detail. Originally it was made out of animal skin or textile products."*

Cladding was therefore the first architectural act, the first detail and needed to be considered before the choice of the structural elements of the building. The importance of building skin design in architecture is noted by many architects as it is also clearly stated by Adolf Loos.

The aim of this thesis is to investigate the importance of architectural tectonics in the sense of building skin and search for the design possibilities of the skin with the materials "glass" and "concrete". Architects, Mies van der Rohe, Le Corbusier, Herzog& de Meuron and Tadao Ando will be considered as key references for a strong understanding of modern and contemporary applications of building skin.

Works of Mies van der Rohe and Le Corbusier will highlight the twentieth century architecture and their approach to building skin. Possibilities for building skin design increased with the development of new materials and advanced technologies during the first half of the twentieth century. In order to understand the meaning of the building skin in today's context, it is important to analyze the works of contemporary architects Herzog & de Meuron and Tadao Ando. Their influential work and varying interpretations of building skin deserve to be investigated throughout this thesis.

The skin is a very significant element of the building because it forms a large part of our first impression. Defining the boundaries of personal properties, the building skin is the first thing that reflects the design concept from outside. We cannot imagine a building without its skin. The building skin is a transitional element between the interior and the exterior. These make the study of the building skin increasingly important. In this context, the changes in the tectonic features of building skin with developing techniques and applications, their reflection on the design of architectural spaces will be investigated in this thesis through four different architects from modern and contemporary architectural periods with their approach to the design of building skin with two materials; glass and concrete.

1.1 THE METHOD OF THE STUDY

The research method for this thesis is grounded in extensive literature reviews and case studies that investigate both the historical and contemporary framework of building skin design. Following a linear trajectory, from theory, history, to practice, the first chapter lays the foundation by defining the problem statement, scope, and method of this thesis. The second chapter sets the theoretical understanding of architectural tectonics by exploring key words, such as “skin”, “cladding”, and “facade,” as defined by various architects, including Karl Bötticher, Gottfried Semper, and Kenneth Frampton. The third chapter investigates the evolution of building skin in its most critical time periods, from primitive to contemporary. The fourth chapter reinforces the importance of material selection and application during the process of building skin design, specifically with glass and concrete. Last, the study concludes with four modern and contemporary case studies constructed primarily of glass and concrete, these include: the Seagram Building, the Carpenter Center for Visual Arts, the Church of the Light and the Prada Aoyama Epicenter designed by worldly acclaimed architects Mies van der Rohe, Le Corbusier, Herzog & de Meuron, and Tadao Ando, respectively. Investigating the influence of these particular building skin designs in detail will strengthen the goal of this thesis.

2. CONCEPTUAL FRAMEWORK: THE TECTONIC ASPECT OF ARCHITECTURE

2.1 THE NOTION OF TECTONICS

The term "tectonics" in architecture has a great relationship with the explanation of detail and structural system that are related to materials and production technologies. Interactions between symbolism in art, new materials and construction techniques have been among the most considerable points of architecture. Trying to associate the corporeal existence of the building and knowledge of art generated a focus on tectonics in different concepts of architecture. In this sense, it is important to know what tectonic means in order to understand the corporeality of architectural space in terms of building skin. Porphyrios (2002, p. 136) states that;

> *"First, the finite nature and formal properties of constructional materials be those timber, brick, stone, steel, etc. Second, the procedures of jointing, which is the way that elements of construction are put together. Third, the visual statics of form, that is the way by which the eye is satisfied about stability, unity and balance and their variations or opposites."*

This statement depicts that experiencing a building is not only about construction, it also includes the idea of tectonics and its conception that is used in the application. Creation of beauty in architecture is both about aesthetic concerns and technical comprehension that meet with constructional requirements.

As an art of construction based on materials rather than structural form, tectonics refers to the material effect on architectural space. It is a notion in an architectural area that is related to such terms as; "*techne*", technique, construction, structure and everything belonging to an architectural work. To have a complete idea about tectonics and its concept, it is necessary to comprehend the words "*techne*" and "*tecton*".

Stating the meaning of techne, its etymological meaning requires a flashback to the Greeks. The Greeks do not differentiate between artist and craftsman; they used the same term “*techne*” for both art and craft. Artist and craftsman were people who had a techne and knew practicing it. Techne does not simply refer to expertise in practical work; it also introduces a kind of knowledge and man’s intelligence that had been integrated into practice with different methods and flexibility (Ballantyne 2001). It is clear from the statement of Porphyrios that “*techne*” refers to either art or craft which has came into being by the intelligence and creativeness of a person using resoning to arrive at conclusions. That person is a builder which refers to a Greek word “*tecton*”. Looking through etymologic meaning of “tectonics”, it derives from the term “*tecton*” indicating carpenter or builder. As a notion “tectonics” represents the composition of technique with art and construction with poetry (LeCuyer 2001).

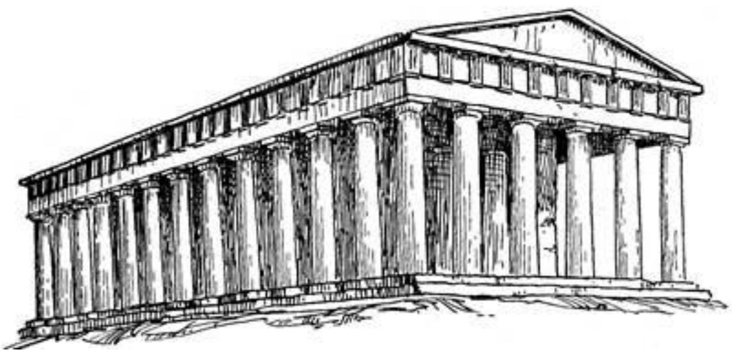
As it is clear from all these expressions, tectonic refers to an activity of compounding building elements to design the whole and giving a form to it. It is necessary to clarify the design idea and tectonic aspect of each element during this activity. A composition of different elements requires consideration of their structural and material nature. Understanding structural principals of the elements and the material opportunities bring creativity in architectural design. In this sense it is time to remember Steven Holl’s statement in the endorsement part of Kenneth Frampton’s (1995, backcover) book Studies in Tectonic Culture that; "The material, detail and structure of a building are an absolute condition. Architecture's potential is to deliver authentic meanings in what we see, touch and smell; the tectonic is ultimately central to what we feel...”

Since the notion “tectonic” is strongly related to architecture in terms of building elements and their materiality, many architects and theorists have formed their own standpoints about tectonics. In this part of the study, inspiring theories and thoughts on tectonic aspect of Karl Bötticher, Kenneth Frampton and Gottfried Semper will be discussed in order to get an idea of the concept of building skin in terms of corporeality of architectural space.

2.2 KARL BÖTTICHER'S THEORIES ON TECTONICS

Karl Bötticher is a German architectural theoretician and archaeologist who wrote about tectonics in his masterpiece, *Die Tektonik der Hellenes* (The Tectonics of the Hellenes), between 1843 and 1852. He described symbolism and tectonic/structural concerns of Greek Architecture in his book. He accommodated Karl Otfried Müller's definition of tectonics which was the first clear definition of the term. In Müller's Handbuch der Archaologie der Kunst (Handbook of the Archeology of Art), published in 1830, he construed the tectonics as combination of practical entities and art; "such as utensils, vases, dwellings and meeting places of men, which surely form and develop on the one hand due to their application and on the other due to their conformity to sentiments and notions of art. We call this string of mixed activities tectonic; their peak is architecture, which mostly through necessity rises high and can be a powerful representation of the deepest feelings." (Frampton 199, p.4). Adopting the definition of tectonics by Müller, Bötticher assembles knowledge of structure from the Gothic's arcuated building systems and representational ornaments form the Greeks.

Figure 2.1: Greek Temple



Source: http://wallpanelling.co.uk [accessed March 5, 2012]

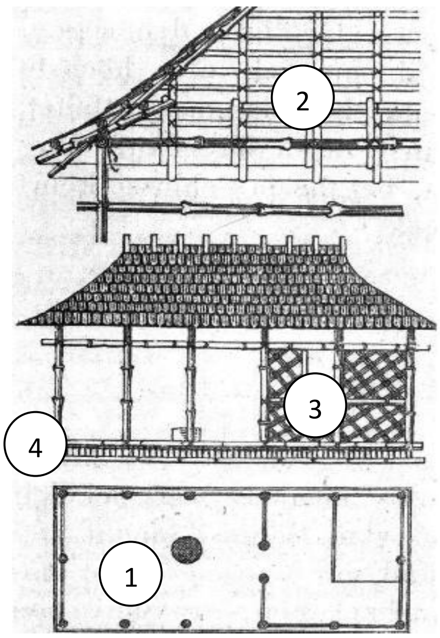
Based on this ideology, Bötticher divided architecture into "Kernform" (core-form) and "Kunstform" (art-form) (Schwarzer 1993). Differentiating between the constructive and the decorative element, he meant to say that "Kernform" is the form of an element which is a mechanically and structurally necessary component. The "Kunstform", in contrast, refers to functionally clarifying characteristics that were not only belonged to the elements, but also to the relationship between the elements. Mallgrave (2006, p.531), in his book “Architectural Theory” interprets Bötticher’s theory and states that; “His distinction between a “core-form” (also work-form; abstractly, actual structural work to be performed) and the “art-form” (its symbolic or artistic representation) became a cornerstone of Greek tectonic theory, and gave rise to an abundance of theorizing on the application of these concepts to new materials and technologies.”

Bötticher’s theory of tectonics is about understanding how single elements form the parts of a harmonious whole. According to him, investigating the role of each building element in a structural system and spatial organization is necessary to understand the tectonic characteristic of a building. Also, static and material studies on the building end up with the different forms of building elements (Frampton 1995). Bötticher’s theory, introducing the distinction between “Kernform” and “Kunstform”, made it possible to conceive style as a progress with the agency of new technologies and materials. In this point of view, rereading of Bötticher’s theories is important in order to create potential visions for contemporary architecture.

2.3 GOTTFRIED SEMPER’S FOUR ELEMENTS OF ARCHITECTURE

Theoretical works of a German architect and theorist Gottfried Semper is important when addressing the question of the architectural role of a building skin and its corporeality. Understanding the language of the building skin has a long history, since its consideration in the context of material, materiality and theory of dressing by Gottfried Semper in the mid-nineteenth century. From primitive materials to contemporary ones, his theories provide a strong understanding of the historical origins, in describing the corporeal existence of architectural space in terms of building skin. To conceive the theories of Semper, one needs to refer back to 1840s. Under the influence of technical developments in that period of time, Semper tried to form his architectural theory. In the lectures that he had given in Dresden Academy, he talked about “primordial forms” in architecture, defining the “enclosure” and the “roof”, then he added “hearth” to the list. Later on, he summarized his theory in the fifth chapter of “The Four Elements of Architecture (1851)”. In the first chapter of the book, he stated that, Greek civilization was not spontaneous, rather it was influenced by exterior motives and borrowed cultural ideas from other civilizations referring to Laugier’s primitive hut and Quatremere’s cabin. These influences shaped the material selection and construction methods of Greek architecture. The Caribbean hut at the Great Exhibition demonstrated the use of the four elements perfectly. All of these four elements could be transformed rapidly and naturally by the pressures of industrialization (Curl 2000). Semper presented the four elements generating architectural form: the hearth, roof, enclosure, and mound. The idea of roofing was related to creation of a tectonic or structural framework including table and chair making. The idea of mounding was about raising the hearth above the dampness of the soil, also connected with terracing, even the masonry wall. The creation of enclosure was an activity about weaving and braiding. While defining the four elements, using the term “elements”, Semper did not mean to refer their material elements or forms, but described them as “motives” or “ideas” as technical operations based in the applied arts. In Semper’ s point of view, the method of understanding the general principles of art form and architectural work was about investigating the development of industrial arts. Different techniques in the process of development might be an initiator to create new styles both in art and architecture. Each motive took its origin from different crafts (Semper 1989).

Figure 2.2: Caribbean hut; 1. Hearth, 2.Roof, 3.Enclosure, 4.Mound



Source: Der Stil, 2004

Interpreting the method of ancient artisans, Semper limited his concern to the concentration of three factors which were; the technical application, the function of objects that was performed, the features of the materials used. This approach was called "practical aesthetics" (Hermann 1984). While concentrating on these factors Semper clearly specified that; "Material must always be subservient to the idea; it must never be the only decisive factor for the embodiment of the idea. Making the idea manifest must not conflict with the material that conditions it, yet it is in no way absolutely necessary that the physical appearance of the material as such is an additional coefficient of the art phenomenon."

In his book *Style in the Technical and Tectonic Arts, or, Practical Aesthetics* (1860), Semper classified these motives that are at the basis of architectural creation as; textiles, ceramics, tectonics (carpentry), and stereotomy (masonry) and related each motive to different craft. The first motive was "textiles" which was a flexible and a tough material, resistant to tension. The second was "ceramics" a soft, plastic material and "carpentry" which was sticklike. Lastly, he dealt with solid aggregates, resistant to compression referring to "masonry". Additionally, he described metal as the fifth class which progressed after these four classes by the aid of the others. (Table 1) (Semper 1989).

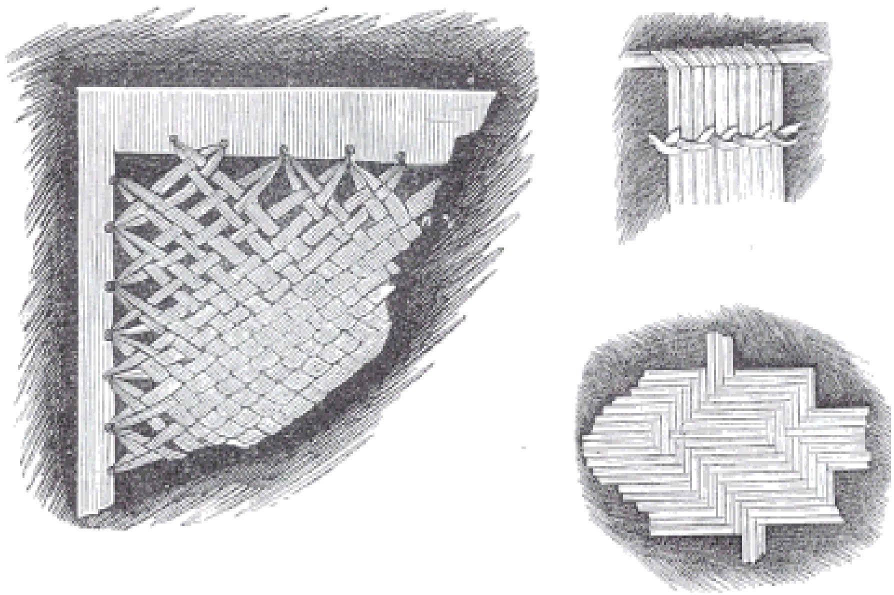
Table 2.1: Four elements of architecture, Gottfried Semper

FOUR ELEMENTS	MATERIAL	TECHNIQUE
HEARTH	CLAY	CERAMICS
ROOF	WOOD	TECTONICS
ENCLOSURE	FABRICS	TEXTILE
MOUND	STONE	STEREOTOMY

Through these classifications, functional, technical and material factors that have influence on the four motives were investigated. As a consequence of representing four motives and the factors, Semper focused on the “enclosure". Semper (1989, p.103) continued to describe:

> *“According to how different human societies developed under the varied influences of climate, natural surroundings, social relations, and different racial dispositions, the combinations in which the four elements of architecture were arranged also had to change, with some elements becoming more developed while others receded into the background. At the same time the different technical skills of man became organized according these elements: ceramics and afterwards metal works around the hearth, water and masonry works around the mound, carpentry around the roof and its accessories. But what primitive technique evolved from the enclosure? None other than the art of the wall fitter, that is, the weaver of mats and carpets.”*

Figure 2.3: Weaving techniques assigned to textiles



Source: Der Stil, 2004

Semper advocated the importance of textiles from the primitive times. He assigned technical skills to “textiles” as an element or motive “enclosure”. The alteration of the motive into the idea of “dressing” characterized his famous theory. The motive that

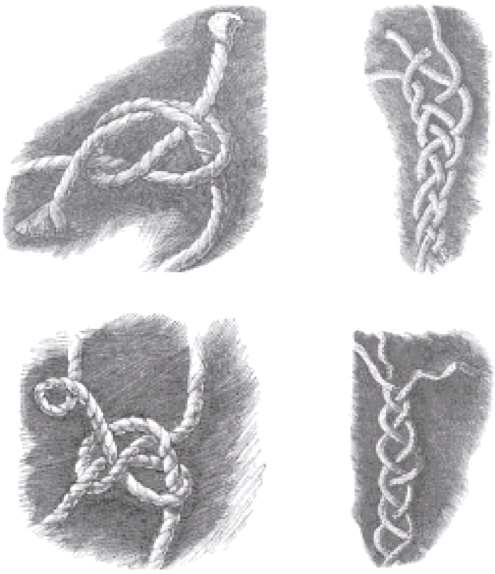
Semper deduces first appeared in the primitive braiding of tree branches, converted into bast and wicker weaving, then woven threads (Semper 1989). In "Style in the Technical and Tectonic Arts", a part titled as "style as conditioned by the treatment of materials" contains the information that textile methods improve the transformation of raw materials into graceful and strong products with their valuable features (Semper 2004). The forms used for binding and fastening, adoptable surfaces have the aim of covering, containing, dressing, enveloping, and so on. This section demonstrates the idea of taking the material treatment to its limits to create an architectural style and an important issue to focus on.

The early actions with playing the limits of materials; threads, spun or twisted yarn, braiding, seaming, matting, the loop, weaving and the knot are some of the inspiring activities that helped to shape future works. Semper deals with the production of primary motives as bands, threads, knots and their applications in a more complex system as nets, lace and plaited works. At this point it can be said that, according to Semper, "knot" is an important technical detail which is emphasized in Joseph Rykwert's (1983, p.125) essay:

> *"By a curious use of word-play, Semper foreshadows his later reference to the knot as the essential work of art… when he considers the term Naht: the seam, the joining. It is, he says, an expedient a Nothbehelf for the joining of two planes of similar or dissimilar material. But the very juxtaposition of Noth and Naht suggests the connection. The seam is an analogue and symbol which has archaic roots, for the usage of joining originally separated planes. Here he presents the reader with a primary and most important rule of art in its simplest form: to make a virtue out of a necessity."*

Usage of "knots" while giving form to materials such as wood, textile and so on is a old technique. It is obvious that this technique takes a strong part in the development of architectural forms from past to today. Semper had investigated and questioned architectural practice in the process of basic techniques to complex textile knitting in his writings. His final work has an influential effect on the meaning of building skin today. Semper focuses on the connection between form, material and technique in the definitions that he stated and he interpreted the skin/wall that abstracts the notion of interior and exterior space, also has the function of covering, protecting. For this reason, the wall type that emerges from the need of meeting with these purposes is not masonry structure but "the knot" that comes into being with the basic techniques or "the textiles" that are formed by interweaving of elements. Semper was interested in the appearance of the textile work in architecture to present his most important theory "dressing" with the different techniques (Semper 1989). Later on, these textile products had required more stable structural system for a support. Transformation of the textile products that were used to define and limit the space in terms of technique and materials had shaped the meaning of "building skin".

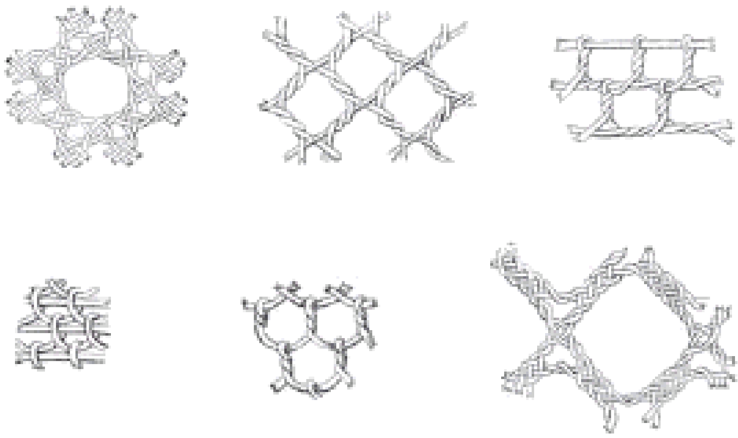
Figure 2.4: Weaving techniques assigned to textiles



Source: Der Stil, 2004

Even though understanding the limits and the treatment of materials are important, investigating the reasons for the emergence of different living spaces and material selection are other tasks of architecture. For allocating properties from each other, covering floors and protecting it from cold, separating interiors, the use of wickerwork, mats and carpets were used earlier than masonry walls. Wickerwork as an original space divider retains the importance of its earlier meaning after the transformation of the wickerwork into clay tile, brick or stone walls. It becomes a basis for the wall (Hvattum 2004).

Figure 2.5: Weaving techniques assigned to textiles



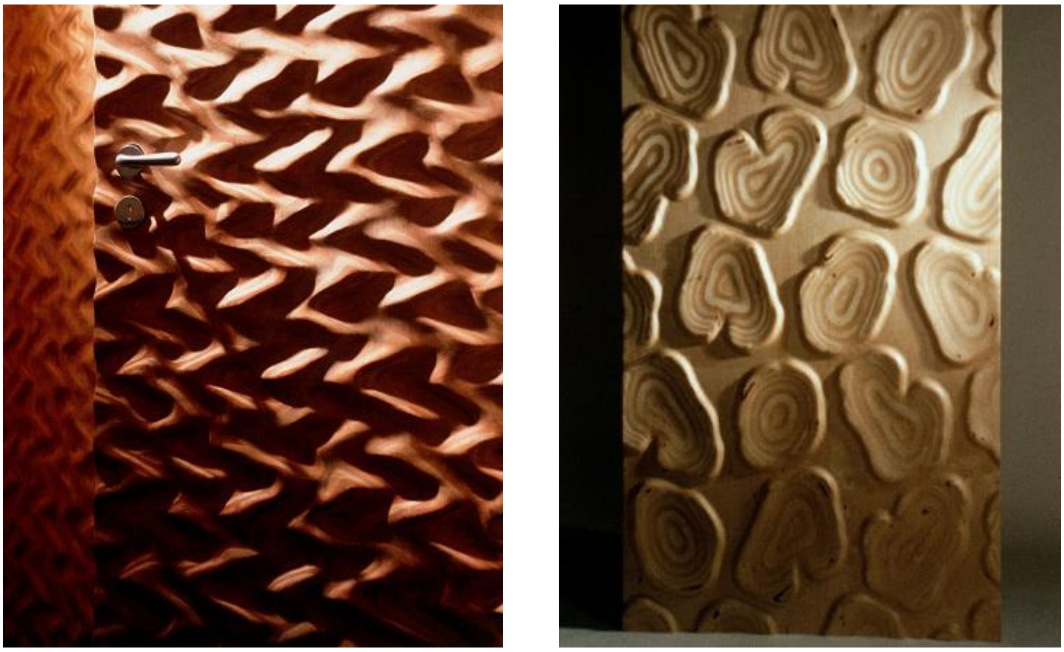
Source: Der Stil, 2004

At this point it is remarkable to note that the German word *wand*, meaning wall has a single root with the German word *gewand*, meaning dress. These two German words with common root "dress", demonstrate that the wall is formed by a woven material. One of the woven materials, hanging carpets preserve as the origin of walls that are the borders, separators of space. However, changing factors that do not have an effective role in conception of space but rather in creation of more secure, durable and permanent spaces became necessary (Semper 1989). The need for more solid walls to negotiate with these requirements appears and consequently the "*textile*" enclosure becomes a "*dressing*". Later, "*surrogate dressings*" take place of textiles, such as stucco, wood and metal plaques, terra cotta facings, and alabaster and granite paneling.

