Investigating the Correlation between Interior Space, Form and Structure in Case of Cultural Centers

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ABSTRACT

Interior space, formal appearance and formative structure are elements and concepts of an architectural project that faced major developments during the twentieth century onwards by various influential architects. The architectural project was studied by those architects to create a more comprehend and unified design in terms of the determine aspects between the space, form and structure. This study, intends to study the space, form and structure of an architectural project to emphasize their relation and defining elements. Therefore, this thesis aims to investigate the generator role of interior spaces on formal appearance and formative structure of an architectural project. However, it investigates the relation in the case of cultural centres. To implement this relation, a theoretical research was conductto analyse the development of these aspects by the various architects and a further theoretical study on the defining elements of each aspect in design. So, 10 constructed case studies of cultural centres was analysed according to the literature definitions of an architectural project to study the generator role of space on form and structure. The analysis shows the strong created design in the cases of reflecting the interior spaces characteristics on the exterior form and the used structural system. It is understood that developing an interior-oriented architectural project results in an integrated design through the different layers of the project.

Key Words: space, form, structure, architectural project, cultural centres

ÖZ

İç mekân, biçim ve strüktür ilişkisi, yirminci yüzyılın başından itibaren önemli mimarlar tarafından ele alınmış, farklı mimari projeler bağlamında çeşitli öğeler ve kavramlar ile yorumlanarak büyük gelişmeler göstermiştir. Mimari projeler, dönemin önde gelen mimarları tarafından iç mekân, form ve strüktür arasındaki belirleyici unsurlar açısından daha anlaşılır ve bütünlüklü bir tasarım yaratmak amacıyla araştırılmış ve kullanışmıştır. Bu çalışma, mimari projelerin mekân, form ve strüktürel yapısını, aralarındaki ilişkileri ve tanımlayıcı unsurları araştırmayı, tartışmayı ve tanımlamayı amaçlamaktadır. Tezin amacı, iç mekânların mimari projeler bütününde biçimsel ve strüktürel çözümler üzerindeki rolünü araştırmak ve söz konusu ilişkileri bir analiz yöntemine dönüştürerek kültür merkezleri özelinde araştırarak sonuçlar çıkarmaktır. Söz konusu ilişkiyi saptamak için, çeşitli mimarlar tarafından bu yönlerin gelişimini analiz etmek ve her bir yönün tanımlayıcı unsurlarını saptamak için teorik bir araştırma yürütülmüştür. Böylece, mekanın biçim ve strüktür sistemi üzerindeki biçimlendirici rolünü incelemek için mimari projelerin literatür tanımlarına göre kültür merkezi olarak tasarlanmış 10 örnek seçilmiş ve analiz edilmiştir. Analiz, iç mekân özelliklerinin dıştan algılanan formal kompozisyona ve kullanılan taşıyıcı sisteme yansıtılması durumunda dengeli, uyumlu, bütüncül ve etkili bir tasarım oluşturulduğunu göstermektedir. Diğer bir deyişle iç mekânın bir mimari projede projenin somutlaştırma unsuru olarak bir itici güç ve belirleyici bir role sahip olduğu görülmektedir. İç mekân odaklı bir mimari proje geliştirmenin projenin farklı katmanları üzerinden bütünleşik bir tasarımla sonuçlandığı anlaşılmaktadır.

Anahtar Kelimeler: iç mekân, form, strüktür, mimari proje, kültür merkezleri

DEDICATION

This Thesis is dedicated to

My parents (Majed & Laila)

My siblings (Saleh, Sameeh & saba')

&

My fiancé (Laith Hamad)

For their constant love and support

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This thesis took a lot of efforts from me but it could not be possible without the constant support and help from many individuals. So I want to express my sincere gratitude and thanks to them.