According to Semper's theory, load carrying and supporting wall elements do not reflect the original meaning of the wall. It is the "dressing" that represents the motive and spatial character of the true wall (Semper 1989). The reason why materials other than carpet such as wood, metal or terra cotta were used because they were able to last longer or they were more outstanding. But still, the solid walls behind them had nothing to do with the creation of space, they were the invisible structural elements used to support the dressing (Hermann 1984). At this stage, a textile-like wall panels were not to be treated as decorative surfaces, but "dressings" or "masks". As Mallgrave (2005) stated; "Architecture's denial and transcends of its real or material basis thus became for Semper its highest ideal." He continues that Semper's ideas about "materiality of stone" does not mean “covering it up”. But, truly transforming it and integrating it into a “pure form”

Semper finds his place in today’s architecture with his influential theories and his practice. With the investigation of Semper’s “theory of dressing”, Bernard Cache, an independent architect, appraised his own architecture in his article “Digital Semper”. While working on a pavilion in Archilab conference in Orleans, he realized that his work has lots of similarities with Gottfried Semper’s theory that was expressed in Der Still (1863). Bernard Cache compares his concept on the pavilion with principles of Semper’s theory and claims that, affinity to Semper’s theory is neither because technical arts are efficiently used to create the architectural product, nor it is about invention of new materials to produce new designs, but because the effective usage of decorative wooden panels is uniform with Semper’s “theory of dressing”. Also his investigations into the generation of software to map key elements of modern topology, like knots and interlacing, consists of a contemporary transposition of Semper’s *Urmotive* or primitive pattern.

Figure 2.6: Effective usage of decorative wooden panels



Source: http://www.archilab.org/public/1999/artistes/obje01en.html [Accessed March 10, 2012]

Cache's interest in Semper emerges from his "conscious articulation of technology and history in architecture." Today, focusing on the structure, Cache summarizes Semper's theory in four propositions;

1. Architecture, as with the other fine arts, finds its fundamental motivation in the technical arts.
2. The four major technical arts are: textiles, ceramics, tectonics and stereotomy.
3. Among these four technical arts, textiles lend many aspects to the other three techniques.
4. The knot is the fundamental mode of textiles, and therefore of architecture, in as much as this monumental art is subordinated to the cladding principle (Cache 1998).

Cache creates a scheme which provides oversimplified reading of Semper's system that was explained in the first chapter of the introduction, then he expresses a brief outline of Semper's theory. Taking Semper's method to analyze technical arts in terms of two different aspects; "the general-formal" and "the technical-historical" into consideration, Cache's table demonstrates abstract procedures and traditional materials including fabric, clay, wood and stone. Each material has its own imperative character which can be shaped by the abstract procedures of textile, ceramics, tectonics and stereotomy.

Table 2.2: Historical and Traditional Materials, Bernard Cache,"Digital Semper"

Abstract procedures	Textile	Ceramics	Tectonics	Stereotomy
Fabric	Carpets, rugs, flags,curtains	Animal skin flask, Egyptian situla		Patchwork?
Clay	Mosaic, tiles, brickwork, cladding	Vase-shape, earthenware, Greek hydria		Brickwork, Masonry
Wood	Decorative wood panels	Barrels	Furniture, carpentry	Marquetry
Stone	Marble and other stone cladding	Cupola	Trabeated system	Massive stonework

*Source:*http://fielddesignlab.files.wordpress.com/2009/07/digital-semper2.pdf [Accessed March,10, 2012]

Creating a relationship with Semper's historical and traditional schemes of materials, Cache expands the method and introduces another table which demonstrates modern and contemporary materials including, metal, concrete, glass, and biology and information.

Table 2.3: Materials of the Modern and Contemporary Architecture, Bernard Cache, "Digital Semper"

Abstract procedures	Textile	Ceramics	Tectonics	Stereotomy
Metal	Hollow metal cladded statuary; Olympian Jupiter reconstituted by Quatremere de Quincy; metal roofing; articulated metal structures; curtain wall	Metal vases or shells	Cast iron columns	Forge, ironworks
Concrete	Prefabricated concrete screens; light warps; curtain wall	Ruled surfaces; like: hyperbolic paraboloid	Slabs on stilts	
Glass	Thermoformed glass; curtain wall	Brown glass	System glued glass (pictet)	Glass bricks
Biology	Mollusks	Radiates D'AT: Surfaces de Plateau	Vertebrates D'AT: skeletons and bridge structures	Articulated, D'AT: bees' cells
Information	Modulation interlacing (Eurythmy)	Revolving solid, polar coordinates	Translation, Cartesian coordinates	Boolean operation, tiling algorithms

Source: http://fielddesignlab.files.wordpress.com/2009/07/digital- semper2.pdf, [Accessed March,10, 2012]

Throughout the research that Cache made, he states that, "*The origin of architecture is no longer unique, since it comes from four technical arts, and, we might add, is no longer Greek. We could even say that there are no more origins at all, but instead a composition of several lineages of transposition by which the four abstract procedures constitute themselves by switching from the material to the other.*" (Cache 1998). Asking the questions;

> "*What does it mean today to refer to Gottfried Semper ?...Why would we need to reconnect the end of our iron, concrete and glass century to the history of wood, stone, clay and textiles?.... Do we not run the risk of a new technological determinism, by which the information age, the so-called – 'third wave,' would create a second break with the past, definitely negating any historical experience, leaving us with no alternative other than a choice between the dinosaurs and the space shuttle?*"

Cache decided to work on Semper's theories and introduced the "Digital Semper". This clearly shows us that it is really important to go back to the roots where there might be some similarities supporting and helping us to develop architecture. Architecture is transforming from, one material to the other, one technique to the other, one technology to the other, being able to command each point of view and following the opportunities of time is essential in order to come with innovative architectural products.

2.4 KENNETH FRAMPTON'S "STUDIES IN TECTONIC CULTURE"

Kenneth Frampton an important architect, critic, historian with his writings on tectonics and architectural practice is one of the theorists who revived "tectonics" as a notion in architectural statements in the beginning of 1990s. Frampton published his book called "Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture" in 1995 and "Rappel A L'ordre: The Case For The Tectonic" which aim to explore the primary characteristics of architecture in terms of tectonic understanding. In his book, Frampton states that "We may claim that the built invariably comes into existence out of the constantly evolving interplay of three converging vectors, the topos, the typos, and the tectonic." (Frampton 1995). "Studies in Tectonic Culture" section will focus on Framton's understanding of tectonics and his method for investigating tectonics. He explains his interest on “tectonics” with this statement; “I have elected to address the issue of tectonic form for a number of reasons, not least of which is the current tendency to reduce architecture to scenography. This reaction arises in response to the universal triumph of Robert Venturi’s decorated shed […]”(Frampton 1996).

Kenneth Frampton analyzes influential architects and their buildings in terms of construction methods and material usage in his book. His studies in tectonic culture are significant for illuminating the origins of tectonics in terms of material usage, structural principles and methods with the investigation of influential works of architectural history. It is a kind of a study that theoretically looks at the works of the past in relation to construction techniques. As indicated by Adam Erbaugh (2006) in his Master’s Thesis; “The Interaction of Poesis and Tekne in Tectonics”, Frampton (1996) investigates influential architects with their studies and presents the notion “tectonic” in various references, such as;

> *“Structural expressivity in relation to Eduard Sekler, tendency towards lightweight/efficient structure as a polarity to the stereotomic or in reference to Gottfried Semper, organic as to the use of material in its strengths in relation to some of Frank Lloyd Wright’s concepts, ordered organization as is expressed in the buildings of Louis I Kahn, tectonics is a basis for integrated design and is therefore capable of incorporating other doctrines, such as avant-garde; as displayed by Mies van der Rohe, the degree to which the usefulness of an artistic product has been achieved as per Adolf Heinrich Borbein, composed as an intelligent integration of the artistic (kunstform) and technical forms (kernform) as described by Karl Botticher.”*

Understanding the meaning of the “tectonic” requires a thorough investigation of theories of various architects throughout history, just as Kenneth Frampton did in his studies. Analyzing different ideas helps us to create different points of view in the field of the study. He takes ideas both from Karl Bötticher and Gottfried Semper to create his theories and his definition of tectonics as “the poetics of construction”. Taking Semper’s classification into account, Frampton states that Semper would divide building crafts into two basic concepts as the tectonics of the frame and the stereotomics of the earthwork. Tectonics of the frame refers using lightweight, linear components to surround a spatial matrix and the stereotomics of the earthwork refers using heavyweight elements to connectedly form mass and volume (Frampton 1995). Frampton explains these two methods of art of construction, at the same time he mentions about the existence of three different conditions: the technological object, which arises directly out of meeting an instrumental need; the scenographic object, which may be used equally to allude to an absent or hidden element; and the tectonic object, which appears in two modes; ontological and representational tectonic. In this regard Framton declares the togetherness of these two modes, differently than Semper's distinction. According to him, from the discerning emergence of the notion with the writings of Karl Bötticher and Gottfried Semper in the middle of the nineteenth century, the tectonics not only refer to a structural and material value but also to poetics of construction. (Frampton 1996) According to him, structure and material takes an important part in the creation of an architectural space and its transformation from technological object to tectonic object. Evaluating Kenneth Frampton's studies in terms of understanding the structure in the sense of materials and considering methods to express the true essence of a building is very important. Investigating logics of construction, analyzing structural elements clearly with their details and a well-designed concept would bring better architectural spaces.

Researching the meaning of the tectonics and re-reading of architects' studies on the topic such as Karl Bötticher, Gottfried Semper and Kenneth Frampton help us to interpret the tectonics in a more productive way. Bötticher divided architecture into two forms; structural (core form) and representational (art form). In his point of view tectonic was a connecting sytem of all elements related to a building. He focused on the expression of the structure and new materials in connection with the arts and craft. Semper also described a separation as structural and symbolic in architecture. He was interested in architectural dressing as a skin and focused on the material and construction techniques. Frampton's understanding of tectonics was about demonstrating the significance of the building. According to him structural materials and the method for putting them together was important because he understood tectonic as craft. In light of this information, it is strongly necessary to investigate the relationship between tectonic, building materials and elements of the building.

Considering the building skin as a part of the building, this study would help us to understand the design opportunities of the “skin” and its role in the corporeal existence of an architectural space.

3. EVALUATION: THE ROLE OF THE BUILDING SKIN AS AN ARCHITECTURAL ELEMENT

3.1 DEFINITION OF THE BUILDING SKIN

People need a space as a shelter that covers, provides safety and protection from undesirable conditions since primitive times. These basic requirements make the building skin one of the most vital elements of the building which requires a detailed study in the early stages of design.

Building skin is both separating and linking element between inside and outside. Its' functional, constructional, formal and environmental occupations take an important part in the architectural design process that requires to be studied extensively. Building skin provides protection from outer elements, creates privacy and defines a boundary around personal property. Its' aesthetic and cultural function are equally important. As stated by Christian Schittich (2006); "The building skin-and especially the facade- is the calling card of a building and its designer. Set into context, it characterizes the face of a city. No wonder that it draws more attention than any other building component."

"Building skin" as a term was used only for the vertical element of a building in many sources. It was designated as the side presented to the public. Eventually different ideas on the definition of building skin were developed. One of them is the presence of a horizontal and vertical surface element of the building as a whole. Essentially, natural cave in primitive times is an example of horizontal and vertical surface of the building as a continuous element. Later, a division between vertical and horizontal element appeared in the construction of the skin. The wall started to be practiced as the vertical element and the roof started to be practiced as the horizontal element. Recently new terminologies for building skin have been developed. Schittich mentions about the "true skin" which is related to the building where roof and wall are one continuous element without visible transition. A thorough study of history is essential in understanding the design of "true skin" and the wall as a skin, and their applications. The next section will concentrate on the building skin and its development in history form primitive to contemporary.

3.2 BUILDING SKIN – PRIMITIVE TO CONTEMPORARY

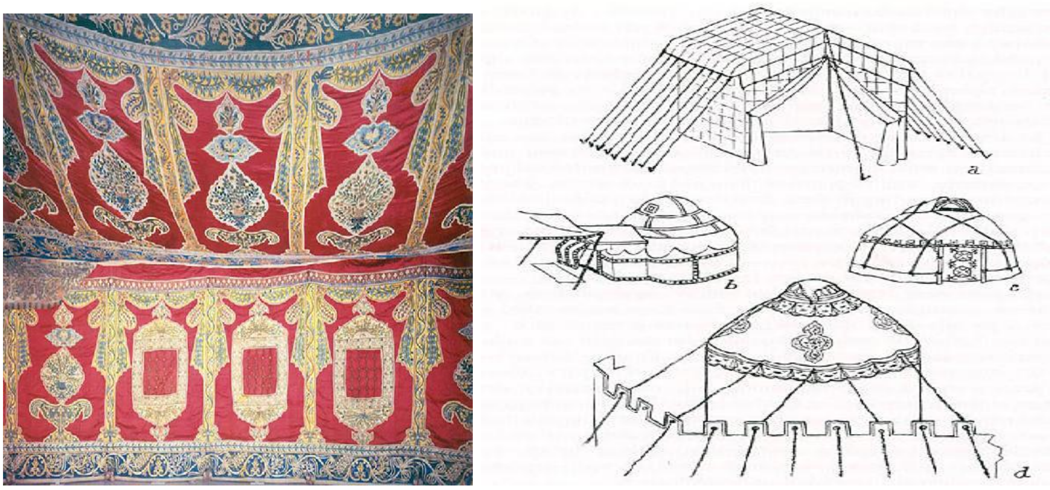
Starting from the ancient times, people have tried to find a shelter in nature. Holes in the ground, caves in rocks, or spaces made by very dense vegetation were used as shelter. The reason for seeking shelter in nature was mostly to satisfy the need for a space suitable for protection and survival (Herzog, et al. 2004).

Figure 3.1: A cave in Vietnam

Source: http://epod.usra.edu/blog/2011/01/title-infinite-cave-in-vietnam-photo-011photographer-carsten-peternational-geographic-magazinesummary-author-mark-je.html

With the changing conditions, people have tried to find different solutions for a shelter. Rather than resorting to nature for shelter, forms of primitive shelter in ancient times developed by some nomadic tribes like the Jurts. The round tent as one of the examples of those forms of shelter evolved among the Turkish tribes and the ancient Mongolian tribes (Schittich 2006).

Figure 3.2: The round tent of the Turkish tribes



Source: http://www.turkishculture.org/military/tents-176.htm

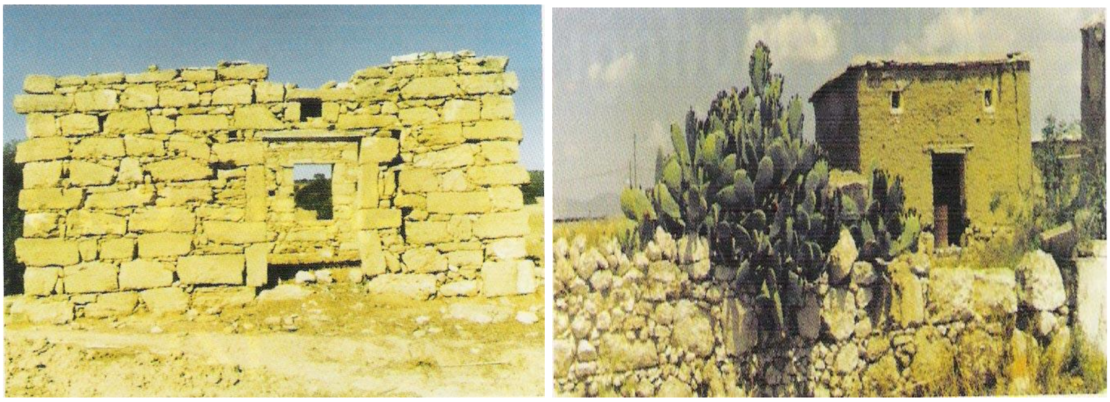
Throughout history, architectural improvements have coincided with the development in societies. The architectural styles and variations of building skin have also developed alongside, emerging building techniques and materials. From primitive building skin to contemporary counterparts, this section will focus on the evolution of the building skin that came into prominence as a result of important developments in history.

3.2.1 BUILDING SKIN – THE WALL

The awareness of new local building materials and changes in the lifestyle lead people to search for new building methods and people have found alternatives for their shelters. These methods allowed people to build their own shelters after nomadic culture evolved to a more sedentary one. During this building process, roofs and walls were formed and the external surfaces of these shelters became an important part of the whole because of the tasks given to the building skin. The building skin started to become thinner than the existing massive stone or earth face of the ready-made caves and natural holes in these human made buildings. The thinner walls also redeveloped the meaning of “inside and outside” while defining interior and exterior space clearly (Herzog, et al. 2004).

One of the most considered themes in architecture, regarding the building skin is the relationship between window and wall, or more broadly – solid and void. Initially, wall openings on traditional buildings were smaller and their sizes were determined mostly by the construction technique. Not only it was difficult to create large window openings in a massive stone or sun baked clay structure, but it was also a requirement for protection and shelter. As glass was not a common building material, creating large openings also equated with losing significant quantities of energy, dictating that the opening should be as small as possible (Schittich 2006).

Figure 3.3: Traditional small openings



Source: http://www.kibris1974.com/geleneksel-kibris-insaatciliginda-tas-t759.html

Since the beginning of human existence, "wall" is one of the most essential part of buildings and effects of different architectural movements could be easily traced on the walls. The creation of large openings in the walls was first implemented in Gothic architecture. Emerging in the first half of the 12th century and continuing well into the 16th century in Northern Europe, Gothic architecture pioneered the methods for creating larger openings in the stone-faced shells of sacred buildings. The novel application of stained glass emerged on the expansive windows of scared spaces, creating a mystic atmosphere for worship. Releasing large sections of the external wall from their load bearing function in order to create large openings became usual in building design as "architectural space opened towards the light." (Schittich 2006).

After the Industrial Revolution usage of massive wall component in the design of building skin decreased in order to get more sunlight into the space. As a result of the developing industry, materials such as cast iron, steel, and glass became widely available. Joseph Paxton, a very important architect of the 19th century, designed his buildings considering the functional aspects as priority in his design. His most influential architectural work, Crystal Palace, constructed for the World Fair in London in 1851, is the most memorable example among transparent buildings with its transparent building skin made of glass and steel. According to J. Mordaunt Crook (1987),

> *"The Crystal Palace (1851-4) seemed to lie outside the world of architecture, outside even the world of engineering. The criteria by which it might be judged still awaited formulation. In Hitchcock's words, Paxton's scheme "owed its aesthetic qualities to factors hitherto unrecognized — the repetition of units manufactured in series, the functional lace-like patterns of criss-cross trusses, the transparent definition of space, the total elimination of mass and the sense of tensile, almost live, strength as opposed to the solid and gravitational quality of previous masonry architecture." The vocabulary of a machine aesthetic had yet to be developed."*

Every detail of this pioneering structure was progress according to the requisites of the given function that allows a maximum amount of incident sunlight into the space. Scale and span, the cost, prefabrication, and assembly time were dictated by the circumstances. Its concept reflected a sense of limitlessness with its transparency and it became a basis for modern architecture (Schittich 2006).

In the middle of the 19th century, functional and economic needs of the changing world led changes in the facade. The void in urban facades reached to a reasonable level. Confidence in the reality of a transparent facade came with the presence of necessary technology. The importance of the openings becomes clearer with the statement of Le Corbusier who is one of the most influential architects of the 20th century; "The history of architecture is the history of the window." (Hochberg, et al. 2010). The meaning of the wall and the ratio of the solid and the void has been changing since primitive times. Wall and window blend into each other in the sense of structured opening. External envelope opened up and the changing demands and technologies have shifted building skin from more massive, solid element to more transparent one.

3.2.2 BUILDING SKIN- STRUCTURE

There is a great shift from massive masonry construction technique to today's construction technologies in terms of building skin design. From building skin of readymade structures of the primitive times to contemporary period, skin and structure relationship is an important field of study for the design of building skin.

Gothic architecture was one of the most considerable architectural periods that affected the building skin design. It was based on a load transferring structure whereby the walls were no longer load-bearing. This structural approach allowed for the creation of large windows on the external walls. Greeks and Romans also used the column and beam building system to construct their buildings and then covered them with stone, brick, and cement. Similarly, stained glass, which was placed in-between arches supported by the columns of medieval cathedrals, existed as one of the nameless examples of the curtain wall system for ages (Hunt, 1958).