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I want to extend my gratitude to my family for their love and support. First I would like to acknowledge my appreciation and thanks for my father for his forever love and support. He always encouraged me to seek knowledge and made this opportunity possible for me. Also, great gratitude goes to my mother for her unconditional love and support. She always loved and believed in me. Next, I owe my brother Saleh an extreme appreciation and thanks for his encouragement, love, support, and guidance. Finally, I would like to thank my younger brother and sister, Sameeh and Saba', who without realizing support me in many ways.

I must mention and recognize the constant love and support that I have received from my fiancé Laith Hamad. A special gratitude and thanks for my life partner. He has been there for me throughout my research period with his constant patience, care, love, and encouragement to finish the thesis and reach this stage.

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INTRODUCTION

1.1 Background to the study

Historically, the design of space has been significantly developed according to users' needs and technological achievements. Since the start of 20th architecture, buildings became more formative and stylistic. Many architects created extraordinary designs due to the new materials and technologies during the 20th century onwards. Moreover, the appearance of a new understanding and expanding the various fields of architecture. The inside and the outside of the building have two hypotheses in architecture during the 20th century. First, the social program of the building meant to be recognized from the outside without the need for written discretion. Second, the exterior should also reflect the interior spaces and volumes formation (Schumacher, 2002).

The important standards during 20th century are the use of various materials and the structural balance. The 20th century comprehends many lessons from the Medieval Cathedral in both structure and construction. On one hand, building's perspective in terms of skeleton and skin. On the other hand, the function of the various parts should be distinctly emphasized. Many architects were aware of these ideas such as Frank Lloyd Wright and Le Corbusier. The composition between structural rationalism and functionalism is the new path in architecture. Moreover, structure became an essential feature during the 20th century. Each material represents an

individual form and structural equilibrium which create variety on formation for the buildings (Ford. 1996).

George Hersey mentioned this improvement in his book “High Victorian Gothic” using the phrase “Automatic Functional Picturesque”; he talked about the role of the size, decoration, situation of the door and windows in declaring their use. Hersey also mentioned William White and his work of the way he express the function using the volumes not only the façade (Hersey, 1973). On another argument, Hersey criticized a building in Oxford saying “from the exterior it is difficult if not impossible to obtain an idea of what the interior arrangement is, or what may be the object of the building”. And on his Royal Academy lecture, he discussed this phenomena “The construction of the exterior should, as far as possible, show the arrangement of the interior, and you ought at once to know something about the positions of the floors, the shape of the roofs, and the sizes and uses of the principal rooms, merely by examining the exterior of the building” (Schumacher, 2002).

1.2 Statement of the problem

The development in architecture during the modern movement created the idea that no need for more concerns on the architectural form and rather it can be focused more in functions. It claimed that form is just a consequence. On the other hand, the architects of 20th century onwards were influenced to create various creative forms. But during the late of twentieth century, the architectural elements of a form were only representing as signature for the architect and neglecting the function. The discovery of functionalism leads to disregard the form of the building. Functionalism became the role of any design by 1955. Elements of architecture were created for each design individually regarding the certain design and not being used for another project (Corona-Martínez, 2003).

The interior spaces in relation with form were treated differently during the 20th century. Architects have a conflicting attitudes at their designs concerning "the inside" and "the outside"; a group were not convinced in combining both in the design while the other group presented their work in which the exterior displays the interior organization. The relation between the interior and exterior is not on reflecting all the interior details on the exterior wall rather it's for the exterior be able to indicate the interior expression (Schumacher, 2002).

This research will investigate the role of interior spaces as the generator that defines form and structure since interior space was treated differently with the start of 20th century. The architects have conflict attitude to deal with the relation of space, form and structure with different thoughts and ideas. So, this research will focus to investigate the ability of space to be the defining layer in an architectural project and proven its ability to define form and structure.

1.3 Aim and objective of the study

20th century architecture has witnessed a unique and freely formation of buildings and this research will examine the role to maintain collaboration between space and form and structure in the light of architectural projects in order to investigate the generator role of "space". The aim of this theoretical research is to study the relation of interior spaces with form and structure in architectural design in the case of cultural centers dating back to 20th century onwards. This study will explore the significant to integrate interior spaces with form and structure in the same design. The thesis will benefit interior architects and architects in understanding the architectural elements and the relation between them to create a unique design as well as a strong united building.