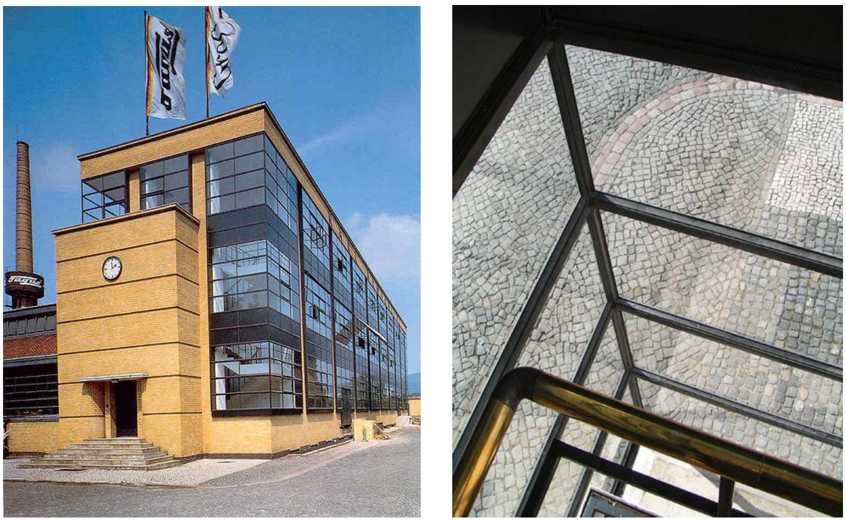
Figure 3.4: Western Facade of Notre Dame de Paris

Source: http://en.wikipedia.org/wiki/File:NotreDameI.jpg

As the 17th century gave rise to the Enlightenment, a cultural movement of intellectuals in the 18th century Europe and America, aimed to reform society and advance knowledge and changes in the structure of the societies. The 19th century took these ideas and evolved into the Industrial Revolution. The Industrial Revolution affected almost every part of human life, also architecture. As a result of developments in technology, new building materials and construction techniques carried building facades to extraordinary limits. Before the Industrial Revolution buildings were limited to natural materials like wood, stone, and sun-baked clay. The progressive relationship between architecture and manufacturing opened expansive opportunities, making new building types, materials, and techniques possible. The external skin and the load-bearing structure were able to be completely separate. Developments in construction technology made the steel skeleton available as a reliable construction method and this sequentially made the wider span of windows possible on external walls. Beginning in the United States, the development of elevators also allowed iron load- bearing structures to expand in height. These developments were able to increasingly influence the independence of external skin from their structural function. A complete separation of the external skin was first seen in industrial buildings. The external walls were designed as fully glazed openings to achieve more light inside (Schittich 2006).

One of the early examples of “curtain wall” was Walter Gropius’ design for The Fagus Factory, between 1911-1919, which has eliminated corner piers and therefore achieving a fully glazed corner across three floors. Walter Gropius and Adolf Meyer managed to suspend a curtain wall in front of an industrial hall as a filigree, transparent skin that did not have any load-bearing function. This was meant to demonstrate the freedom of the building skin.

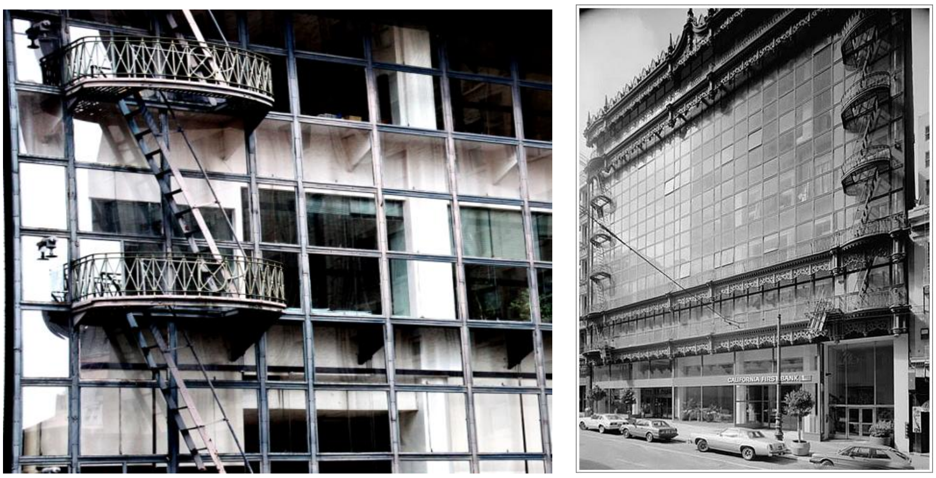
Figure 3.5: The Fagus Factory



Source: http://en.wikiarquitectura.com/index.php/File:Fabrica_fargus_23.jpg

The building assigned as the first pure application of the curtain wall system throughout architectural literature was the Hallidie Building, designed by Willis Jefferson Polk in 1918 in San Francisco. The suspended glass wraps the seven story tall building between columns spaced approximately one meter apart (Brock 2005). Polk was influenced by natural light and he wanted to facilitate construction while producing a completely glass facade. The structural grid for the glass facade was composed of mullions with three vertical subdivisions on each floor. The glass skin was carried on a concrete sill and cantilevered out from the upstand beam (Frampton 1983).

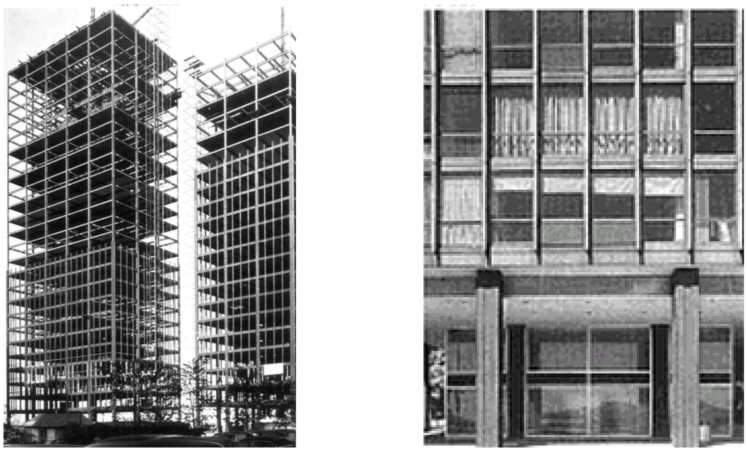
Figure 3.6: Hallidie Building



Source: http://waviness.wordpress.com/2010/10/23/hallidiebuilding/

An influential architect Mies van der Rohe brought a different touch to the facade with his re-interpretation of the curtain wall according to his own aesthetic with the design of the Chicago Lake Shore Drive Apartments in 1951. The building highlights another significant curtain wall structure built after the Hallidie Building (Schittich 2006). The panels of the facade were inserted into the secondary structure that was supported by the primary steel skeleton of the building. The building facade was designed in two different ways. The facade facing the lake is flat and the other facing the land forms a double T-shape. Both styles incorporated no structural function into the facade, rather the sole purpose of the facade design was to stress the verticality of the building (Cohen 2007).

Figure 3.7: Lake Shore Drive Apartments



Source: http://www.amazon.com/Ludwig-Mies-Rohe-Louis- Cohen/dp/3034607342/ref=sr_1_9?s=books&ie=UTF8&qid=1338730399&sr=1-

Another example, Mies' Seagram Building in New York did not use mass-produced components; instead, expensive components in bronze that accentuated the cross section were used. Using the golden brown colored glass panes – a color produced by iron oxide and selenium – resulted with an almost opaque volume (Schittich,2006).

Figure 3.8: The Seagram Building

Source: http://5wsofdesign.blogspot.com/2012/02/what-seagram-building.html

Glass curtain wall buildings spread rapidly around the world until the early 1970s and have become one of the defining elements of the International Style. A gridded glass facade also became the primary symbol for office buildings as greater attention was given to office design. The smooth and uniform curtain wall was advocated by the reproduction of commercial architecture and creative, elegant facade design soon become monotonous (Schittich 2006).

From the mid-sixties, a new method about glass fixing techniques emerged in the US. Fixing external glazing walls through the agency of silicon and the other techniques played an efficient role in the change of architectural facades. These structural innovations make it possible for a building shell to act as a skin by creating a continuous structure from facade to roof. All possible geometric forms can be enclosed in a system (Schittich 2006).

Figure 3.9: Zuev Workers' Club and Town Hall by Noi Trotsky

Source: http://en.wikipedia.org/wiki/Constructivist_architecture

Today architecture is no longer restricted by the load bearing wall. Glass manufacturing technology have made a great progress allowing light to be used more creatively to light interiors and redefine facades. Developments both in the building technologies and availability of new materials changed the facade design approach. The external part of a building gained another meaning as a result of these changes. But a common goal that aims to give a building skin a face still continues (Schittich, 2006).

3.2.3 BUILDING SKIN- EXPRESSION

Building skin was used solely to meet with specific functions such as protecting from external effects, defining boundaries and providing privacy until people started to decorate the building skin as they would also decorate their clothes. Consequently people started to add decoration to their shelters, such as tent, hut, or cave. Patterned clothes and painted decorations on the walls were first customs used to decorate shelters. This application then extended to simple homes, then to Greek and Chinese temples, Islamic palaces, and mosques as frescoes in different cultures and eras (Schittich 2006).

Frescoed Exterior Walls

Source: http://bobholley.wordpress.com/

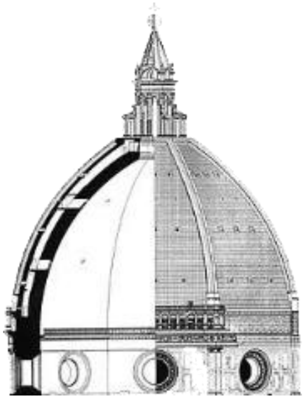
Intensified and complicated usage of ornamentation in the 12^{th} century emerged in the Gothic period. In Gothic architecture the expression of life in Greek ornamentation took a wider range and various suggestions of nature and resemblance to many different species of vegetation appeared on building facades. An extensive architectural flora used to decorate the exterior of the churches in that period (Moore, 2003).

Figure 3.10: Exterior view from Cathédrale de Troyes and Cathedrale Sens


Source: http://en.wikipedia.org/wiki/Martin_Chambiges

Just like all other architectural movements, Gothic movement consumed itself because of its intensifying and complicated ornamentation usage. With the change of massive and decorated style of Gothic to the cleaner classical lines of the "Renaissance" movement emerging in the 15th century, facades were separated from the structure and they started to drape over the front like a new "cloak" in the Renaissance. The reason for this separation was all for aesthetic purposes. The design of facades in the classical architecture has played an important role in the design process. The proportion and division by means of architraves, columns and rusticated ashlar stones were the important factors that had to be taken into consideration during this process (Schittich 2006).

Figure 3.11: Santa Maria Novella and the dome of Florence cathedral

Source: http://wkp.maluke.com/en/History_of_construction#Construction_in_the_Renaissance

During the Renaissance period in the 15th century, the external walls were designed to give the effect of an "exhibit". This effect became stronger as humanism that symbolizes an intellectual movement flourished in the Baroque era between 17th and 18th centuries. Impressive, artistic means were reflected by the facade. Facades became the expressive face of the streets with their decorations (Herzog, et al. 2004).

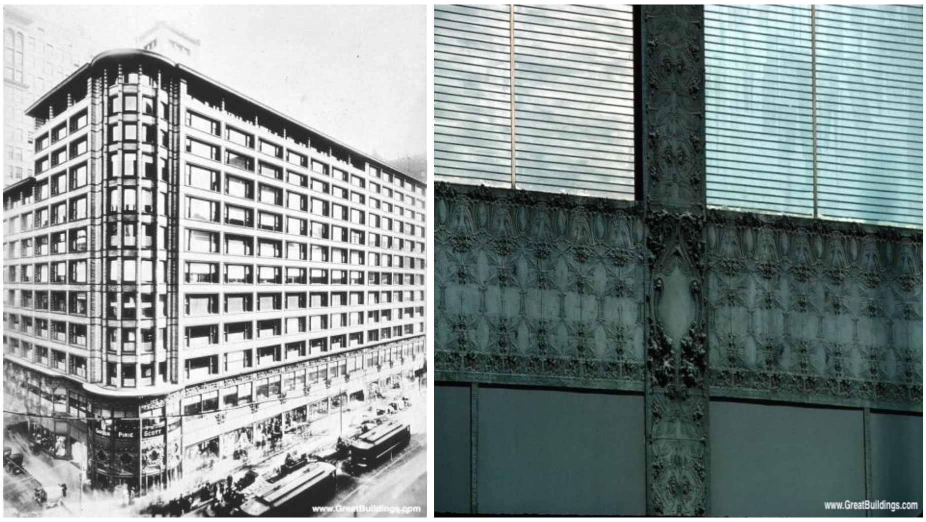
Figure 3.12: Cathedral of Santiago de Compostela and Basilica di Superga

Source: http://en.wikipedia.org/wiki/Baroque_architecture

After the Industrial Revolution in the 19th century, new construction techniques and materials were incorporated, first, in England and then expanded to Central Europe and United States. Germany widely accepted the new construction techniques and materials promoted by the Industrial Revolution and adopted the essence of its architectural design. The influence of the Industrial Revolution on architectural design advanced rapidly on the architectural stage. In particular, the rationalist expression of the structural system and materials of the building skin indicated the emergence of a new architectural approach known as "functionalist tradition." The guiding principle of the functionalist tradition implied a clear expression of the structural system and materials. Practical concerns such as use, material, and structure, also determined the form of a building (Richards 1968).

Based on the functionalist tradition of a clear outward expression of function, another architectural approach evolved to counteract the dissatisfaction of the architects with the historical revivalism in the 19th and early 20th centuries. The statement “form follows function” by American architect Louis Sullivan in the 1880s, made him known as one of the pioneers of modern architectural design. Sullivan designed the Carson Pirie Scott Store, originally known as the Schlesinger & Mayer Store and presently known as "Sullivan Center" in Chicago (1899–1904). This masterpiece radiates his design principles by demonstrating the clear division of the horizontal sections in relation to the floor slabs. This division makes the construction of the load bearing structure visible on the facade, which accurately illustrates Sullivan’s design theme that the exterior of a building must depict its internal structure and function. This design approach explicitly reveals the structure’s relationship between interior content and external form. One of the building’s most innovative features is its usage of material. The steel-frame structure allowed for bay-windows, which consequently created a great amount of available light in the building. Also, his ideas about ornamentation were summarized by Schittich (2006, p.12):“Yet Sullivan is equally convinced of the necessity of ornamentation. He is intent on enriching the building in its details, adding to the strength of its expression. But in doing so, his ornamentation is never superficial: it is always an integral component of the whole.”

Figure 3.13: Schlesinger and Mayer Department Store



Source: http://www.greatbuildings.com/cgi bin/gbi.cgi/Schles_Meyer_Store.html/cid_aj1852_b.html

During the 19th century, the positive relationship between England and Germany influenced researchers and architects traveling to both countries to bring new and innovative ideas back to their own country. For instance, German architect Karl Friedrich Schinkel was very impressed by the factories after traveling to England and back to Germany and his observations influenced his design approach. As Aurora Cuito (2003) indicated that: “His works can be interpreted from a Neo-Classical and Romantic viewpoint, but in his use of materials and construction techniques he also sought an architectural reasoning that went beyond the symbolic and archeological debates in which Neoclassicism sometimes raveled.”

In this context, Schinkel’s Bauakademie building could be referred to as ‘an announcer of modern architecture.’ It deserved to be taken into consideration because of its uncommon usage of red brick and streamlined facade in its iron frames structure (Micale & Dietle 2000).

Figure 3.14: Bauakademie

Source: http://de.wikipedia.org/w/index.php?title=Datei:M_Bauakademie_Berlin_1888.jpg&filetimestamp=20110325180646

Between 1860 and 1910, an international architectural design movement known as the "Arts and Crafts Movement" emerged as a reaction against the impetus to reduce decorative arts. Its fundamental principles were to emphasize the qualities of the materials used and to remain true to material, structure, and function. The building reflecting the fundamental principles of The Arts and Crafts Movement – in a radical way - is Otto Wagner's design for the Austrian Post Office Savings Bank in Vienna. In the early 1900's, this design was considered radical in Europe because it was the first functionally-inspired modern building to demonstrate the facade as a monumental element. Aluminum was used decoratively from the covering of the nails that hold the marble cladding on the walls The Austrian Post Office Savings Bank is another example of a strong modern architectural presence through the structure of the building skin and the clear expression of the materials. Aluminum gains more importance than other building materials with its dominant usage in this building (Glynn 2007).

Figure 3.15: The Austrian Post Office Savings Bank in Vienna

Source: http://www.greatbuildings.com/buildings/Post_Office_Savings_Bank.html

The architecture of the 1970s aims to give symbolic meaning to the building skin while referring back to the history. Its impulse in architecture does not propose imitating historical buildings. It is about using historical reference as a way of analyzing, and learning. Designing simple "decorated sheds" with rich, complex and often shocking ornamental flourishes, an American architect Robert Venturi (1984) stated that; "I am for richness of meaning rather than clarity of meaning. I like elements which are hybrid rather than 'pure,' compromising rather than 'clean,' distorted rather than 'straightforward,' conventional rather than 'designed.' "

Figure 3.16: Allen Art Museum Addition and Hôtel du Département de la Haute-Garonne

Source: http://www.architectureweek.com/cgi-bin/awimage?dir=2005/0406&article=design_1-1.html&image=12659_image_1.jpg

Venturi has never argued for a return, his aim was never taking architecture back to the principles of the previous architectural movements. His usage of historical forms was about integrating it into a wide-ranging and in the end, a contemporary whole. He also studied symbolism as a significant element of architecture. In one of his interviews he (http://www.archdaily.com/130389/interview-robert-venturi-denise-scott-brown-by-andrea-tamas/) states that;

> *"In ancient Egypt hieroglyphics covered the walls and columns of temples. They were both pictures and communications and it's been that way ever since. Italian church frescoes were only incidentally great art. They were there to give information to worshippers who couldn't read. And today's architecture may communicate via electronics. But although the buildings we design may allude to history, they don't copy it."*

Figure 3.17: Illuminated advertising Tokyo and Museum of Modern Arts, Graz

Source: http://www.architonic.com/ntsht/media-faade/7000408

In the contemporary buildings, the innovative use of construction techniques, the manipulation of structural elements, the exploration of color and texture of the materials transform the meaning of ornamentation in today's architecture. New materials such as bead-blasted metal or textured and tinted glass, brick, molded sheet metal, glass panels pierced screens in metal and concrete and ornamental patterns used on these materials play an important role in the new way of ornamentation (Burden 1997).

Figure 3.18: The Young Museum and The Cube

Source: http://www.makearchitects.com/#/projects/0012/

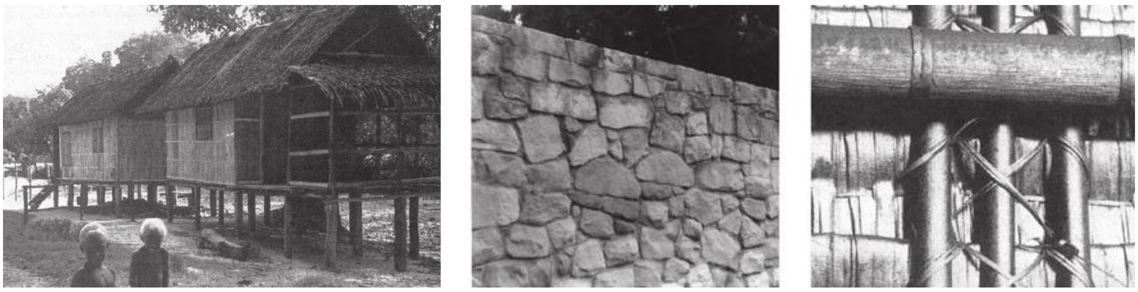
The application of a building’s skin has shifted from applied ornamentation of pre-modern notions to the removal of ornamentation in the modern period. The ornamented skin has reemerged in postmodern period and today building skin design interprets the use of ornamentation with various materials, different architectural approaches and sophisticated details.

4. BUILDING SKIN- MATERIALS

There are two methods generally used for researching the evolution of building materials. One of them is the transmission of existing materials into a new framework and the other is the discovery of new materials. New technologies and new materials open way to opportunities in architectural design.

Design of building skin was usually limited to the local available building materials and traditional building construction techniques in the past. People usually tried to find ready-made shelters such as holes in the ground, caves in the rock because they need for shelter for protection in primitive times. Eventually people used materials as they appear in nature without treatment. Some of the most common primitive building materials could be listed as; natural stone, adobe or mud brick, pise, limewash, clay and light timber frames.

Figure 4.1: Applications of primitive building materials



Source: K. Ward-Harvey, 2009. Fundamental Building Materials.

Building skin is a protective shell from the external environment for human beings. It declares the physical appearance of buildings, at the same time it is the expression of cultural and historical background of the society. Building skin envelops architectural space in different forms like dynamic or static, light or heavy, plain or patterned. The relationship between building skin and materials is an important issue to consider during the design of building skin.

People started to give form to the materials after identifying their characteristics and discovering their limits. Building material is one of the most important tool for architects to make ideas real. It influences the design of building skin where the idea becomes real as a tangible means of architectural expression. One of the best examples of giving form to the material could be found in Gothic Architecture with the usage of stone. Although stone is known as a massive building material, Gothic architecture paid more attention on the expression of the stone skin as an enclosure, as a reflection of the religious power. They managed to use stone, thinner and lighter.

Great progress of building materials started after the Industrial Revolution. The growth of heavy industry brought a flood of new building materials for building skin such as cast iron, steel, and glass (Schittich 2006). These developments made it possible to access various materials in different sizes and forms usable for different functions. Today, building materiality is an exciting and growing concern in architectural design process. Contemporary architects are trying to use materials in an innovative way. In addition to the industrially produced materials such as glass, different types of plastics, metals and concrete, they are also using traditional materials like stone and wood usable in different contexts in the design of building skin. Using different techniques and materials, building skin plays an important role in architectural design. New building materials started to be used in the building skin applications such as polyurethane sheeting, corten steel plates, stainless steel strip meshes, copper sheets, domed aluminum discs, translucent glass blocks, EFTE sheeting, wooden shingles and solar photovoltaic panels.

Investigating the materials used in building skin design is an extensive field of study. It is essential to understand the material properties, design potential and their integration into the building skin design. Taking this fact into account, this section will focus on two selected materials; glass and concrete. Both glass and concrete have been used attractively as building skin materials from the beginning of their invention until today. Dating back to more than five thousand years, glass has been playing an important role in architecture with its various manipulations (Bell 2006). It is a versatile material with its useful properties that leads architects to be more creative. Concrete has also been one of the most influential building materials from the times of Romans. It is a material that can be designed in any form and it is suitable for various surface treatments. The advantages of concrete support innovative building skin designs as it is clearly understandable from its diverse use in architecture. Glass and concrete's unique properties and roles in the building design revolutionized architecture. These unique features are the reasons why they are selected to be studied in this thesis. Encouraging innovative design and dramatic statements, these two materials with their pure usage or compositions enabled architects to embrace different architectural movements.

Glass as a transparent material and concrete as an opaque material has often existed together in buildings. Eventually both glass and concrete became materials that architects never give up using in their buildings. It is possible to transform glass and concrete in terms of its appearance or structure through different techniques. The following sections of the study will investigate glass and concrete as building skin materials with their properties, types and applications in different case.