This thesis will answer the main questions:

- Is the interior space is the core of the design?
- What is the relation of interior space with form and structure?
- Which element is more related with interior spaces?
- Is it important to have a relation between the interior space, form and structure?

1.4 Limitations of the study

The terms interior space, form and structure are introducing a wide and diverse fields of researches. These concepts were developed through the history and each one of them have an individual background that need to be studied more in order to understand their values in the design. And to study the relation between all of them will create a variety of perspectives. There are many aspects that this relation can be studied but this thesis was not able to cover all the aspects because of the given period. This thesis will study the characteristics of these concepts in terms of design and architecture but it will not consider different aspects such as materials, sustainability, technology, economics and any quantitative approach due to the available time.

This thesis will focus on 20th century onwards as time frame. During the 20th century, many fundamental changes were acquired and led to the current architecture which makes it an essential period to study

According to the different needs of users and emerged new functions, 20th century architecture have introduced new solutions and building types. Each type had its own way to design in terms of the scale of the project, number of users, private or public,

etc. In the scope of this study, a certain type of building has been selected to provide common background for comparisons and discussions. After conducting a research, the chosen type was cultural centers regarding their importance in the city and their value to present the cultural of that city with iconic architectural solutions designed by internationally recognized architects and architectural firms. However, cultural center is a new typological building in architecture which causes difficulties to select cases.

A research method that can be used for such research is observation. It could be valuable to visit the buildings of the case studies and observe the characteristics of these buildings. Observation will give a realistic experience; moving from outside to the inside and observe the different relations and sense the building's characteristics will give an important perspective to the research. But with the begun of COVID pandemic which started in December 2019 until the current time causes many restrictions on people's lives. Moreover, cultural centers and many other public buildings are limiting the visitors and they are not being used like in a normal case which will mislead the observer judgment. As a result of the above mentioned limitations, cases for this study have been selected by literature survey.

1.5 Methodology and organization of the study

To investigate the relation of interior space with form and structure, qualitative methods will be used to achieve the aim of this thesis. The methods are including the use of literature review and data collection for the case studies. A literature survey was conducted on the characteristics of the interior space, form and structure starting from the 20th century architecture. First, the major architects that have influenced 20th century architectural development with their different ideas on architectural space

and applications on various ways have been defined. Then, the various aspects of interior space, form and structure will be displayed to give wider perspective to determine the relations between them and the major characteristics of an architectural project. This will allow finding the connecting features of spaces with both form and structure. Above mentioned studies will lead to build or framework for the analysis of the selected cases in order to explore the role of the interior space in architectural project. Cultural centers interior space, form and structure relations will be analyzed and discussed.

Case studies method is essential for this research to study the relation of interior space with form and structure in built examples. The selection criteria of cultural centers cases are based on international and known buildings and also from different well-known architects. Selecting the cases went through different stages: first define the scope of the study which is starting from 20th century onwards (20th and 21st century). While searching for cultural centers, it understood that they are a new typological building; there are few buildings in 20th century and became much more in 21st century. The selected building are meant to be diverse in years of construction through 20th century onwards so the selection was to look for building in each decade and select centers. Then looking into the centers in terms of the architects who designed it and different and significant urban fabrics to study the cultural centers since is related to the city. Also, the selected cases wanted to be different in design from one case to another and in case of any similarity were chosen the most significant one between them. When the selection reaches to 10 case studies with diversity in architects, locations, urban fabrics, design and year of construction, it felt that they are efficient to study the relation. For each case studies, it will be analyzed

their interior spaces, their formation and their structure technique then it will be compared between these elements to figure if there is a relation between them and how they are connected. Next is to compare all the case studies together to create a better understanding on the relation between interior space, form and structure in the cultural centers. The analysis and discussions will bring new insights to the field and connect these findings to the international literature on the role of the interior space in architectural project.