4.1 GLASS AS A BUILDING MATERIAL

In contemporary building skin design, glass is one of the building materials that is mostly used. Although it is one of the oldest building materials, its noteworthy progress in terms of its structure, texture, size is worth investigating. The considerable diversity of transparent facade design in architecture supports the development of glass, glass constructions and products of glass facade. This fact makes glass as an important building skin material to investigate. Research on the subject, the acknowledgement of the available glass products will open new horizons in the design of building skin for architects and designers. In this section glass as a building skin material will be investigated in three sections; history of glass, glass as a building material and glass as a building skin material. The first section covers the definition of glass, expresses the milestone of the glass in history such as its origins and production method in the middle ages and the advancements after the industrial revolution. The second part contains the properties, types and surface treatments of glass in detail, and the last part is about understanding the meaning of glass as a building skin material.

4.1.1 History of glass as a building skin material

The term “glass” is derived from a Germanic term “glaza” that means “amber”, “glare” or “shimmer”. It is one of the oldest building materials whose origin can be detected at least 5.000 years ago. It is a composition of earthen elements which are transformed by fire. Glass is a solidified liquid without crystallization, and its components are silicon dioxide (SiO_2), calcium oxide (CaO), sodium oxide (Na_2O), magnesium oxide (MgO) and aluminum oxide (Na_2O) (Hegger, et al. 2006).

Glass used in the building industry today is mainly soda-lime-slica glass. Glass is an indispensable building material in buildings as a uniform, transparent, brittle material with various types and different properties (Schittich, et al. 2007). It seems that glass as a material will continue to exist. But many new applications and manufacturing processes will be involved in the production of glass, in combination with other materials.

Glass is one of the oldest building material. As a natural material, its origin was from volcanic finds that had been discovered almost more than 5000 years ago in Mesopotamia. The earliest objects made of glass in beadlike forms, vases and jugs, appeared in the tombs of Egyptian Pharaohs in the 4^{th} century BC. These could be the references of the first glass manufacture, although the origin of glass manufacture is not certain. Bottles and the first window panes for buildings became available with the usage of heat for the transformation of sand, seaweed, brushwood, and lime into a range of forms and colors in Egypt around 2^{nd} century BC. An important invention on glass that is still used today was the blowing of iron. Production of blown glass, which led to the production of thin transparent sheets strong enough for windows was first used in Syria around 200 BC. This invention made the production of hollow glass objects possible which gave a start for the relationship between glass and architecture. The production method easily extended to Europe in time because Syria was part of the Roman Empire at that time. Later, the production of the first flat, hardly transparent glass emerged with the casting method by the Romans (Bell 2006).

Figure 4.2: Pompeii and Herculaneum

Source: http://www.als-travels.com/Italy/herculaneum.htm

Replacement of opaque stonelike sheets of alabaster or marble to transparent glass windows had occurred after the method of pouring the molten glass onto a table in the sixth century AD. Glass became thinner, and more translucent with this method. The excavations in 79 AD reveal the first use of glass as a part of building envelope which had been practiced in villas at Pompeii and Herculaneum. Small flat panes of glass were made by the Romans. These panes that were set up with or without frame were approx. 300x500 mm and were 30-60 mm thick (Schittich, et al. 2007).

Production of glass was made generally for the churches and monasteries in the Middle Ages. Glass was used to create a spiritual environment with a great display of colors and shimmering light. Besides, it was a representative element of the Christian faith in Medieval and Gothic cathedrals in celebration of cultural and symbolic understanding. Colored glass was first used in Byzantine Empire and spread to Normandy, Burgundy and the Rhineland. Glass was often painted and organized into small segments to get the external light into the space with aesthetic properties, to display the architectural structure and surface qualities (Richards & Gilbert 2006). Since the Middle Ages, the two most important methods; the blown cylinder sheet and crown glass process were the basic glass sheet production techniques, used until the late nineteenth and early twentieth century. Both methods aimed to create pure and hard glass material.

Figure 4.3: The crown glass production

Source: http://www.sashglass.co.uk/your-sash-window-glass.html

The city of Venice was the leading producer of glass objects and mirrors that were exported to Germany and France between fifteenth and seventeenth centuries using glass without color or painting (Schittich, et al. 2007).

Casting hot, molten glass on a large copper table and spreading it out with a heavy metal roller was a new method of making plate glass. It was invented in 1687 by a Frenchman Bernard Perrot. Starting in the seventeenth century, glass was not only used for churches and monasteries but also for glazing palaces and houses. As a result of increasing use of glass, producers tried to find new methods of production. Simple and economical method of production made it possible to produce the first large sheets of relatively-undistorted glass measuring up to 1.2x2 m. After several improvements in the original batch technique culminated in the Bicheroux process (1918), glass was received by power-driven rollers then delivered into thinner sheets of greater length. Even with these new production techniques, glass continued to be an expensive material by the end of the 18th century (Schittich, et al. 2007).

Figure 4.4: The production of polished plate glass

Source: http://www.londoncrownglass.f9.co.uk/History.html

Developments of new glass production methods that started in France made great progress in the 19th century. Production of huge glass panes in great amounts became possible in a short period of time, for the construction of Crystal Palace in England in 1850-51. This success demonstrated the enormous potential of glass as an architectural material.

Figure 4.5: The Crystal Palace in England

Source: http://en.wikipedia.org/wiki/File:Crystal_Palace.PNG

It became an important issue to develop mechanical production techniques of sheet glass because of the growing demand for glass in the construction industry and the requirement for ever larger expanses. This was achieved in the early years of the twentieth century. Exchanging ideas between Belgian, British and American manufacturers, glass production techniques rapidly developed. One of these techniques of manufacturing drawn glass, called the Fourcault process was developed by Emile Fourcault in Belgium in 1904. With this method, drawn sheet glass was produced by dipping a leader into a vat of molten glass, later pulling that leader straight up while a film of glass hardened just out of the vat. Undulations as a result of the pulling and the stress occurred after its use which made it difficult to cut were some disadvantages of this method (Schittich, et al. 2007).

The next major step in the evolution of sheet glass production was the development of Libby-Owens process in America in 1905 which made it possible to produce high-quality glass sheets economically in large quantities for the first time. Irving Colburn improved the method and the glass was bent horizontally over a steel roller differently than what Fourcault proposed. These changes made glass more flat and cutting became easier (Hegger, et al. 2006). Another important progress about cast glass production was developed by Max Bicheroux in 1919. He combined different methods to produce cast glass. The hot glass was shaped by cooled rollers. The panes that were cut out of hot glass in dimensions of 3 x6 m were made possible (Hegger, et al. 2006).

After more than several years of research, the most important step on the way to producing really flat glass was Alastair Pilkington’s float glass production method. That is a method of production that is used in the most of the glass used in architecture industry today. In this process, the glass was poured onto a bath of liquid tin. It floats on the level surface and spreads out regularly. At the end of the process, the glass exits from the bath, gets cooler and finally cut to size. This method gives glass sheet a uniform thickness, flatter surface and a possibility to be produced in larger sizes. Alastair Pilkington’s float glass production method is used worldwide and formed the basis of most glass production today (Schittich, et al. 2007).

The building skin has become a progressively important part of building design in recent years. New construction techniques, availability of new building materials brought different opportunities into the architectural design arena.

Although many new materials appear, glass, as one of the oldest building material, still remains to be important and it is one of the most commonly used building skin material as a symbol of the contemporary facade. Different characteristics of glass like transparency, reflection, color and different functions of glass like weather protection, daylight regulation make the role of glass material more important. Overwhelming improvements in glass technology over the last two decades made inconceivable things possible. Instead of the clear transparency of the glass today the exploration of the range of transparency and translucency is gaining importance. This transition could be experience with the techniques of printing, etching, coating the glass surface or overlapping metal sheet in front of the glass.

Today glass is tinted, laminated, coated with different materials, perforated, layered, insulated, wired, tempered, fritted for different cases. Architects and researchers respect traditional usage of glass but they also try to find different forms of glass as a building skin material. In the following section, the glass as a building skin material will be investigated as case studies.

4.1.2 Properties of glass

Consisting of sand, soda, lime and other additives, glass is a hard material and it is resistant to wear. Besides, it is a brittle material that is weak in tension because of its non-crystalline molecular structure. Glass fractures immediately when glass is stressed beyond its strength limit. The other prominent property of glass as a building material is its transparency. It absorbs radiation just like all other building materials, but this absorption is not detectable by the human eye. That is the reason why glass appears transparent. It's transparent to a range of wavelength known as visible light. It also controls light, saves on energy costs providing natural day lighting and it helps to harmonize a structure with its environment (Schittich, et al. 2007). Glass is an incombustible material, but it starts to soften at about 700°C. The siliceous component of glass provides great resistance to aggressive substances except hydrofluoric acid and hot alkaline solutions. About its acoustical properties, glass is a good conductor material compared to other building materials because of its low mass structure (Weller, et al. 2009).

All these general properties make glass one of the important building materials of our time. There are many different types of glass used as a building material and each have different properties. Different types of glass and their properties will be studied in the following section.

4.1.3 Types of glass products

The types of glass with different features for various functions are available today. This section will study glass in three parts; the types of glass according to their commercial role; the types of glass in terms of the production methods and special types of glass.

4.1.3.1 Basic types of commercial glass today

Characterizing by their composition and use, there are six basic types of commercial glass today. The six basic types that are soda-lime, lead, borosilicate, aluminosilicate,%96 silica and fused silica glass which will be described in this section (Bell 2006).

In the field of construction and in other industries, glass has a wide application area. Types of commercial glass used mostly for purposes other than building skin are; lead glass, borosilicate glass, aluminosilicate glass, %96 silica glass and fused silica glass. Lead glass is used for different purposes such as electrical applications and some art work. As a result of the developments in glass industry in the twentieth century, a new lead glass of high optical clarity was produced and used for decorative vases, bowls, and glasses notably in Art Deco style. It is still used common in industrial and decorative applications. Borosilicate glass is used where combinations of high thermal fatigue resistance, high dielectric strength and good chemical resistance are needed. It is used for light bulbs, headlights, pipes, laboratory glassware, bakeware and high temperature thermometers. Aluminosilicate glass is a low-expansion; chemically resistant glass contains aluminum oxide. It is used for high performance military power tubes, traveling wave tubes and applications similar to borosilicate applications. It is produced by float glass method and used for fired resistant glazing. %96 silica glass is a borosilicate glass that contains 7-15 percent boron oxide. This type of glass is used for fire protection, windows of space vehicles and some laboratory glass wares. Fused silica glass is a pure silica glass that is rarely used because it is very expansive, difficult to fabricate and it has too high a softening temperature. It is only used for critical applications such as medical and chemical equipment (Bell 2006).

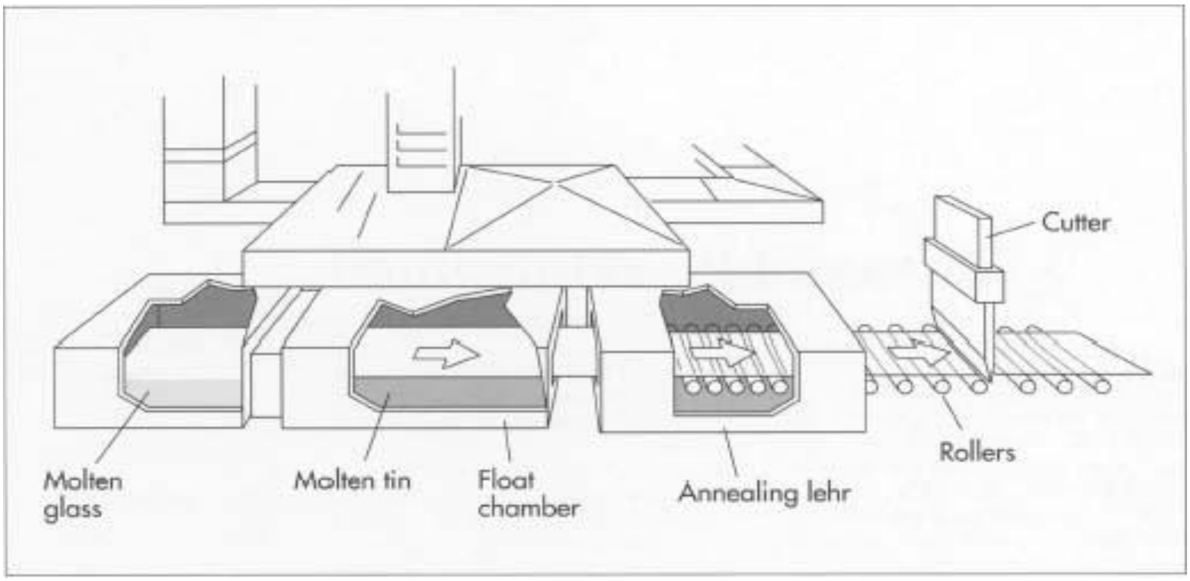
Among the six basic types soda-lime is the most commonly used glass today. It is the cheapest type of glass and almost %90 percent of all glass produced today is soda-lime glass. The majority of architectural glass is some type of soda-lime glass. It is composed of about %70 percent of silica, 12-18 percent soda and 5-12 percent lime and much smaller amounts of various other compounds. Because it is inexpensive, chemically stable, reasonably hard, and extremely workable, it is convenient for manufacturing for a wide array of glass products (Schittich, et al. 2007).

4.1.3.2 Basic types of glass according to production methods

This section of the study will concentrate on glass in terms of production methods which are; float glass, cast glass, pressed glass, glass fibres and foam glass and glass ceramics.

Float glass is most commonly used form of basic glass today. The float glass production method was developed in 1960 and became a breakthrough in the history of production of flat glass. This development changed the method of glass production which was used in construction industry, because it made possible it to produce large quantities of glass that are clear and transparent with nearly flat surfaces. In this process, glass is moved from the melting tank to the float bath at a temperature of about 1050°C. Next, the molten glass runs onto a flat bath of molten tin and it cools down to about 600°C. Its lower gravity gives its flat shape and this process ends up with parallel faces, flat surfaces and perfect transparency. It is the primary material for the greater part of single and double glazing systems used for facades today. The available thickness of the float glass is in between 0.5-25 mm, the practical thickness used for buildings is usually in between 2-19 mm. The maximum sizes of the panes are nearly 3.20 x6.00 m (Schittich, et al. 2007).

Figure 4.6: The float process



Source: http://www.enotes.com/automobile-windshield-reference/automobile-windshield

Cast glass is one of the oldest glass production methods used in history since the fifteenth century B.C. Cast or rolled glass is produced by a method in which the glass passes through a continuous ribbon of glass between cooled rollers. It is possible to develop the cast glass with different applications. The patterns that are inscribed in the rollers give the glass it's patterned, undulating shape for ornamental or patterned glass. The rollers make it possible to incorporate a wire mesh to produce a wired glass. Profile glass is also a form of rolled glass. Cast glass is architecturally used to design private space or achieve diffusion of daylight (Achiller & Navratil 2009). It is mostly used in the forms of channel glass products, glass blocks or patterned glass. Glass bricks, glass ceiling tiles and concrete glass are known as the term "pressed glass". Two bodies of glass are pressed together with the pressing method. After it gets cooler, the hollow space between two bodies provides good sound insulation. Today pressed glass is primarily used for transparent roofing tiles and ferroconcrete structures. The drawn glass plays an assisting role in the glass production industry. In this method, the endless ribbon of glass is drawn vertically out of the melt. This type of glass often used for restoration projects on old buildings (Hegger, et al. 2006).

4.1.3.3 Basic types of special glasses

Tempered glass, sometimes called toughened glass, is known as a safety glass. It is produced by heating it at least 640 °C and quickly cooling it. All sheet glass products could be used for tempered glass production. Tempered glass is a very strong material and when it fails it breaks into many small pieces which avoid injuries. This type of glass is used for architectural purposes like building facade and most of the large sheets of glasses are tempered. The sizes of the tempered glass product changes according to the manufacturer, but the possible tempered float glass dimensions at present are 3.21x8.0 m (Bell 2006).

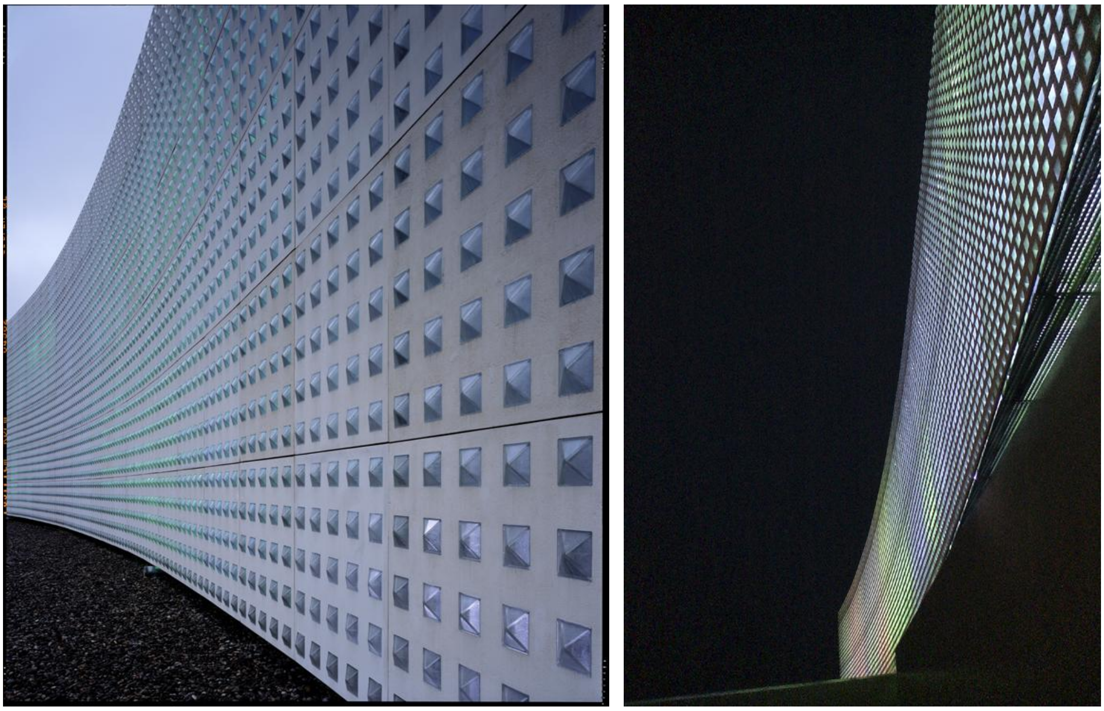
Laminated glass is a combination of one or more sheets of glass with interlayer of polymers such as polyvinyl. This glass is particularly suitable where it is important to ensure the resistance of the whole sheet after breakage such as: storefronts, stair-railings, skylights. It can be also used for recording studios to provide insulation (Bell 2006).

Figure 4.7: Shanghai Oriental Art Center's laminated skin

Source: http://www2.dupont.com/SafetyGlass/en_US/whats_new/oriental_art_center.html

Another type of special glass is glass blocks. Melting the glass and casting it into shells is the starting point of the glass block production method. Fusing two of these shells together, sometimes with a space in between, is the method to make one glass block. These massive glass blocks are available in different colors, shapes, textures, sizes and they can be used for interior and exterior walls (Weller 2005).

Figure 4.8: Backlit glass bricks of Le Prisme in France



Source: http://www.archdaily.com/5390/le-prisme-brisac-gonzalez/

Channel glass is a type of glass that can be used for almost all applications in architecture. It is a self-supporting system of cast glass channels and usually produced in U-shape. It is usually set in a vertical aluminum framing system. Channel glass is a textured material and allows architect to design with more glass providing large areas of light transmitting (Bell 2006).

Figure 4.9: Channel glass used in Gardner 1050 in USA

Source: http://www.archdaily.com/23336/gardner-1050-lorcan-o%E2%80%99herlihy-architects/

Insulating glass is constructed with two or more sheets of glass and separated by a sealed space to provide thermal insulation and condensation control. The space between two layers of sheets can be filled with dry air or low-conductivity gas. This space filled with gas also helps with sound insulation. As an insulating glass, different thicknesses of sheet glass products, flat or curved can be used. The width of the space between two layers is in between 12-20 mm today (Hegger, et al. 2006).

Wire glass is a type of rolled glass that is produced as a result of continuous rolling process. The difference between rolled glass and wired glass is that a wire mesh is put together with the glass sheet to provide more secure and fire resistant glass. The maximum available dimensions of wired glass are 1980x3820mm. The wired glass actually is not stronger than the glass without wire mesh, but it keeps the glass together if a breakage happens (Bell 2006).

4.1.4 Processing of glass – surface treatments

The properties of glass can be adopted by various surface treatments. These applications are used either for creating new functions or achieving aesthetic effects. Even these treatments are usually for aesthetic purposes, adding a coating to the surface might change its properties. Coating the glass with a thin film of metal or metal oxide is an important part in the process of a surface treatment. The most common surface treatment types are; enameling, obscuring processes, silk-screen printing and optically effective coatings (Schittich, et al. 2007).

Enameling process starts with the application of enamel powder onto the surface of glass and continuing with the baking until it produces ceramic coating that is corrosion-resistant coating. These ceramic ink treated enamel glasses are thick-film coatings applied to the whole surface on one side of the glass or just to specific parts by different techniques. Enameled glass can be produced opaque, translucent or transparent depending on the color or the thickness of the glass. Obscuring process is about decreasing the transparency of the glass surface. There are chemical and mechanical methods available. One of them is acid-etching that can provide matt finish to the glass surface with hydrofluoric acid or its vapors treatments. Patterns and pictures can be applied on to the surface by masking certain areas. Another technique is sand-blasting method to create translucent glass surface. Similar to the acid-etching technique, applying patterns by masking is possible. Silk-screen printing is a treatment about printing the pigments on to the glass and baking it in an oven. With the help of mesh stencils it is possible to provide glass panes with different motifs and patterns printed on them. The size of stencils is usually 2.0x3.5 m and the size of pattern on the surface is determined by the size of stencils. Multi- colored graphics, photographs, any form of decorations can be provided by this treatment method (Schittich, et al. 2007).

Figure 4.10: Silkscreen printed skin of Stadshuis Nieuwegein in Netherland

Source: http://www.archdaily.com/220899/stadshuis-nieuwegein-3xn/

Optically effective coatings reduce the reflection from the glass surface. There are two ways to achieve the reduction of the surface reflection. One of them is applying layers on the glass surface and the other one is embossing microscopic structures in a layer of synthetic material that reduces the refractive index of the glass. The treatments that are described above are the most commonly used ones, but there are other treatments still in use. Surface treatments of the glass as a building material enrich the corporeality which also provides enrichment in building skin design.

4.2 CONCRETE AS A BUILDING MATERIAL

4.2.1 History of concrete as a building skin material

Concrete is a mixture of water, cement and aggregate originally. Concrete started to be made with different types of cement and also additives, admixtures and various aggregates (Neville & Brooks 1987). Concrete is an artificial and heterogeneous building material that has played an important role in the development of buildings in history. Concrete is a durable, massive and monolithic material and easy to work with. It is a material that is strong in compression and it is easy to shape it by casting method. It can be designed in any form, size and texture which is one of the most essential features of concrete that makes it an important building material (Bell 2006).

The origins of concrete as a building material extend as far as ancient times. People used lime mortar as a building material around 12.000 B.C. The invention of *opus caementitium* a concrete like material dates back to the 2^{nd} century B.C. The *opus caementitium* was used by the Romans and its application can be traced in their architecture. Pantheon in Rome (A.D.118) and its advance use of concrete has been very influential in architectural history. With the fall of the Roman Empire, the *opus caementitium* lost its importance and was not rediscovered for nearly 1500 years (Herzog, et al. 2004).

Figure 4.11: Pantheon in Rome

Source: http://www.travel-tidbits.com/tidbits/005824.shtml

The wide spread use of concrete as a building material has started after the invention of Portland cement. Joseph Aspdin patented the cement which he called as Portland cement in 1824 and it was known as the most prevalent cement used in the production of concrete by the technical changes. I.C Johnson used different method and produced the first true Portland cement in 1845. After the invention of good concrete, next step was to reinforce it, combining with iron. Concrete was strong in compression but weak in tension. The reinforcement was applied in order to use concrete in a more innovative way, with making longer spans possible (Croft 2004).

Engineers from different countries tried to develop reinforced concrete during the 1850s. Joseph Monier registered for a patent for his reinforced flowerpots with iron mesh in 1867, after that, he built concrete water tanks, bridges, beams and columns. William Wilkinson from England was the pioneer of the concrete used in the construction of a house. Thaddeus Hyatt designed reinforced concrete beams and his principles are similar to the basic use of reinforced concrete today. The first reinforced concrete house in the United States was built in New York by W. E. Wand in 1875. A French builder named Francois Hennebique patented his reinforced concrete system in the 1870s (Bell 2004).

By the end of the 19^{th} century, widespread use of reinforced concrete was seen in different types of buildings. Concrete as a composite building material started to dominate the building construction. Large and complex structures started to be built in short periods of time and concrete became an important building material of experimental architecture. By 1900, concrete and reinforced concrete became the primary elements of the building construction in all around the world. One of the most important architects who started to use concrete in an influential way was Auguste Perret. He designed the apartment block in Paris in 1903 and its facade was the first example of concrete facade for a residential building. Reinforced concrete frame structure was revealed in the highly glazed facade of Rue Franklin Apartments.

Figure 4.12: Rue Franklin Apartments by Auguste Perret

Source: http://www.greatbuildings.com/buildings/Rue_Franklin_Apartments.html

Architects were excited about the possibilities of reinforced concrete as a new building material. They tried to experience its sculptural possibilities. Besides its structural and sculptural properties, the visible concrete surface started to be used as is. Architects such as Le Corbusier, Ludwing Mies van der Rohe, Louis Kahn used concrete in an innovative way. Frank Lloyd Wright's Unity Church at Oak Park in Illinois (1904-06), Louis Kahn's Jonas Salk Institute at La Jolla (1959-65) were some of the good examples of concrete used in buildings (Herzog, et al. 2004).

Figure 4.13: Louis Kahn's Jonas Salk Institute at La Jolla

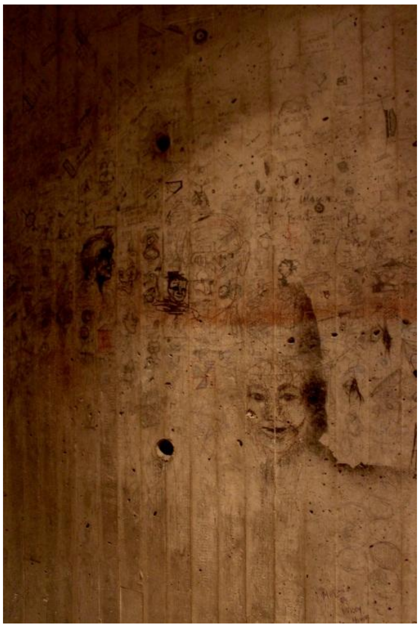
Source: http://www.dailyicon.net/2008/07/icon-jonas-salk-institute/

By the emergence of the new brutalism during 1960s, architects started to focus on the rough surface of the concrete skin with different textures and patterns on it. Under the influence of this new architectural movement, Louis Kahn stated that concrete gains its aesthetic qualities by the way it is created. He supports his idea with his thoughts about the Yale Art Gallery as;

> *"...the formwork was made from floor to floor, and this line was accented; because what we tried to do in the expression of the building was to show in every way how it was built. This formwork was made of small floorboards, and the little holes that you see there indicated the tie thoughts in the formwork. These were left as holes in the concrete so that in every way, how it was made is apparent. We accentuated the struggle of building… When you take the forms off, something always happens in an ugly soupy way... if you actually know that (and you put in a joint) so you can really*

see it, then it sets up its own pattern. And I believe that these joints are the beginning of ornament." (Latour, referring to Kahn 1991).

Figure 4.14: Yale Art Gallery



Source: Sezegen, A.

During the 1960s and 1970s, architects started to use the advantage of the three-dimensional mouldability of the building skin in concrete. They also added an artistic expression on to the surface of the concrete skin. The pilgrimage church in Neviges (1963-68) by Gottfired Böhm was one of the good examples of this approach (Herzog, et al. 2004).

Figure 4.15: The pilgrimage church in Neviges

Source: http://www.flickr.com/photos/seier/3165564453/in/photostream/

In contemporary architecture concrete applications can be seen in different forms. Exposed concrete with different textures or silk-screened photographs on the concrete surfaces are some of the ways concrete is used in buildings. The Swiss architects Herzog & de Meuron are known with their influential use of concrete. The Japanese architect Tadao Ando is known as “concrete poet” and design influential buildings by using concrete. Ando (2000, p.51) explains his use of concrete as;“The way I employ concrete, it lacks sculpturesque solidity and weight. It serves to produce light, homogeneous surfaces. I treat concrete as a cool, inorganic material with a concealed background of strength. My intent is not to express the nature of the material itself, but to employ it to establish the single intent of the space.”

Concrete’s simple production, easy manufacture, sculptural possibilities and many features have made concrete one of the most important building skin materials. Its various potentials in the design of building skin have influenced architects in using concrete in an innovative way.

4.2.2 The Properties of Concrete

Concrete, a mixture of Portland cement, water, and aggregate, usually crushed stone or gravel is strong in compression but weak in tension. When it is reinforced with steel it gets stronger in tension. It also gains strength over time. It is naturally a fire proof building material that does not burn. It is a versatile material that is used for various building types. Compared to other building materials it is low in cost. The proportions and characteristics of cement, water and aggregate affect the quality of the concrete. The water/cement ratio of the concrete defines its strength; less water provides more strength. Aggregate gives the main structural capacity to the concrete and for an ideal strength it is good to use graded mix of fine and coarse aggregate (Bell 2004).

Concrete is a shapeless building material and it is easy to shape it in any form with framework. This is one of the most important advantages of concrete for architects. The various possible forms, sculptural and structural possibilities have made concrete one of the most influential building materials.

4.2.3 Types of concrete material

There are different types of concrete used for building skin. Concrete will be investigated in two different categories in this study; the most common types of concrete and the special types of concrete.

4.2.3.1 The most common types of concrete

The most common types of concrete used in construction can be divided in five different types as; reinforced concrete, cast-in place concrete, precast concrete, concrete masonry units, autoclaved cellular concrete.

Concrete is a material that is strong in compression. Steel is embedded in concrete in order to make it strong in tension and this composite material is called “reinforced concrete”. Reinforced concrete is a composition of two materials; steel and concrete and their performance against resisting forces strengthens each other. Structurally, this material is convenient for the cases where both strength in compression and tension is required.

Figure 4.16: Wire reinforcements placed before the pouring of concrete

Source: http://www.britannica.com/EBchecked/topic/496607/reinforced-concrete

Steel is used as steel reinforcement bars, high-strength cables or steel mesh in concrete for reinforcement. Reinforced concrete is mostly used for structural columns, beams, wall panels, slabs, or different structural purposes (Peck 2006).

Cast in place concrete is also known as poured-in place concrete or site-cast concrete. This type of concrete is poured directly on site with the help of formwork. The concrete is cast into the formwork which is removed after the concrete gets strengthened. Because cast in place concrete is poured in place particularly for a specific project with specific features, it gives a unique expression to the building. There are no limitations of size or shape and this feature of cast in place concrete strengths the sculptural quality of concrete. Cast-in place concrete is relatively more expensive and takes more time during construction (Bell 2004).

Precast concrete is also called as "prefabricated" concrete. Precast concrete is produced in a factory and then moved to the site for the application. The production of precast concrete in a controlled environment helps to decrease the cost of the construction and it saves time.

Figure 4.17: A precast concrete walled in construction

Source: http://www.articlesweb.org/home-and-decorating/precaste-concrete-walls

There are many different types of precast concrete applications in different sizes, to meet with the demands of different functions. Precast concrete can be produced in the forms of panels, slabs, beams and other different purposes as well as enclosure elements (Bell 2004).

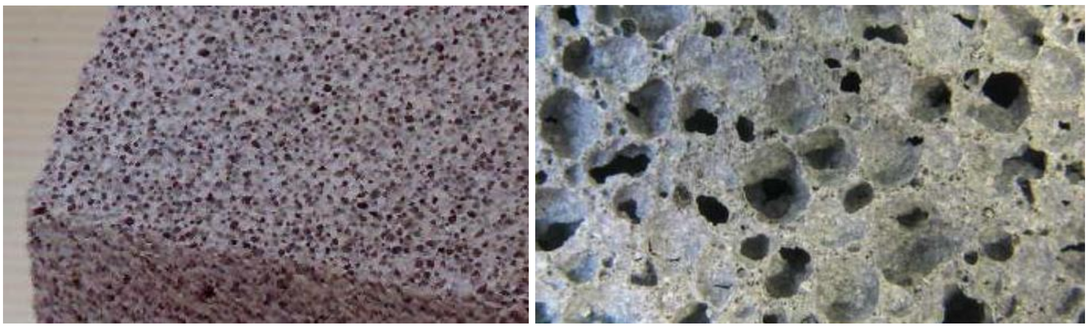
Concrete masonry units are concrete blocks which are produced as casting into formworks. They are produced in size of 203x203x406 mm as standard concrete blocks with hollow cores. Their strength can be improved by filling the cores with steel and concrete. Concrete Masonry Units can be found in various sizes, colors and textures depending on the designer’s selection. Its most common use is in walls of the buildings (Bell 2004).

Figure 4.18: A modern block plant in operation and its application in site

Source: http://www.cement.org/masonry/block.asp

Autoclaved cellular concrete, also called Autoclaved aerated concrete is a lightweight and precast concrete. It has been used in European countries since 1920s. Its light weight also saves cost in construction and energy in transportation. In low-rise buildings, it can be used as load-bearing walls and in high-rise it can be used for curtain walls.

Figure 4.19: Autoclaved aerated concrete block with a sawn surface



Source: http://www.understanding-cement.com/autoclaved-aerated-concrete.html

It has a low density but its thermal insulation values are two times more than conventional concrete. It can be designed in the form of lintels, floor slabs, blocks and panels (Bell 2004).

4.2.3.2 Special Types of Concrete

There are also special types of concrete that designers are able to use in their buildings. The two most recently used types of concrete that are: translucent concrete and textile-reinforced concrete.

Production of translucent concrete that is also known as light transmitting concrete was developed by Hungarian architect Aron Losonczi. Concrete was embedded by fibre optics to transmit light from one side to the other. These fibres transmit the light up to 20 meters without serious light loss. This feature brings new opportunities in the use of concrete as a building skin material.

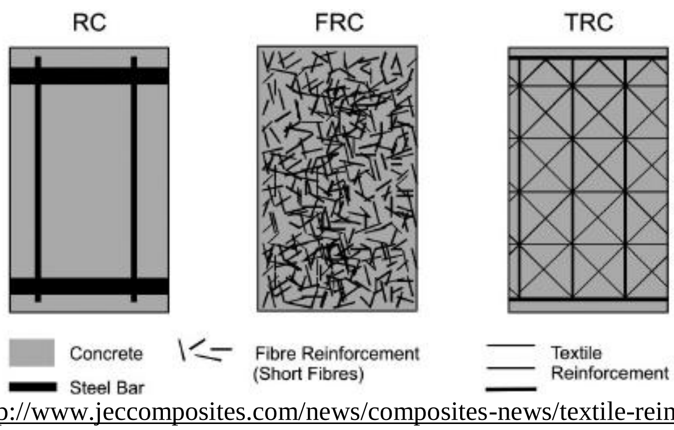
Figure 4.20: White, translucent alabaster is cast in beige glass fiber-reinforced concrete in the skin of the Louis Vuitton flagship store in Ginza, Tokyo

Source: http://www.aokijun.com/en/works/047

Its inventor Áron Losonczi explains the new type of concrete as; "Thousands of optical glass fibers form a matrix and run parallel to each other between the two main surfaces of every block. Shadows on the lighter side will appear with sharp outlines on the darker one. Even the colors remain the same. This special effect creates the general impression that the thickness and weight of a concrete wall will disappear." (http://www.eskyiu.com/aainter1/index_files/transmaterial.pdf) Translucent concrete break the cold expression of concrete as a building material on the facade. It aims to create building skin that reflects interior to the exterior and vise versa which creates architects a building skin that can change with the changes of light. The versatile use of the light transmitting concrete opens new horizons in the twenty-first century architecture (Peck 2006). Using fibres as a reinforcing element in concrete creates fibre-reinforced concrete. This composite material contains fibres made from glass, synthetic materials, steel or carbon. These short and randomly oriented fibres increase the tensile strength of the material (Hegger, et al. 2006).

With the developments in concrete technology, textile-reinforced concrete is one of the most influential composite building skin materials in contemporary architecture. Textile reinforced concrete is a product that started to be used after the development of the fibre-reinforced concrete. The difference between textile reinforced concrete and fibre reinforced concrete is the form of the fibres. Instead of the short fibres, textile reinforced concrete uses nets, waves and textiles. These textiles are made from glass, carbon or aramid fibres.

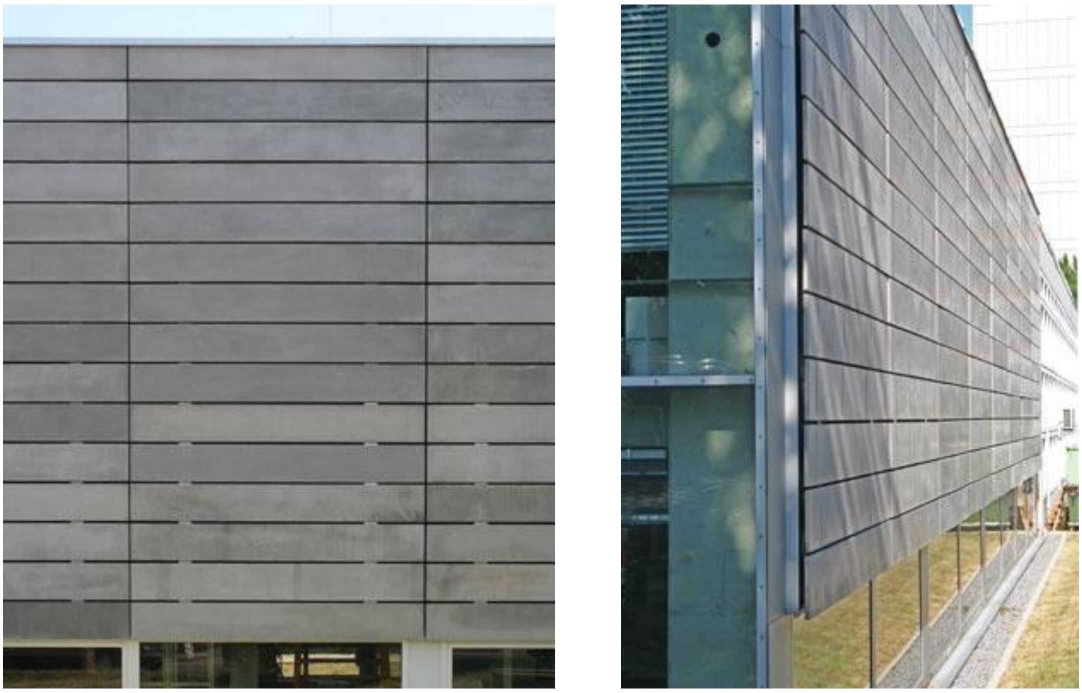
Figure 4.21: Different reinforcing systems



Source: http://www.jeccomposites.com/news/composites-news/textile-reinforced-concrete-high-performance-carbon-fibre-grids

Textile-reinforced concrete technology makes thinner building skin and high-quality fair face concrete possible. Wide spread use of textile reinforced concrete with its influential features can be seen in the design of the load-bearing structure, the internal finishes or the building skin. It can also be used as sun shading elements on the facade (Peck 2006).

Figure 4.22: Development of a textile reinforced concrete facade, RWTH University, Aachen

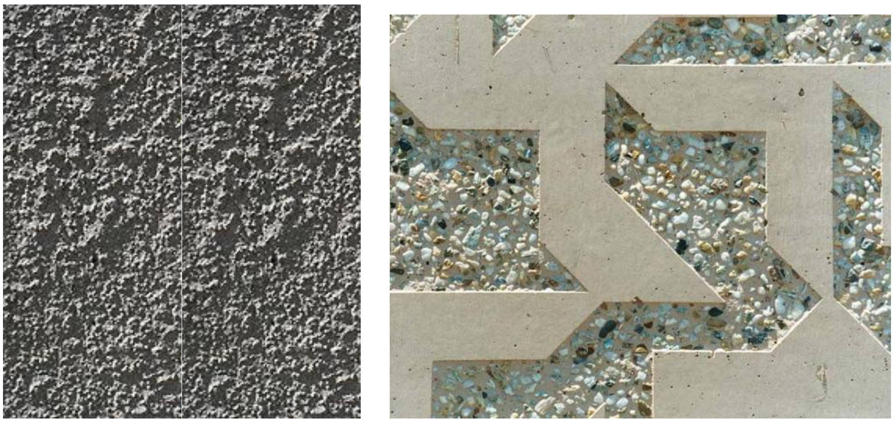


Source: http://www.huping.de/pages/english/refs/textilbeton.html

4.2.4 Concrete - Surface treatments

Various surface treatments can create different aesthetic effects. Acid-etching, sand blasting or flame-cleaning can be used to roughen the concrete surface to create semi-matt surface finish. Use of white cement, colored aggregates or pigments create special effects on the concrete surface by traditional stonemason techniques such as bush hammering, pointing, chiseling, and splitting.

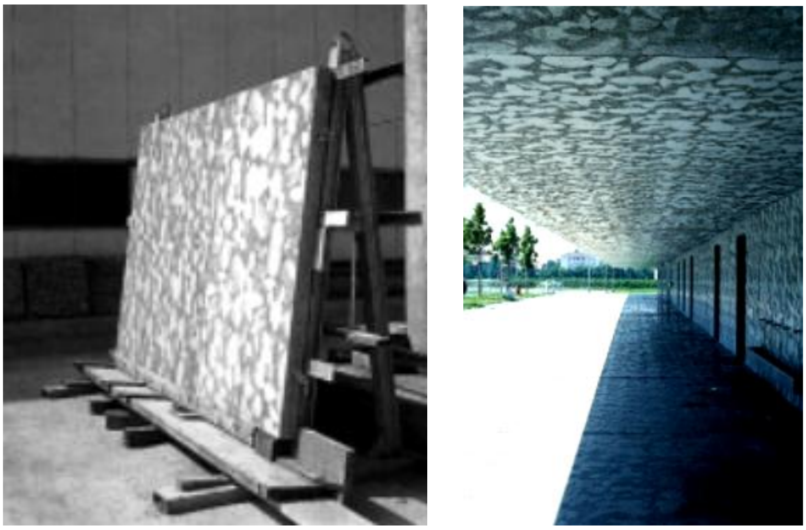
Figure 4.23: Sand blasted concrete



Source: http://www.dreamstime.com/royalty-free-stock-photography-sand-blasted-concrete-rough-surface-image11604957 / http://www.paul-brown.com/GALLERY/PUBLICAR/IPSWICH.HTM

Another surface treatment is about printing images on to the concrete surface. One of the first examples of this treatment is the skin of the Pfaffenholz Sports Centre designed by Herzog & de Meuron. In this method, screen of images were applied to the underlying aggregates of concrete panels to design the building skin. Photographic images are printed on to a polystyrene sheet and placed under the formwork which concrete will be cast into. After two days the formwork is turned out and the concrete panel is wash cleaned.

Figure 4.24: Pfaffenholz Sports Centre



Source: http://www.concrete.net.au/publications/pdf/mix05.pdf

These surface treatments that are described above are the most commonly used ones. There are also other treatments still in use. Concrete with surface treatments as a building skin material provide architects more design possibilities.

5. DESIGN OF BUILDING SKIN IN MODERN AND CONTEMPORARY ARCHITECTURE

Design of building skin is becoming one of the most interesting fields of contemporary architecture. The expression of building skin expression provides functional, visual and traditional identity to buildings. Building skin design influences both the appearance and performance of buildings. The various properties of the building skin encourage new design concepts in architecture. In the previous sections, the historical background of the building skin and its development, considering building materials were studied in detail.

Glass and concrete as indispensable building materials for building skin were selected in this section of the study. Great possibilities of these two materials lead architects to develop and research both glass and concrete. As a result architects try to find new ways of using these materials in their projects. Investigating the projects designed by the influential architects, using glass and concrete will be enlightening to understand design possibilities of glass and concrete as building skin. The design opportunities cannot be developed without understanding the precedents. In this sense, four architects which are well-known for their use of glass and concrete for building skin will be studied in the following section with their influential projects.