The outline of this thesis is organized in 5 chapters, the first chapter which is the introduction chapter and the rest are the following:

1. Chapter1: This is the introduction to the thesis in which it displays a background on the study, statement of the problem, aim and objective, the limitation and the methodology and organization of the study.
2. Chapter 2: This chapter is the first part of the literature survey which it introduce the 20th century, to create an image of the development of architecture during this period. It represented many fundamental architects that developed the aspces of the architectural project of the 20th century onwards.
3. Chapter 3: The literature review is extended in this chapter. This chapter discusses the architectural project specification during 20th century architecture. It contains the different design elements, the interior space characteristics including plan, functions, space organization, etc., the form characteristics including the façade, form organization, free-form, etc., and the structural characteristics including defining the structure in architecture,

structural formation, etc. These elements were derived from the architects' discussion of the previous chapter.

4. Chapter 4: This chapter represents the various selections of case studies, criteria of selection and their analysis in terms of interior space, form and structure to investigate the generator role of the interior spaces to shape the form and structure and the discussed outcome.
5. Chapter 4: This chapter summarizes the outcomes and the conclusion of this thesis.

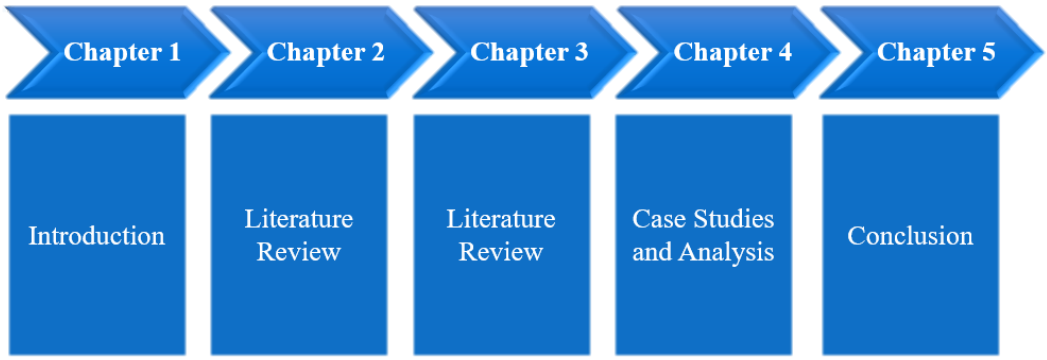


Figure 1: Organization of the study (Source: Author)