Representative of the two architectural periods; Modern and Contemporary, two influential architects for each period will be studied through their buildings, concentrating on the materiality of the building skin. For the former period the projects of Le Corbusier and Mies van der Rohe are chosen. Le Corbusier, being one of the pioneers of modern architecture, used concrete as a building material in many of his buildings and he brought a new understanding of building skin into architecture. Along with Le Corbusier , Mies is also known as one of the pioneers of modern architecture. His dominant twentieth century architectural approach brought clarity and simplicity into architectural design. He became famous for his “skin and bone” concept in architecture and he dominantly used glass in the design of the skin. For the contemporary period two architects, Tadao Ando, for concrete and Herzog& de Meuron, for glass will be investigated with their influential use of these two materials. Tadao Ando is famous for his innovative use of concrete in most of his buildings to achieve the idea of simplicity. Ando was influenced by Le Corbusier's architecture which makes it important to investigate both of the architects to see how they use the same material as a building skin. Herzog& de Meuron are famous contemporary architects with their innovative use of building materials for exterior surfaces and applications for building skin. Louise Huxtable's states about Herzog & de Meuron that; "They refine the traditions of modernism to elemental simplicity, while transforming materials and surfaces through the exploration of new treatments and techniques.". It is clear from the statement that they are focused on different building materials in their projects. They used mostly the glass material with its comprehensive set of features while designing building skin for their projects.

Modern architecture recalls the ideals of machine age, using concrete, glass and steel as building materials and by the absence of ornament or any other minimal external expression. It is important to understand the form and the quality of the building skin as a space definer and an interface between interior and exterior in relation to the building and to the building material. Also, with the aid of further studies, potentials for new building skin can be investigated. The case studies in this section aim to reflect the diversity of ways in which glass and concrete can be used and to show the possibilities of the building skin and its surface using the same material.

5.1 MIES VAN DER ROHE'S APPROACH TO DESIGN OF BUILDING SKIN

Ludwig Mies van der Rohe a German architect was born in 1886. His well-studied and clearly detailed projects were built as a result of increasing demands of the twentieth century architecture. His ideas were clear and simple statements, using materials that were shaped to express their individual characteristics which reflect his ideas as declared by his most famous dictum "less is more". According to him, it was enough to use minimum of the required element on the way to a desired target. The statement of "less is more" became a motto of the minimalist architecture where there is no unnecessary details, no wasted time or no ornamentation (Cloninger 2008). Mies minimized the expression of the modern architecture. He formed his architecture with modern building materials in a forthright and simple way. These features of his architecture influenced the design of the building skin. The skin of his buildings was constructed by fewer elements in a seemingly simple expression but actually depict a mature language of minimalist architecture with the given importance to the details and an extraordinary sense of proportion. His desire of flowing spaces to each other with a detached structure and wall system became a primary reason for him to design a new construction technique consisting of a glass skin (Hartoonian 1994). The idea of clear construction revealed in his statement; “The greatest effect with the least expenditure of means. The materials are concrete, iron, glass. Ferroconcrete buildings are essentially skeleton structures. Neither noodles nor tank turrets. Supporting girder construction with a non-supporting wall. That means skin-and-bone structures.” (Cohen 1995)

Mies van der Rohe’s approach of a “skin and bone” architecture changed the static and compact effect of the brick and stone skins into transparent surfaces. Mies was strongly interested in the opportunities that became possible as a result of industrialization. According to him, industrialization was one of the central problems of architecture at that time. He thought that social, economic, technical and artistic problems which had occurred during building design process would be solved by realizing the industrialization of construction materials (Cohen 1995). Transparent skin within the framework of the possibilities enabled by technological developments in architecture strengthens his concept of “skin and bone” architecture with clarity and simplicity. According to his concept, the “skin” is the exterior surface of the building and “bone” is the structural framework. As it is clear in his statement that; "Reinforced concrete structures are skeletons by nature. No gingerbread. No fortress. Columns and girders eliminate bearing walls. This is skin and bones construction." His skin design in American high-rise buildings was a re-interpretation of curtain wall with his aesthetic rules. He used profiles that had no structural function in front of the facades. He tried to give an expression of the volume instead of the mass and simple surfaces without ornamentation. His attempts to demonstrate the internal structure of his tall buildings on their skin progressed into symbolizing a concept of clear structure.

5.1.1 Glass as a building skin in Mies van der Rohe's architecture

Mies van der Rohe's understanding of "contemporary building" of his time matches with modern building materials and modern building techniques. In the early 1920s, he explains that thinking as; "The building art is the spatially apprehended will of the epoch. Alive. Changing. New."(Cohen 1995). His ideas were stated with clarity and simplicity, using materials that were configured to show their individual characters. Mies looked for an artistic expression in combination of steel framework and glass walls since the early 1920s and tried to find an understanding of a new order (Giedion 1967). In this context, Mies (1924) explains his ideas in his essay named "Industrialized building" that;

> *"So long as we use essentially the same materials, the character of building will not change, and this character, as I have already mentioned, ultimately determines the forms taken by the trade. Industrialization of the building trade is a question of material. Hence the demand for a new building material is the first prerequisite. Our technology must and will succeed in inventing a building material that can be manufactured technologically and utilized industrially, that is solid, weather-resistant, soundproof, and possessed of good insulating properties. It will have to be a light material whose utilization does not merely permit but actually invites industrialization."*

After Mies started to think about clear and honest structures beyond formalism, he investigated the new materials; steel, reinforced concrete and glass. When he experienced these materials, he arrived at a statement of "honesty" as an important motto. As a result of his famous motto, he defined representative materials of strength as steel and concrete as the "bones" of his buildings. He designed "skin" of his buildings which could be covered over the "bones" with shimmering cloak, glass. He described a clear division between the skeleton inside and the skin outside through his "skin and bone" architecture. Actually, he made a separation of materials with the distinction of clear structure and non-structure (Blake 1997). Combining the advantages of new steel structures, Mies reflected his goals with the use of glass. He experienced the idea of exterior glass walls in his buildings. Glass as a building skin would be one of the most influential materials for him to represent his ideas. Glass skin envelopes the steel structure. This "skin and bone" combination allows the integration, mirror and reflection of the glass skin with the structure. Mies believed in the importance of clear and honest structures. He designed his buildings according to these ideals. Besides his structural division, his material selection played an important role in design. His use of glass as the primary skin material brought a new understanding into architecture which is clearly stated as;

> *"Skyscrapers reveal their bold structural pattern during construction. Only then does the gigantic steel web seem impressive. When the outer walls are put in place, the structural system, which is the basis of all artistic design, is hidden by a chaos of meaningless and trivial forms...Instead of trying to solve old problems with these old forms we should develop new forms from the very nature of the new problems. We can see the new structural principles most clearly when we use glass in place of the outer walls, which is feasible today since in a skeleton building these outer walls do not carry weight. The use of glass imposes new solutions."* (Mies 1922)

He strongly believed in the importance of glass skins. As he stated that; "*The use of glass does compel us to go new ways.*" he used glass as one of the components of his buildings rather than just a building material (Richards & Gilbert 2006).

5.1.2 Case Study- Seagram Building

Seagram Building is one of the most influential buildings of Mies van der Rohe where the concept of simplicity and transparency created with the glass skin. Material use and application of the details are important. In one of his most famous buildings Seagram Building in New York, he demonstrated his clear and honest steel frame and glass skin structure. As its importance stated in a book called "Mies van der Rohe" that;

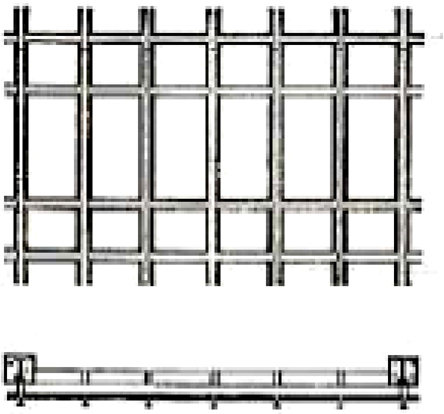
> *"The inescapable drama of the Seagram Building in a city already dramatic with crowded skyscrapers lies in its unbroken height of bronze and dark glass juxtaposed to a granite-paved plaza below….The commercial office building in this instance has been endowed with a monumentality without equal in the civic and religious architecture of our time....The use of extruded bronze mullions and bronze spandrels together with a dark amber-tinted glass has unified the surface with color.... The tower is no longer an isolated form. It addresses itself to the context of the city."* (Speyer & Koeper, 1968)

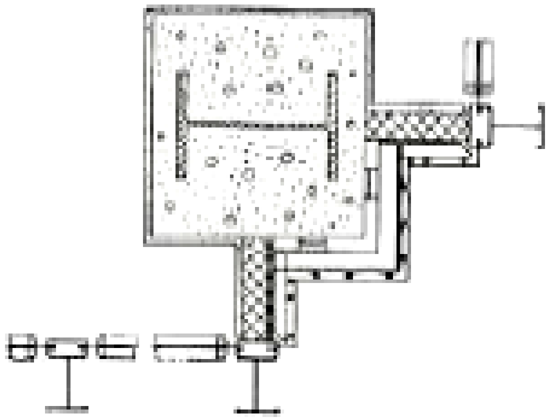
Figure 5.1: Exterior view of Seagram Building

Source: http://www.dwrl.utexas.edu/content/seagram-building 0/http://www.lightinfusion.de/2007/11/seagram_building_nyc.html

Refining architectural design into a simple form, the building was a glass infill structure that skin and structure were designed on the same plane. Then, bronze "I-beams" were applied on the entire facade of the building as vertical compelling decorative elements. The Seagram Building with its thirty eight story high facade made up of bronze-clad pillars and amber-tinted glass gives warm and sensuous color to the building skin. Its skin designed with floor-to-ceiling windows that make the wall a curtain of glass. The vertical bronze I-profiles connected to the mullions demonstrated the verticality of the facade (Zimmerman 2006).

Figure 5.2: Relationship between the skin and structure

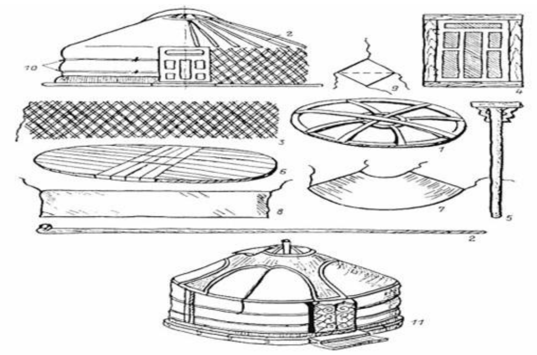


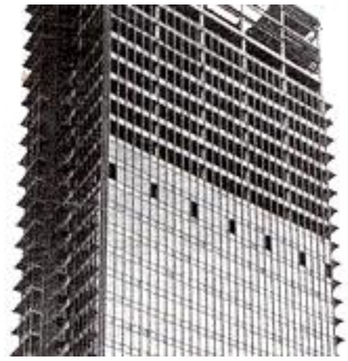


Source: Frampton, K., 1995. "Studies in Tectonic Culture-The Poetics of Construction in 19th and 20th Century Architecture"

The relationship between building skin and textiles hung on the structure as the space definer stated by Gottfried Semper was still valid in Mies's steel and glass building skin structures. Assembling glass panel components to the grid system consisted of vertical and horizontal steel profiles, a new building skin design technique was used in Seagram building in 1958.

Figure 5.3: "Skin and bone" architecture of a nomadic tent and the Seagram Building





Source:http://www.face-music.ch/highaltai/jurte/jurtebild_g01.jpg,
http://www.flickr.com/photos/8534413@N03/5269695991/

The Seagram building was one of the most famous examples of Mies' masterful use of glass skin. Mies spent great effort on clarity and precision. The discovery of a building skin that matches to the new structural ideas and qualitative changes in building skin by the use of transparent material, glass and non-structural glass wall were important features of his skin design approach, and Mies achieved to apply these features of his architecture into Seagram Building perfectly.

5.2 HERZOG & DE MEURON’S APPROACH TO DESIGN OF BUILDING SKIN

Herzog & de Meuron are two influential Swiss architects sharing prestigious Pritzker Architecture Prize. They are well-known for their material use and innovative constructions. Their architecture focuses on formal clarity and strong concepts with pure detailing. They treat architectural surface as a skin of the building and this approach to the building skin makes the exploration of surface, the primary theme of their architecture. According to them, architecture is a way of communication embodied by changing perceptions instead of static forms. This aim is achieved by reconsidering the surface-volume relationship and changing the facade idea into immaterial pictorial layers. At this point, it is a reference to “skin” as a cover of the architectural space and it is a source depicting their interest on Gottfried Semper. Semper’s definition of architecture was an interest on the visual perception of the space that was formed by the enclosure, the skin. He aimed to strengthen the relationship between the space and its integral by his interest on visible covering, skin. This interest influenced contemporary architects Herzog and de Meuron and it became a central discovery in their architecture (Herzog & Meuron 2005).

In their most influential projects, since the 1980s, they have been designing facades performing as images or in Jacques Herzog’s words “positively saturated with images”. Experiencing these images as independently underlying structures, the facade shapes a building skin that creates a relationship between inside and outside (Herzog & Meuron 2005). In this sense Herzog & de Meuron architects tried to focus on the outer surface of the building as a skin and tried to make their design stronger by experiencing various materials.

5.2.1 Glass as a building skin in Herzog & de Meuron's architecture

> *"We look for materials which are as breathtakingly beautiful as the cherry blossom in Japan, as dense and compact as the rock formations of the Alps or as mysterious and unfathomable as the surface of the oceans. We look for materials which are as intelligent, versatile and complex as natural phenomena, in other words materials which don't just appeal to the eyes of the astounded art critic, but are also really efficient and appeal to all our senses – not just vision but also hearing, smell, taste and touch."* (Mack, reffering Herzog 2005, p.230)

Herzog & de Meuron stand at same distance from all materials and try to increase material's role in building skin design. They aim to experience material's poetic quality and don't want to limit its characteristics just into its external surface. According to them, their concentration is on the material's atomic structure which defines a separation. They state that;

> "*We have little faith in the material's external appearance because we are unable to derive any self-evident quality from it. After all, we are dealing with solid bodies, which therefore have a crystalline structure, understood in the chemical sense. These crystalline structures, which represent a kind of spatial imprint of the forces that exist between the individual atoms, are invisible to the naked eye. Yet they are a reality; they permit access to an understanding of the materials' qualities, which are more interesting and complex than the usual applications of the construction industry or the understanding that the creators of Modernism had of the concept of honesty towards materials."* (Herzog 1997, p.216)

With the increasing focus on the building skin, Herzog & de Meuron aimed to transmit the pressure between deep space and the surface usually defined by the use of glass as a transparent building material. They use glass with its various conditions and focus on its changing effects such as mirror effect, coloring and light. They explain this attempt with the statement that; "One moment it is transparent; then it is reflective only to turn semi-transparent in the next minute." Practicing glass as an optically temporary boundary and visible filter between interior and exterior, they interpret glass in terms of its transparency and its relation to physical attitude of the building (Lupton 2007). In this context, the following section will be about Prada Aoyama Epicenter in Tokyo, a strong example of Herzog & de Meuron’s work to show how they design building skin and interpret glass as a building skin material.

5.2.2 Case Study- Prada Aoyama Epicenter

Prada Aoyama Epicenter is designed in relation to the surrounding buildings in Omotesando fashion area in Tokyo with a prismatic form to utilize from the permitted height and distance. There is no signboard outside the building and whole glass skin is like a shop window (Schittich 2006).

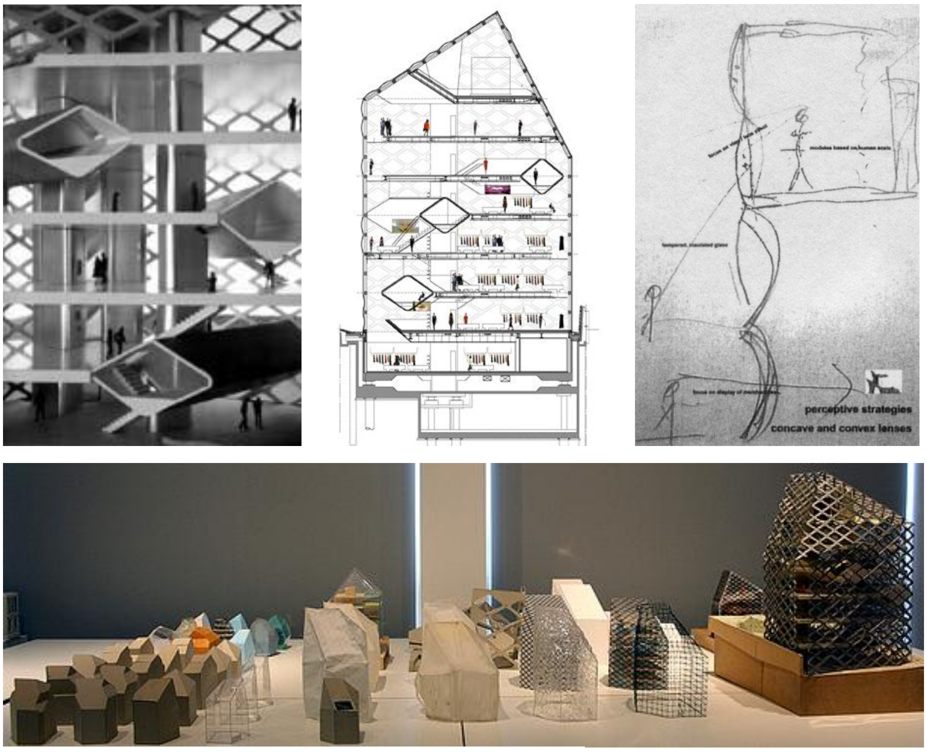
Figure 5.4: A view of Prada Aoyama Epicenter in the district of Omotesando

Source: http://www.herzogdemeuron.com/index/projects/complete-works/176-200/178-prada-aoyama/IMAGE.html

The six story building has a skin with a rhomboid-shape grid that is fitted by convex, concave and flat panes of glass. Glass skin creates a sensuous relationship between inside and outside of the building with its curves. The reflections of the glass skin also demonstrate the changing pictures of the Prada products, the city and the people. (Herzog & de Meuron 2003). According to the location of the viewer, the effect of the skin from outside always changes as a result of its sculptural design. The changing character of the building is strengthened by its affective surface structure

design. Jacques Herzog describes these glass panes as “an interactive optical device. Because some of the glass is curved, it seems to move as you walk around it. That creates awareness of both the merchandise and the city there's an intense dialogue between actors. Also, the grid brings a human scale to the architecture, like display windows. It's almost old-fashioned.”
(http://www.galinsky.com/buildings/pradatokyo/index.htm)

Figure 5.5: Model photos and drawings of the Prada Aoyama Epicenter



Source: http://architettura.it/files/20031023/index.htm

The glass skin is not a usual curtain wall system in Prada Aoyama Epicenter. It is a transparent, structural skin that plays an important role in the building design. Steel sections in the facade and three vertical steel cores support the floor slabs and horizontal tubes brace the structure. These tubes also provide closed spaces for changing rooms. The grill for the glass skin is a diagonal post and rail facade and the panes are wet-sealed with silicone. The curvature of the glass makes it more rigid. To produce convex-concave glass, the flat glass panes were heated in a trapezoid shape frame for nearly eight hours when it gets ready it was depressed by around 150 mm from the center (Schittich 2006).

Figure 5.6: The grill for the glass skin

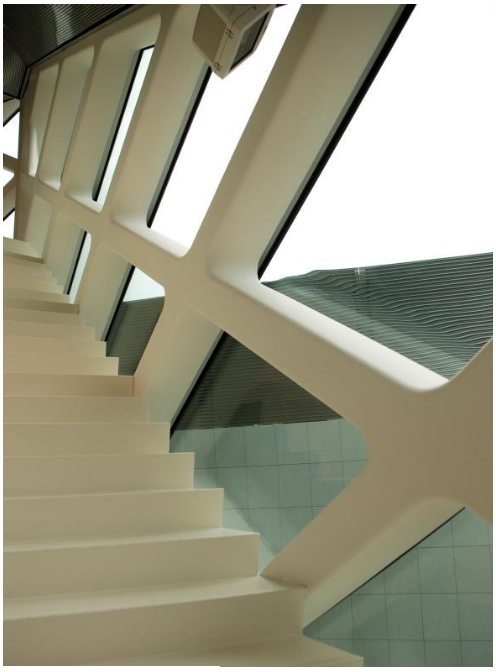


Source: http://architettura.it/files/20031023/index.htm

Herzog &de Meuron explain the effect of the facade out of these curvature shapes of glass as;

> "*The facade becomes almost a sort of interactive screen. Really low-tech. When the glass bends towards you, you are being observed. You are being pushed back. But when it curves away from you, it invites you in. It actually draws you in physically. The glass is really between the world of Prada, Prada goods, and the observer. And it's between the visitor and the city. And the world. It involves every player."* (Herzog & de Meuron 2003)

Figure 5.7: Prada Aoyama Epicenter




Source: Sezegen, A.

Alternating between the flat, concave and convex glasses, the bubbled glass skin of the Prada Aoyama Epicenter was separated from the surrounding residential and commercial buildings. The architectural value of the building is hidden in the glass skin. It raises awareness of building skin design in architecture and creates a strong relationship between interior and exterior. The Prada Aoyama Epicenter is an influential example designed with almost one of the oldest building materials, glass, in a totally new way.

5.3 LE CORBUSIER'S APPROACH TO DESIGN OF BUILDING SKIN

The brute character of concrete in Le Corbusier's buildings and the smoothness of concrete in Ando's are worth investigating to see the relation between the building skin in the example of concrete as a buildings material. As one of the early pioneers of Modern Architecture, Le Corbusier was born in a Swiss town La Chaux-de-Fonds in 1887. During his architectural education he had a chance to work with influential architects Auguste Perret (1908-1909) and Peter Behrens (1910). Just like some other contemporaries of his time, he believed that there was a need for a new beginning in architecture as a result of the opportunities of the new century. He concentrated on the discovery of new architecture for the twentieth century based on utilizing technology and industry. His famous statement: "The house is a machine for living in." is a good summary of his ideas (Moffett, et al. 2003). In response to his concentration on the discovery of new architecture and admiration of mechanized design, Le Corbusier established "The Five Points" of architecture in 1926, as the necessary components of architectural design. The five points toward a new architecture were;

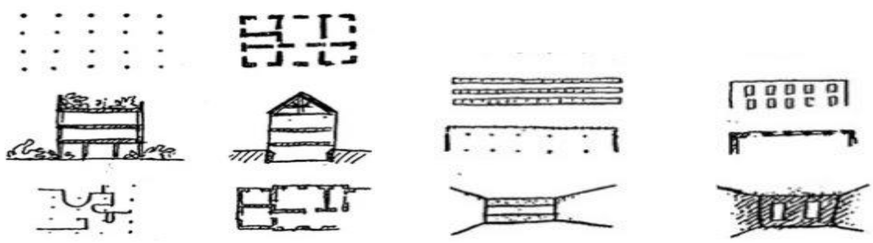
1. The pilotis: Reinforced concrete made possible the design of these supporting columns and it resulted with elevated floors.
2. The roof garden: Design of a flat roof instead of inclined ones and utilization of it with different purposes.
3. The free plan: Removing supporting walls form the interior. Plans were no longer limited by the structural walls owing to reinforced concrete technology.

4. The elongated window: Horizontal windows to get more natural light as a result of the developments in the structural system.

5. The free facade: The structural support elements set back from the facade to free facade from its structural function.

These five points were considered in most of his projects until 1950s to create a new aesthetic (Moos 2008).

Figure 5.8: Le Corbusier - cinq pointes d'une Architecture Nouvelle



Source: http://www.sbi.dk/arkitektur/beredygtighed/arkitektur-og-beredygtighed-artikelsamling/de-signed-ecology/

According to Le Corbusier, the window is one of the most important elements of a building. In "Towards a new architecture", he focused on the horizontal window on the building skin. The window can be designed as a long, uninterrupted, ribbon in order to take light inside more efficiently and consequentially spatial experience of the interior gets stronger. Continuous windows on the facade became popular on the non-structural skin of his buildings. The freely-designed facade, unconstrained by load-bearing considerations, consists of a thin skin of wall and window. As a result of this, architects are free to design these non-supporting walls as a building skin.

5.3.1 Concrete as a building skin in Le Corbusier's architecture

Beginning in the early twentieth century, architects have used concrete and reinforced concrete to take advantage of the sculptural possibilities of this material. Other than its structural opportunities, concrete became an innovative building material in architectural design with its surface and Le Corbusier was one of the architects who incorporated concrete as a skin in his design. By harnessing the potentials of new materials, notably reinforced concrete, Le Corbusier aimed to create a modern living space with his architectural principles. Progress in technology provides a revolution in the history of the facade with the aid of reinforced concrete and he was one of the most important architects who demonstrated the advantages of concrete in building design.

Concrete became an important point for Le Corbusier's architectural success. His five points became possible as a result of concrete technology. Reinforced concrete provides the support, it makes the structurally homogenous flat roof possible and its structural capacity transforms the character of the facade. The possibilities of concrete as a building material opened new horizons to architects (Moos 2009).

Figure 5.9: Concrete skin of Ronchamp Chapel

Source: http://figure-ground.com/ronchamp/

The critic Reyner Banham indicated as Le Corbusier's so called "beton brut" as; "*Le Corbusier conjured concrete almost as a new material, exploiting its crudities and those of the wooden formwork to produce an architectural surface of a rugged grandeur."*
The following section about Carpenter Center, a representative of Le Corbusier's "beton brut" architecture will study the building as a case study, to investigate concrete as a building skin.

5.3.2 Case Study- Carpenter Center for the Visual Arts

Carpenter Center may be considered to be one of the strong examples of Le Corbusier's ideas. The first and only project by Le Corbusier in the United States was the Carpenter

Center for the Visual Arts, located at Harvard University campus in Cambridge. The site was surrounded by Neo-Georgian buildings of unnatural brick and Le Corbusier designed a radical raw concrete building inserted between those buildings (Whiffen 1983). Curtis (1994, p.216) summarized the center with these words;

> *"At the heart is a cubic volume from which curved studios pull away from one another on the diagonal. The whole is cut through by an S-shaped ramp which rises from one street and descends towards the other... The layers and levels swing out and back from the grid of concrete pilotis within, making the most of cantilevering to create interpenetrations of exterior and interior, as well as a sequence of spatial events linked by the promenade architecture of the ramp."*

Figure 5.10: General view of Carpenter Center for the Visual Arts

Source: http://www.flickr.com/photos/scottnorsworthy/3391026174/in/photostream/

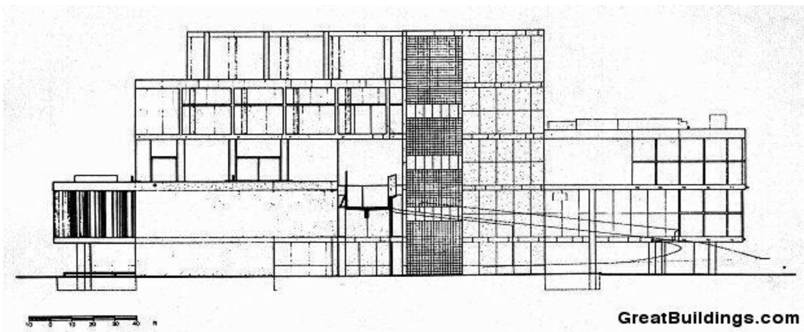
Carpenter Center has a cast in place concrete skin and reinforced concrete structure. It uses concrete as an adaptable building material to various forms with its natural clarity for structural purposes and the skin. The center links interior and exterior spaces by the exterior ramp which passes through the center of the building. Horizontal floor plates of the Carpenter Center are clearly visible on the facade (Borden 2010).

Figure 5.11: The facade of the Carpenter Center

Source: http://www.oobject.com/18-brutalist-buildings/carpenter-center-harvard/7954/

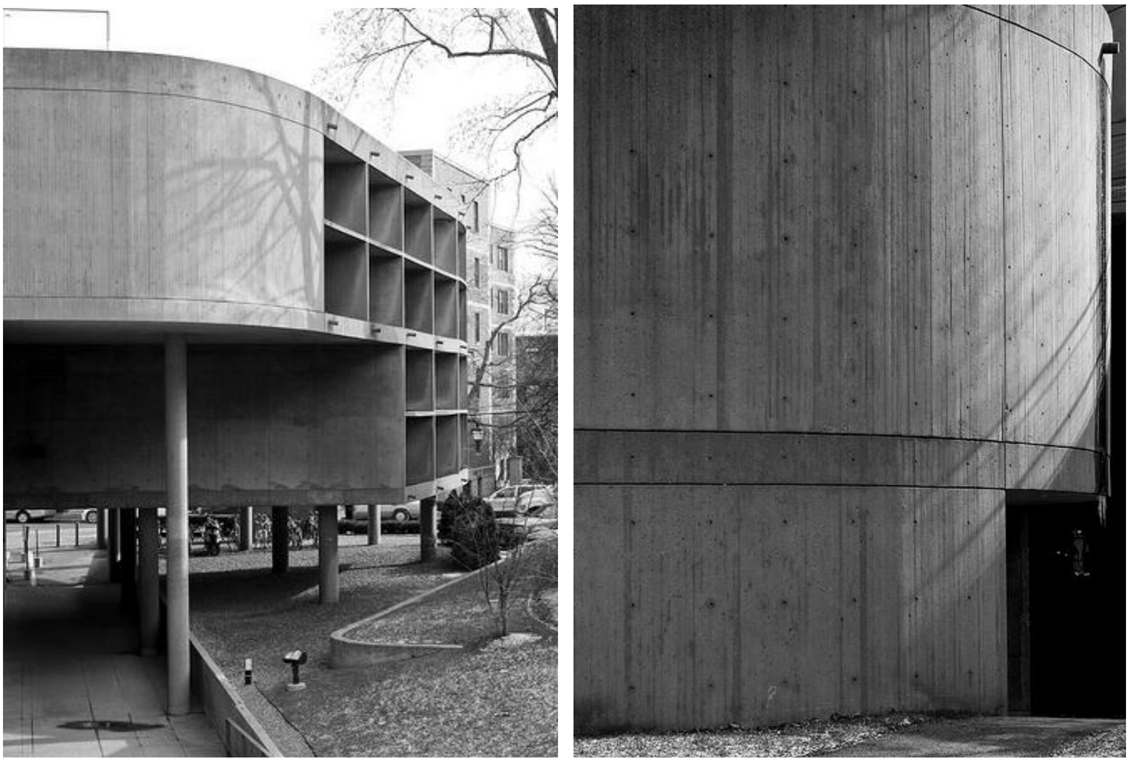
Although the building has a concrete skin, there are some openings on the skin for specific functions. There are four main types of openings on the skin: full floor to ceiling glazing, brises-soleil which was related to the simple patterned concrete walls, ondulatories which were the vertical mullions between strips of glass and aerateurs which were vertical pivoting doors. The composition of these four types of openings forms the renewed facade system of Le corbusier from the 1920s. With the new free facade system he aimed to design each element serving and embodying specific function (Curtis 1994).

Figure 5.12: Carpenter Center facade drawing



Source: http://www.greatbuildings.com/buildings/Carpenter_Center.html

Figure 5.13: Exterior view of the center and the exposed concrete surface



Source: http://www.flickriver.com/photos/scottnorsworthy/3390210497/

Le Corbusier found the beauty in natural creation of concrete by the formwork and used it raw, not treated, even with the marks and mistakes. Rather than designing an applied skin, he used concrete in its corporeal form. He thought that they would be the part of the aesthetic characteristics of the building (Gargiani 20011). Based on these thoughts and principles Le Corbusier designed the Carpenter Center and its smooth concrete skin still plays an important role in architectural studies for bringing new visions to innovative concrete skin design today.

5.4 TADAO ANDO'S APPROACH TO DESIGN OF BUILDING SKIN

Ando is a self-educated architect. He is influenced by the projects and writings of the famous architects, Le Corbusier. Le Corbusier had the first considerable influence on him, besides traditional and modern buildings of Europe, Africa, and the US that he visited. The influential Japanese architect, Ando, was influenced by Modern Architecture of 20^{th} century. His design approach is a combination of Japanese cultural understanding and perspective of modernism in Europe. His statement in a writing entitled '*How to Deal with the Hopelessly Stagnant State of (Contemporary) Modern Architecture*' clearly explains Tadao Ando's architectural design approach. He states that; "I want to readopt modernism, which has supposedly been dead, and thrust it in a new direction. One of the strategies I seek is to personalize modernism with the simple but potent aesthetic consciousness unique to Japan." (Ando 1989, p.21)

He never rejects formal aspects of modern architecture, but believes that modern architecture does not take into consideration the cultural dimension, and does not concentrate on the spiritual features of humanity. He absorbs what exists on the land and uses that knowledge along with the contemporary thinking to interpret what he sees.

Ando may be called an architect of the "walls". He designed many spaces with his experimental use of exposed concrete and large, powerful walls in his buildings which always played an important role in this process. Wall regulates movement in space; it acts as a guide, a commander, a divider and brings order to people's lives. He explains what walls mean to him with his statement; "At times walls manifest a power that borders on the violent. They have the power to divide space, transfigure place, and create new domains. Walls are the most basic elements of architecture, but they can also be the most enriching." (http://www.pritzkerprize.com/1995/bio). Explaining the "walls" of Tadao Ando, Masao Furuyama in his book "Tadao Ando" states that*;*

> *"Ando's walls maintain a physicality which defy metaphor. Minimalist, they abjure sentimentality. His free standing walls function like the planes of conceptual paintings, eliminating surface illusion, reducing the world to its essence. Beyond its visual beauty, Ando's architecture has the intensity of its naked materials*." (Furuyama 2006, p. 13).

The load bearing structure and the "walls" of Ando are the same element in many of his projects. The load bearing function is hidden in the concrete building skin.

Figure 5.14: Exposed concrete walls in Church of the Water in Yufutsu and Chichu Art Museum

Source: http://frankigoodwin.com/2009/07/26/highly-illegal-iphone-shots-of-chichu-art-museum-naoshima/img_03511/

Besides the use of wall element, Ando mostly designed pure and simple spaces with gave great importance to details. Harmony with nature and manipulation of light and pure usage of materials are the most important points of his design approach. Ceilings slightly detached from the wall, the ribs on the facade to take the light into the space thoroughly, usage of exposed concrete even the holes of mold are visible; all of these details can be encountered in his buildings. He gave more importance to the spatial organization of a building and this is the reason why he pays more attention to details. He aims to design a space that does not isolate people form nature and a skin that communicates with the nature. This skin is designed to touch human senses and remind them about the presence of nature. The skin that is used in his architecture represents mostly the separation between private and public. He also aimed to get the light into the space with the design of open and closed surfaces on the building skin according to the context. Skin of his buildings is designed as a complete glass skin, concrete skin with glass used as thin narrow strips or completely massive concrete skin with glass holes on it. Although each building skin is designed completely different from each other, there is always an interaction with sunlight through the skin. It is his incursion that one can actually live in harmony, close contact with nature through the voids in the skin. Influenced by Japanese traditional architecture based on these conditions, he made this a reason to have a very high degree of connection between the outside and inside in his projects. The primal power of Tadao Ando derives from his sublime use of concrete.

His work, primarily in reinforced concrete, defines spaces in a unique way that allows constantly changing patterns of light and wind in all of his structures.

5.4.1 Concrete as a building skin in Tadao Ando's architecture

Ando considers authentic materials such as exposed concrete necessary for the crystallization of architecture in his designs. His interest in authentic materials and their pure and brutal use seem to be the result of his attention to Modern architecture (Schittich 2006). Ando himself insists that he is less interested in expressing the nature of the material than using it to create architectural space. Many of his buildings are not entirely made of horizontal and vertical plane; rather they are slightly curves or undulated within the individual framework of panels producing a sophisticated liveliness on the concrete surfaces through the play of shadow and light. In his use of concrete, the shuttering is used to provide texture to the finished building which also supports the concrete while it is setting. Ando's walls are made from exquisitely smooth poured in concrete and his success of using concrete is not in its mixture but it is hidden in the close supervision he provides during construction and in the manual skills of his workmen. He explains his concrete design as;

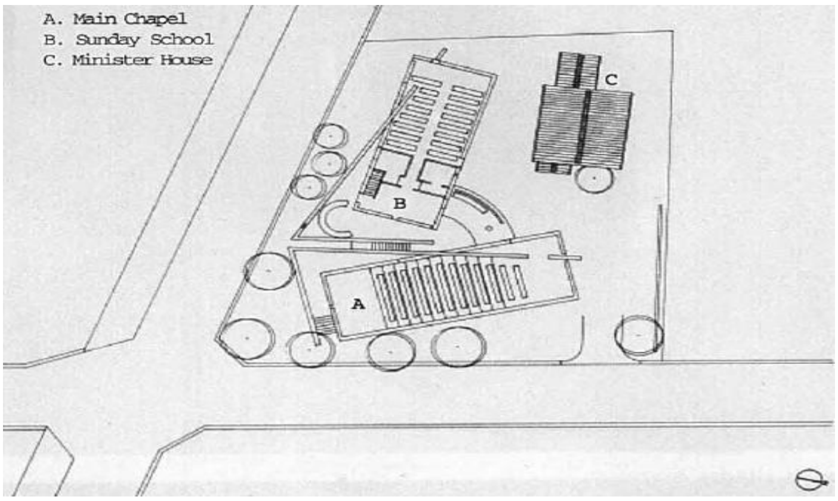
> *"The way I employ concrete, it lacks sculpturesque solidity and weight. It serves to produce light, homogeneous surfaces. I treat concrete as a cool, inorganic material with a concealed background of strength. My intent is not to express the nature of the material itself, but to employ it to establish the single intent of the space."* (Ando 2000, p.51).

Ando's building skin employs a limited range of materials and expresses their textures. His powerful and heavy exposed concrete skin gains its character by his careful attention to materials. It expresses an inner strength and his design convictions. Initially, the architectural concepts that seemed to inspire world-wide followers were generally found in his large scale projects that reflected totally smooth surfaces divided rigorously according to the grid of the framework panels and were perforated by a uniform pattern of true and sometimes "feigned" tie holes. However, in parallel with Ando's work, other diverse protagonists are experimenting with the material and looking for specific contemporary forms of new expression. As part of a new consciousness about this material, concrete is increasingly featured in the full range of its visual forms (Schittich 2006).

5.4.2 Case Study - Church of the Light

Church of the Light is a project of Tadao Ando, built in a residential district in Ibaraki-shi, Osaka-fu. The chapel was constructed in between 1987-1989.Ten years after chapel's construction Sunday School addition was built in 1999. Tadao Ando is known as an architect that importantly considers environmental factors in his designs. Just like all the other projects of Ando, his design concept was shaped and oriented according to the surrounding environment. The other dominant feature of his architecture "use of light" is an important design concept of the Church of the Light.

Figure 5.15: Site plan of the Church of the Light



Source: http://www.scribd.com/doc/24285072/Tadao-Ando-Church-of-Light-Architectural-Analysis

The Church of the Light was distinguished by a clear composition of rectangular volumes of three cubes crossed by a wall at an angle of 15°. The free-standing diagonal wall divides the main space into the chapel and a vestibule. The chapel is a 6x6x18 concrete box consisting of the basic constructional elements; soil, walls, ceiling and openings for light. The project is an example of how to reach a strong design concept with less, to create a rich space.

Figure 5.16: Interior and exterior view of Church of the Light

Source: http://figure-ground.com/church_light/

The most important detail about the Church of the Light is hidden in the design of its skin and the use of light. Both light and darkness, a contrast between light and shadow constituted the main design theme (Furuyama 2006). To make these concepts real, he focuses on the skin and its material. The space is primarily defined by the concrete volume.

The exposed reinforced concrete skin of the chapel defines the space. The wall is the load bearing element. There is a cruciform cut that extends vertically from ground floor to ceiling and horizontally from wall to wall in the concrete skin. It is aligned perfectly with the joints in the concrete. As it is clear in the site plan of the Church of the Light, the chapel's cross cut facade was oriented towards south-east to benefit from natural light in maximum. When the light enters from the cross cut in the concrete wall it creates an effect of an illuminated cross inside and this effect creates a division between the spiritual and the secular.

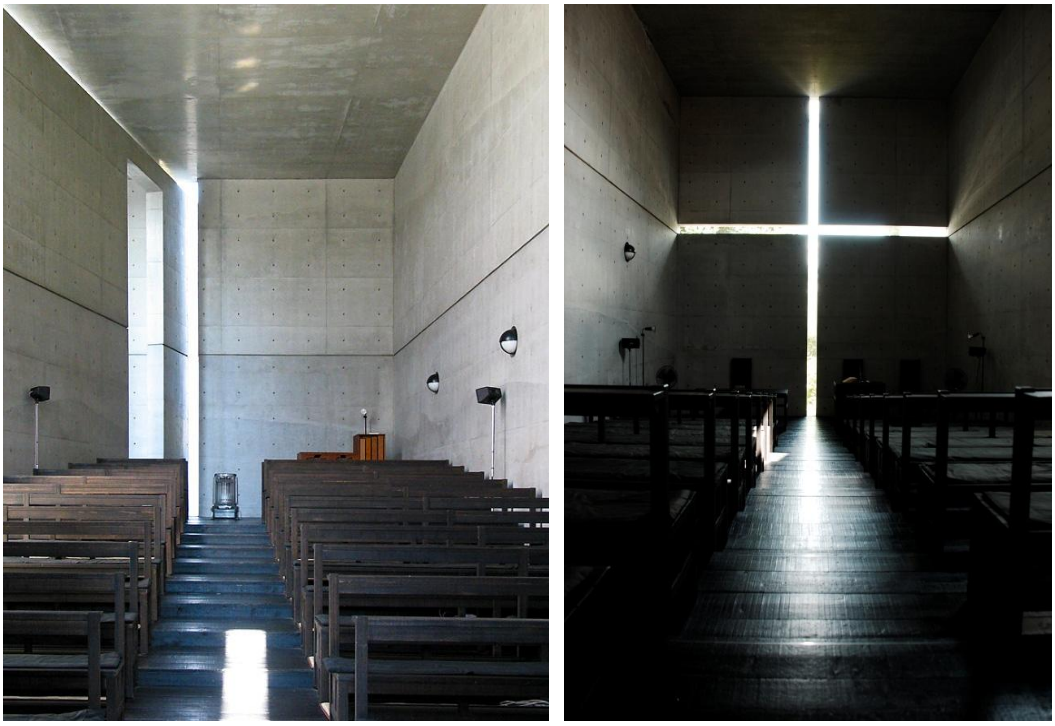
Figure 5.17: The cross cut in the exposed concrete skin

Source: Sezegen, A.

Ando has always been in search of a rich and diverse space in his designs. In contrast to the architects that use expensive materials to design rich spaces, he tried to achieve this goal with a basic building material mostly concrete and glass and natural elements such as water and light. He uses materials as a connecting tool between nature and human. The main element defining space in the Church of the Light is the light but it does not create this effect by itself. The natural light gives this impression by the cut on the exposed concrete wall. The way concrete is poured and formed gives the concrete a luminous quality when exposed to natural light. Exposed concrete is a suitable material that gives the intended impact for Ando with its pure character. According to Masao Furuyama, the reason why he mostly uses concrete in his design is stated in his book Tadao Ando (2006) ;

> *"Ando is critical of the present tendency to eliminate materiality in architecture and to use characterless, artificial materials in the name of economic rationalism. He always uses natural materials for parts of the building with which people come into physical contact. He believes that materials of substance such as wood, stone and concrete are important for architecture, and that they enable us to sense the building directly through our bodies."*(Furuyama 2006)

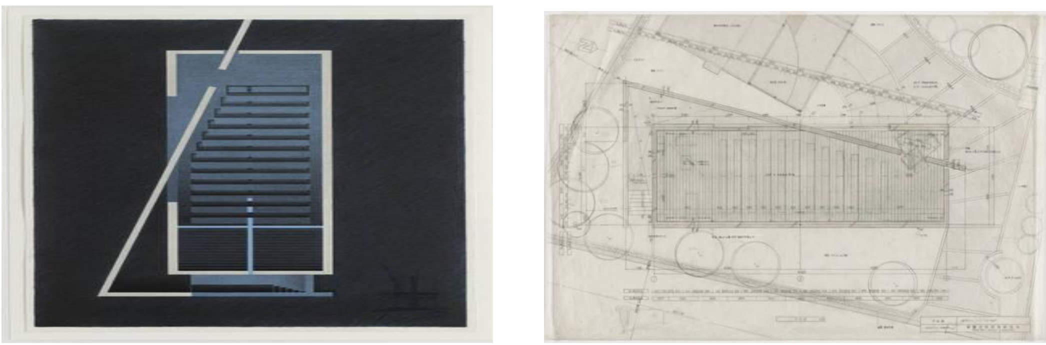
Figure 5.18: Openings on the exposed concrete skin



Source: Sezegen, A.