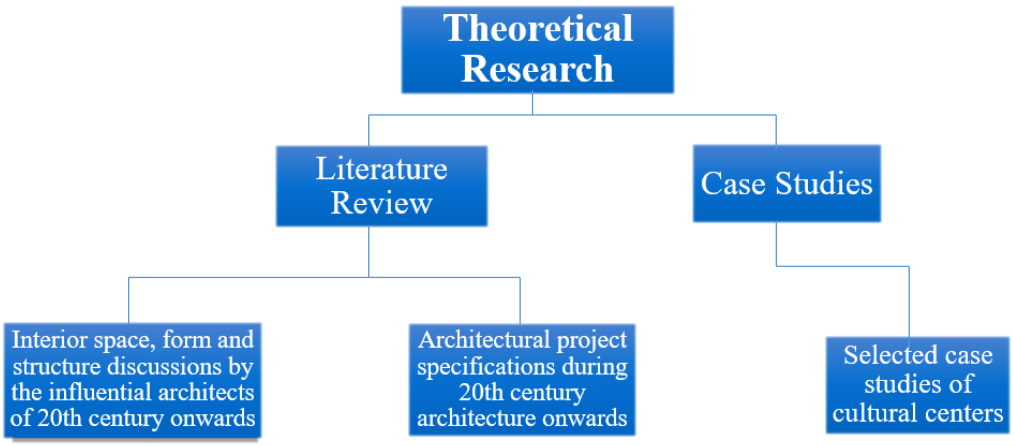


Figure 2: Methodology

Chapter 2

INTERIOR SPACE, FORM AND STRUCTURE DISCUSSIONS BY THE INFLUENTIAL ARCHITECTS OF 20TH CENTURY ONWARDS

In this section, the 20th century architecture with its development regarding space, form and structure will be defined. In the 20th century, the whole design ideas and process have changed and new aspects were introduced. The first half of the 20th century is consider as the revolution for modernism. The Beaux-Arts ideas were demolished and replaced by the Rationalist order. Mies van-der-Rohe referred to 20th century architecture as the result of the development through history which caused revolutions in architecture (Peter, 1994). The 20th century witnesses development in various technical elements and installations as well as progression in structural and materials studies. Also various subjects were grown in an individual manner (Corona-Martínez, 2003).

Twentieth century architecture was a transformation from depending on traditional designs to an investigation for design values to serve the society. The initial movement was by individual architects who originate individual thoughts and ideas. There are many significant architects and movements that are accepted as the founders and major developers of the architecture of the 20th century as mentioned by Johnson and Langmead in their book of Makers of 20th-Century Modern

Architecture: A Bio-Critical Sourcebook. Johnson and Langmead (1997) wrote the book as a reference that gathers the architects who influenced and developed architecture throughout 20th century. The book is outlining the life and innovative activities of the significant architects and their students whose proven their influence on 20th century by their ideas and buildings. Each architect had significant achievements in the field. The authors listed the fundamental architects during the 20th century by the decades that they have influenced the field most. However, the architects continued to present an influential work.

In this chapter Johnson and Langmead classification will be used to represent one influential architect per each decade of the 20th century onwards in order to define a fundamental frame of architecture development with diverse ideas and presentative project examples. Accordingly, studying the mentioned architects will build a comprehension frame on their influential ideas on the 20th century architecture onwards as they replaced the traditional architecture with new design perspective and thoughts. The selected architects are Frank Lloyd Wright (1900s), Walter Gropius (1910s), Le Corbusier (1920s), Buckminster Fuller (1930s), Louis Kahn (1950s), and Robert Venturi (1970s). However, according to Johnson and Langmead (1997) the architects and designs during 1980s reflect styles and acknowledgment based on the previous ideas of the century with few newly philosophies. Also during 1990s, architects reflect the same ideas with innovative individual design (Johnson & Langmead, 1997).

2.1 Frank Lloyd Wright (1900s)

Frank Lloyd Wright is a well-known architect during the 20th century architecture. He was inspired by Viollet-Le-Duc book which is Entreaties Sur L' Architecture

(Wright, 1932). Although, in Wright's designs there is no reference to Gothic style regrade structure or program. But he points out the essentials of Gothic style in terms of simplicity (Ford, 1996). Even though, Wright admitted the effect of Gothic Cathedral and Viollet-Le-Duc on his designs. He said that Viollet-Le-Duc was his master; in which he allowed him to not follow the principles of Ecole des Beaux-Arts (Collins, 1959).

Frank Lloyd Wright believes that a house character comes from the interior space. As he said in his book that when describing a house he refers to its exterior; the exterior is reflection to what is inside (Wright, 1932). Wright considers spaces as an independent element; this leads to a significant architectural development from a rigid box to a free plan (Wright, Kaufmann, & Raeburn, 1967).

As McCarter (2005) maintained the essays that was written by Frank Lloyd Wright. Wright wrote a series of essays under the name of "In the Cause of Architecture" during 1927 and 1928. On his easy "The logic of the plan" (1928), wright discussed the "the fundamental shared principles underlying all great architecture". The essay highlights the significant of the plan, in which the plan's domain includes the beginning and the end of its development in all directions. Wright believes that the ground floor plan is more significant than any other feature. His argue that the way to judge an architect is by his ground plan. Wright described the plan in his essay as "A concept in some creative mind"; a plan is a reflection on the concept which represents the creativity behind an architect. Also he wrote about how a building can reconstruct by only saving its ground plan (McCarter, 2005).