The usage of concrete as a simple building material supports the dual idea of the space as light/dark, solid/void. Exposed concrete structure removes any traditional motifs and helps Tadao Ando to create his own aesthetic.

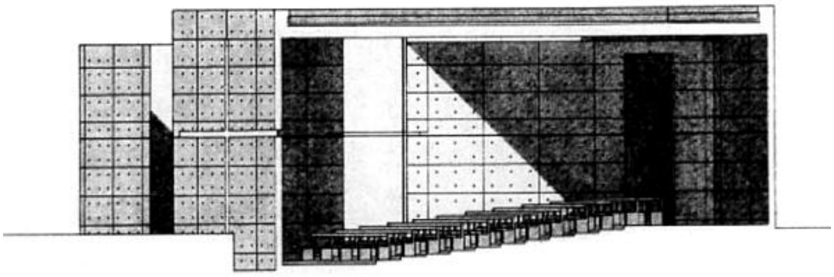
Figure 5.19: Top view drawings of the chapel



Source: http://www.moma.org/collection/object.php?object_id=340

Besides an extruded cross from the east facing facade, the church is composed of a concrete shell. Other than the entrance opening on the free-standing concrete wall, the only opening is on the south-west facade which looks towards the courtyard and takes the reflected natural light inside. The solid concrete surface adds to the darkness of the church by creating a more humble, meditative place of worship.

Figure 5.20: Section drawing of the chapel



Source: http://www-bcf.usc.edu/~kcoleman/Precedents/ALL%20PDFs/Ando_ChurchOfLight.pdf

Figure 5.21: Physical model photos of the Church of the Light

Source: http://www.designboom.com/contemporary/tadao_ando.html

The boxed-shape, exposed concrete building is admired by the people with its power of exhibiting the sensuous qualities of the material and introducing its effective play with natural light. This project is a good example of an effective design of a concrete building skin. Its innovative design shows how building skin can be one of the most important element of a building that reflects the design concept.

6. EVALUATION AND CONCLUSION

Every building is first detected by its external form, which historically, was inseparable from the structure. Architectural movements have redefined building skin throughout history which is being reinterpreted at an ever rapid pace with digital technology. Considering the scope and current characteristics of building skin, it was relevant to focus this study on the art of construction, architectural tectonics, and building skin in regard to theory, history, and its contemporary role in architectural practice.

Analysis of the tectonic character of a building is to understand the role of the building elements within the organization of space and its symbolism in relation to the structural system. When drawing attention to the relationship between tectonics and space, Bötticher believed that artistic symbolism in architecture was tied to functional, technological, and material innovations. Semper's theory defined architecture through the building skin as an activity of construction followed by technological developments with changing materials and technical features in its era. When he defined "the four elements of architecture", he considered the construction system with building materials and emphasized the importance of symbolism in architecture. On the other hand, Kenneth Frampton noted the importance of the structural system as an inseparable part of the space in defining tectonics. He thought that without structure there cannot be a space, so in order to understand the essence of architecture he also emphasized on the symbolism.

Frampton's "tectonics" notion previously defined constitutes a secure basis for understanding architecture. His writings on criticism and analysis of twentieth century architecture have influenced many architects. According to Frampton, composition of different architectural elements forming structure has a significant symbolic value. He described the representational potential of the construction technique while not rejected the descriptions of their stylistic features by historians. He clarifies that the symbolic value of Ancient Greek Temples or Roman buildings is hidden in the use of building materials; by the quality of the joints and details, thereby creating the structural system. The composition of structural and symbolic characteristic and their essence reflect the tectonic character of a building. In other words, Frampton gave importance to the representational potential of the structure. Evaluating the ideas of tectonics revealed that: Bötticher advocated the dominant role of the structural characteristics in the creation of the form; Semper believed that structure as a skin expresses symbolism in architecture; and Frampton can be seen as a common base for these three theorists.

Rereading of the Semper's influential studies on the building in the history of architecture today, different architects have been suggesting their ideas on the topic in the context of contemporary architecture. As Jonathan Hill stated that: "In defining the first architectural act to be the enclosure and the generation of domestic space by surfaces of little substance – lines woven into fabric – Semper doubly ties architecture to the immaterial."

Another important point through these ideas he was focused on the skin and art of space. Semper's concentration on the theory of dressing in the middle of the nineteenth century provided basis for shaping the contemporary building skin. Semper's interest on the enclosure and traditional building materials depicts the importance of building skin in architecture, as well as the dominant role of building materials in building skin design. Essentially mentioned by Frampton, tectonics as a contemporary and controversial issue and is closely related to the building materials and how they are constructed.

Building materials are necessary in the creation of a protected space and, as they evolved with time, their relationship created buildings that had shaped architectural history. Architecture comes to life through building materials. Building materials were restricted to local resources before efficient transportation was available. However, with the Industrial Revolution new building materials emerged and construction methods opened new horizons for architects. New materials, their application and reinterpreting existing ones are closely related to the evolution of building skin design.

Design of building skin has played an important role in architecture from primitive times to contemporary period. Building skin provides protection from outer elements, creates privacy and defines boundary around personal property therefore becomes an essential part of a building. Because the symbolic role and the meaning of the skin is an essential topic of the architecture today, cultural representation of building skin besides its physical functions is also important. Building skin has developed and changed in parallel to the development of mankind with technology.

While the need for enclosed and sheltered spaces was provided by natural elements in primitive times, effects of technology and material usage have taken the notion of building skin to a different level of meaning with the definition of the building skin as a "wall". Building skin design in every sense has been in a constant change throughout history.

As a boundary defining building element, the wall has been identified differently under the influence of ever-changing architectural movements. Previously, walls were designed as thin, enclosing, textile elements. Later, with the use of stone and brick as primary building skin materials, the wall increased in thickness to create more protective shelters. Design of building skin was restricted to local building materials and construction techniques. These materials were not subject to any special surface treatment. New building materials emerged due to the Industrial Revolution allowed for increasingly innovative building skin designs. Glass and steel together worked wonders by making the transparent building skin possible – therefore bringing more light into enclosed spaces. The solid and void relationship of the skin, its development in the concept of structure, and its expressionist behavior constitute some important factors to be considered when designing a more complex building skin.

In this context, investigating the development of the building materials is important in designing better skin. Building materials influence the design of building skin where the corporeal existence of architectural expression becomes real. Availability of the building materials in desired color, pattern, and size and the willingness to discover new construction methods can lead creativity in the design of the skin.–As Mies van der Rohe, an architect who truly understood the essence of material, states:

> *"What would concrete be, what steel without plate glass? The ability of both to transform space would be limited, even lost altogether; it would remain only a vague promise. Only a glass skin and glass walls can reveal the simple structural form of the skeletal frame and ensure its architectonic possibilities … These are truly architectural elements forming the basis for a new art of building. They permit us a degree of freedom in the creation of space that we will no longer deny ourselves. Only now can we give shape to space, open it, and link it to the landscape. It now becomes clear once more just what walls and openings are, and floors and ceilings. Simplicity of construction, clarity of tectonic means, and purity of materials have about them the glow of pristine beauty."*

Investigating the materials used in building skin design is an extensive field of study. It is essential to understand the material properties, design potential, and integration into the building skin's design. These available building materials and construction methods revolutionized the solid and void relationships on building skin.

Among various building materials, glass and concrete have been one of the most influential building skin materials throughout history especially during twentieth century and onwards. Any change in the structure and application of these materials has rapidly reflected in the building skin design. Glass consolidated its position as a leading building skin material after the Industrial Revolution with its spreading use by many architects. Although many new building materials are manufactured, glass – as one of the oldest building material – still retains its importance. Glass symbolizes contemporary building skin.

In contrast to the transparency of glass, concrete has been developed as a leading building material. The solid, cold material properties that have often described concrete, have been overcome through innovative design and technology. Innovations in technology have made the fluid forms of concrete more accessible than ever before. Just like glass material, concrete is an up to date building skin material.

The relationship between building materials and architectural design is important in the design of building skin as it is important for the other elements of the building. To explain it clearly, Mies quoted that; "Thus each material has its specific characteristics which we must understand if we want to use it. This is no less true of steel and concrete. We must remember that everything depends on how we use the material, not on the material itself." According to him, rather than the material itself the way how the materials are used is more important.

His building skin design for the Seagram Building depicts his understanding of glass as a material that led him to move his design concept to the upper level. His master work shows a deep understanding of the character of material that inspired him in a creative way. A contemporary of Mies, Le Corbusier also took advantage of the use of materials. He used concrete which is a versatile material; he focused on its raw character in his building skin design. According to Le Corbusier, investigating the potential of materials brought new ideas into design. His use of materials meets the art of construction in his designs, as it is clear from his statements:

> *"You employ stone, wood and concrete, and with these materials you build houses and palaces. That is construction. Ingenuity is at work. But suddenly you touch my heart, you do me good, I am happy and I say: "This is beautiful." That is Architecture. Art enters in."*(Corbusier, 1927).

Concrete was an influential material for Le Corbusier both with the performance of its structural features and aesthetics. Also, well known for his contemporary concrete aesthetic, is Tado Ando, who differentiates himself clearly from Le Corbusier's aesthetic when he states, *"What I'm attempting to express through concrete is not like Le Corbusier's ruggedness but something more subtle."* His material use was explained more clearly in Furuyams's book "Tadao Ando; The Geometry of Human Space" in 1941, explaining:

"Beyond its beauty, Ando's architecture has the intensity of its naked materials…The touchstone for Ando's grasp of concrete lies in the rhythms of daily life, founded on Japan's unique aesthetics. From his earliest architectural works, Ando has cherished materials with a unique intensity deeply tied to his childhood memories. Ando may be a master of poured concrete, but relies on natural materials for points that a human being may touch…God may well be in the details, but in Ando's architecture memories are in details."(Furuyama 2006).

Just like Tadao Ando, Herzog & de Meuron are important architects with their innovative material use in their building skin design. They try to experience all kinds of building materials to increase the role of the building materials in building skin design. They try to benefit from the characteristics of the materials as much as possible and with the intention to create and experience the poetic qualities of building materials. The role building materials play in the architectural design of Herzog & de Meuron is precisely summarized in these words that;

"Their interest in surface and material, opacity and transparency and the function and variability of images makes architecture speak—not just in quotations and typologies, but by continually redefining raw materials. Their buildings seem to exist simply to present those mysterious and beautiful moments when material is transformed into meaning"." (http://www.lars-mueller-publishers.com/en/herzog-and-de-meuron-naturgeschichte-1)

Herzog & de Meuron's approach to building skin design demonstrates the impact that glass can have as a building skin material. Both glass and concrete have, respectively, constituted a primary role in the influential designs of Mies van der Rohe and Herzog &de Meuron, and Le Corbusier and Tadao Ando. Their works highlighted in this thesis – Seagram Building, Prada Aoyama Epicenter, Carpenter Center for Visual Arts and Church of the Light – demonstrate the breadth of architectural expression that can be reached by these materials.

Contemporary architecture is becoming the architecture of images. Because skin of the building is one of the most important building elements to perceive the image from the outside, design of the skin keeps its importance up to date. The meaning of the building skin has redefined several times as a result of the historical and theoretical investigations. Continuous skin which exists in the natural environment, the skin as a wall, true skin that is related to the building where roof and wall are one continuous element without visible transition are some of its definitions. In this context, the influential potential of the design of the building skin is a notion that should be dealt with in architecture. The developments in the material and construction technology are leading innovative design of the building skin. Although the art of construction have been considered as a separate element of design, it is actually one of the most leading design factors in architecture. The design and the construction cannot be separated in architecture. From the times of Vitruvius's definition of art of construction to the studies of Frampton's tectonics, the notion of architectural tectonics with the interpretation of traditional and new building materials keeps its importance today to be investigated.

An important approach in today's architecture is designing building skin as an important communication tool between interior and exterior space and benefiting from the wide range of available building materials is one of the most important design tools to achieve this approach. New material usage has an influence on the form of the building skin. Use of transparent building materials on the skin of the building aims to reflect the atmosphere of the living space to the people outside. As a result of this approach the interior life becomes a part of the surrounding environment with the aid of the building skin. Different use of building materials with progressive techniques and well considered details increase creativity in the design of the building skin it is really necessary to give importance to the research of building materials. Within the framework of this research, there are some finding that requires attention in the example of concrete and glass. Building skin that is designed with the use of transparent building materials, transforming into opaque surfaces and opaque surfaces tend to transform into transparent skins. The production of more translucent glass material and light transmitting concrete can be example in this context. Environmental issues such as; day lighting, energy efficiency are among the concerns of architects in the design of building skin today. In this context, this study covers an extensive investigation on the essence of building materials, the tectonic culture as a basis for the design of building skin, case studies of architect's innovative works which will constitute an important resource for practicing architects with a conscious concern for tectonics and building materials.

REFERENCES

Books

Ando, T.,1989. *The Yale Studio & Current Works*. New York: Rizzoli International Publications.

Ando, T., 2000. Ando writing in 1986. *Concrete Regionalism (4x4 series)*. London: Thames & Hudson.

Ballantyne, A., 2002. *What is Architecture?*, Oxon: Routledge.

Bell, V.B. & Rand, P., 2006. *Materials for Architectural Design*. London: Laurence King Publishing.

Bertelli, P., 2003. *Herzog & De Meuron: Prada Aoyama Tokyo*. G. Celant & Prada M. (Eds.). Bilingual edition. Fondazione Prada.

Blake, P., 1997. *The Master Builders: Le Corbusier / Mies Van Der Rohe / Frank Lloyd Wright*. Reissue edition. New York: W. W. Norton & Co.

Borden, G.P., 2010. *Material Precedent*. New Jersey: John Wiley & Sons.

Brock, L., 2005. *Designing the exterior wall: an architectural guide to the vertical envelope*. New Jersey: John Wiley & Sons.

Burden, E., 1996. Building Facades: Faces, Figures, and Ornamental Details. 2nd edition. McGraw-Hill Professional.

Cache, B., 1998. *Bernard Cache's "Digital Semper"*. Cynthia Davidson's (Ed.). MA: The MIT Press.

Cloninger, C., 2008. *Fresher Styles for Web Designers: More Eye Candy from the Underground.* Berkeley: New Riders Press.

Cohen, J.L., 1996. *Mies van der Rohe*. London: Taylor & Francis

Cohen, J.L., 2007. *Ludwig Mies Van Der Rohe*. Basel: Birkhauser.

Corbusier, L., 1986. *Towards a new architecture*. New York: Dover Publications.

Crook,M., 1987, *The Dilemma of Style: Architectural Ideas from the Picturesque to the Post-Modern.* Chicago: University of Chicago Press.

Cuito, A., 2003. *Karl Friedrich Schinkel*. illustrated edition. Spain: LOFT Publications.

Curtis, W.J.R., 1994. *Le Corbusier: ideas and forms*. Phaidon Press Limited.

Frampton, K., 1983. *Modern Architecture 1851-1945*. New York: Rizzoli International Publications.

Frampton, K., 1995. *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture*, John Cava (Ed.), London: The MIT Press.

Frampton, K., 1996. *Rappel a L'Ordre: The Case for the Tectonic. Theorizing a new agenda for architecture: an anthology of architectural theory*. K. Nesbitt (Ed.). New York: Princeton Architectural Press

Furuyama, M., 2006. *Tadao Ando: 1941*. illustrated edition. Taschen.

Gargiani, R. & Rosellini, A., 2011. *Le Corbusier: Beton Brut and Ineffable Space (1940 – 1965): Surface Materials and Psychophysiology of Vision*. Abingdon, Oxford, U.K. : Routledge.

Hartoonian, G., 1997. Modernity and its other: a post-script to contemporary architecture. Texas: Texas A & M University Press.

Hegger, M., Auch-schwelk, V., Fuchs, M. & Rosenkranz, T., 2006. *Construction Materials Manual*. Basel: Birkhäuser.

Hermann, W., 1984. *Gottfried Semper: In search of architecture, five manuscripts: a critical analysis and prognosis of present-day artistic production*, Massachusetts: The MIT press Cambridge.

Herzog, J., 1997. Gespräch zwischen Jacques Herzog und Theodora Vischer, Mai 1988. Conversation between Jacques Herzog und Theodora Vischer. *Herzog & de Meuron 1978-1988: The Complete Works*. Basel: Birkhouser.

Herzog, J. & Meuron, P., 2005. *Herzog & de Meuron: Natural History*. P. Ursprung (Ed.). Montreal: Lars Muller Publishers.

Herzog,T., Krippner,R. & Lang,W., 2004. *Facade Construction Manual,* Basel: Birkhauser Verlag AG.

Hochberg, A., Hafke J. & R. Joachim, 2010. *Open/Close: Windows, Doors, Gates, Loggias, Filters*. Basel: Birkhauser.

Hunt, W.D., 1958, *, The Contemporary Curtaion Wall; Its design, Fabrication and Erection*. New York: F.W.Dodge Cooperation.

Hvattum,M., 2004. *Gottfried Semper and the problem of Historicism*. Cambridge: Cambridge University Press.

Kahn, L., 1991. "This Business of Architecture", Lecture at Tulane University, New Orleans, 1955.*Louis I. Kahn: Writings, Lectures, Interviews*. A. Latour (Ed.). New York: Rizzoli International Publications.

LeCuyer, A., 2001. *Radical Tectonics: Gunter Behnisch, Enric Miralles, Patkau Architects, Mecanoo*, illustrated edition, London: Thames & Hudson Ltd.

Loos, A. & Corbusier, L., 2008. The Principle of Cladding, Raumplan Versus Plan Libre: *Adolf Loos [and] Le Corbusier*, M. Risselada(Ed.), Rotterdam: 010 publishers

Lupton, E., 2007. *Skin: Surface, Substance, and Design*. New York: Princeton Architectural Press.

Mack, G., 2008. *Herzog & de Meuron 1997-2001: The Complete Works*. Flett, I. & Schelbert, C. (Trs.). Basel: Birkhauser.

Mallgrave, H.F., 1996. Foreword, *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture*, London: The MIT Press.

Mallgrave, H.F. (Ed.), 2006, *Architectural Theory: An Anthology from Vitruvius to 1870*, Wiley-Blackwell.

Micale, M. S. & Dietle R. L., 2000. *Enlightenment, Passion, Modernity: Historical Essays in European Thought and Culture*. Stanford University Press.

Moffett, M., Fazio, M. & Wodehouse, L., 2004. *A World History of Architecture*. Singapore: McGraw-Hill Professional.

Moore, C.H., 2003. *Development and Character of Gothic Architecture*. illustrated edition. New York : The Macmillan Company; London, Macmillan & Co., Ltd.

Moos, S., 2009. *Le Corbusier: Elements of a Synthesis*. Rotterdam: 010 Publishers.

Neville, A.M. & Brooks, J.J., 2010. *Concrete Technology*. 2nd Edition. Prentice Hall.

Peck, M. (Ed.), 2006. *Concrete: Design, Construction, Examples*. Basel: Birkhauser.

Porphyrios, D., 1992. *Selected Buildings & Writings (Architectural Monographs)*, New York City: John Wiley & Sons.

Porphyrios, D., 2002. From *Techne* to Tectonics. What is architecture? A. Ballantyne (Ed.). Oxon: Routledge.

Richards, J.M., 1958. *The functional tradition in early industrial buildings*. London: Architectural Press.

Richards, B. & Gilbert, D., 2006. *New Glass Architecture*. London: Laurence King Publishing.

Rohe, M., 1974. Mies van der Rohe, Glass Skyscraper: 1922. *Mies van der Rohe at work.* New edition. London: Prager Press.

Rohe, L.M., 1991. “Burohaus” manuscript. *The Artless Word: Mies van der Rohe on the Building Art*. F. Neumeyer (Trs.). Op. Cit. Massachusets: The MIT Press.

Joseph Rykwert, ‘Preface to *London Lecture* by Gottfried Semper’, *RES*, 6, 1983, p. 125

Schittich, C.(Ed.), 2006. *Building Skins: Concepts, Layers, Materials*, Basel: Birkhauser Verlag AG.

Schittich,C., Staib, G., Balkow, D., Schuler, M. & Sobeck, W., 2007. *Glass Construction Manual*. Basel: Birkhauser.

Semper, G., 1989. *The Four Elements of Architecture and Other Writings*, H.F. Mallgrave, W. Herrmann (Trs.), New York: Cambridge University Press.

Semper, G., 2004. *Style in the Technical and Tectonic Arts: Or, Practical Aesthetics*. Los Angeles: J. Paul Getty Trust Publications.

Speyer, A.J., 1968. *Mies van der Rohe*. Chicago: Art Institute of Chicago.

Venturi, R., 1977. *Complexity and Contradiction in Architecture*. 2nd edition. New York: The Museum of Modern Art.

Weller, B., Hart, K., Tasche, S. & Unnewehr, S., 2009. *Glass in Building. In: detail practice.* Basel: birkhauser.

Whiffen, M., 1983. *American Architecture: 1860-1976*. Massachusetts: The MIT Press.

Zimmerman, C., 2006. *Mies Van Der Rohe: 1886-1969*. Taschen America LLC.

Periodicals

Schwarzer, M., 1993. Ontology and Representation in Karl Bötticher's Theory of Tectonics, *Journal of the Society of Architectural Historians*, **52** (3), pp. 267-280.

Other Sources

Biography: Tadao Ando. 1995. [Online]. http://www.pritzkerprize.com/1995/bio [Accessed 24 June 2012].

Brownell, B. (Ed.). TRANSMATERIAL: A catalog of materials, products and processes that are redefining our physical environment. http://www.eskyiu.com/aainter1/ index_files/ transmaterial.pdf [Accessed 15 May 2012].

Curl, J.S., 2000. A Dictionary of Architecture and Landscape Architecture. [Online]. http://www.encyclopedia.com/topic/Gottfried_Semper.aspx [Accessed 04 January 2012].

Erbaugh, A., 2006. The interaction of *poesis* and *tekne* in tectonics. *Thesis for the M.A. Degree*. Ohio: University of Cincinnati.

Glynn, S., 2005. Prada Store, Tokyo. [Online]. http://www.galinsky.com/buildings/ pradatokyo/index.htm [Accessed 02 June 2012].

Jordana , S., 2011. Interview: Robert Venturi & Denise Scott Brown, by Andrea Tamas. [Online]. http://www.archdaily.com/130389/interview-robert-venturi-denise-scott-brown -by-andrea-tamas/ [Accessed 17 February 2012].

Rykwert,J., 1983. Preface to Gottfried Semper. *London Lecture of November 11, 1853*. H. F. Mallgrave (Ed.). RES **6** /1983): 5