Frank Lloyd Wright wrote in 1908 in the “Architectural Record”; “In laying out the ground plans for… these buildings a simple axial law and order and the ordered spacing upon a system of certain structural units definitely established for each structure in accord with it scheme of practical construction and aesthetic proportion, is practiced…and, although the symmetry may not be always obvious, the balance is usually maintained.” Wright also declared “all the forms are complete in themselves. This tendency to greater individuality of the parts emphasized by more and more complete articulation will be seen in plans of Unity temple.” (Wright, 1928). His thoughts oppose the Beaux Art principles. On the other hand, his buildings show an independency in space and structure in the compositional units (McCarter, 1997). It leads to his philosophy of organic architecture which stated that architecture drives form the natural environment. Also it introduces the concept of having harmony relation between the building’s parts and unites them all as one. The organic architecture considers the building as an organism and each part of that building is part of the organism in which they should work together (Wright, 1954). As Organic architecture reflects the natural environment it’s important to consider the time and place of the designed building; the building should grow naturally form the site. The materials of this style consider natural elements such as, water, natural lighting, etc. (Zevi, 1950).

Wright mentioned the role of “room” concept as it’s the starting element of architecture in combining the interior space with the exterior volume. He stated “the room within is great fact about building – the room to be expressed on exterior as space enclosed. This sense of the room within … is the advance through of the era in

architecture" (Wright, 1928). Also Wright used the square and cubes in his work and he considers it as a timeless geometry (Ronner & Jhaveri, 1987).

Wright created an enormous number of considerable buildings that influenced many other important architects. For instance, the Larkin building; was completed in 1906. This building was recognized in its functions, construction, services, geometry and moral progression. The spaces in the plan were distributed from inside to outside; starting with the main function which is the offices in the atrium and placed the rest around it (McCarter, 1997).

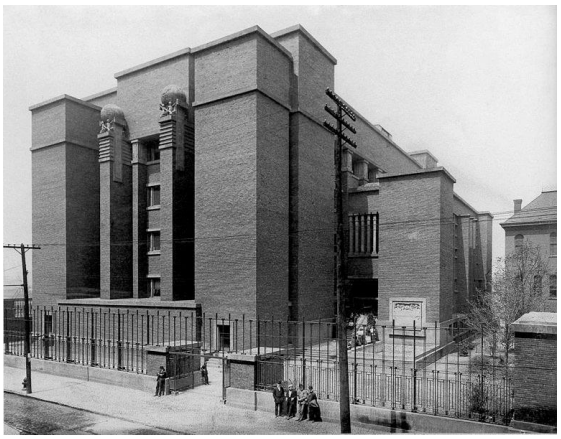


Figure 3: Frank Lloyd Wright Larkin building, 1902-1906 (De Long, 1998)

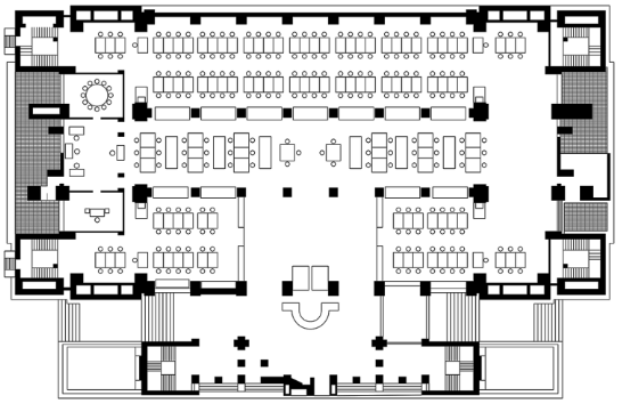


Figure 4: Frank Lloyd Wright Larkin building plan (Gou, 2017)

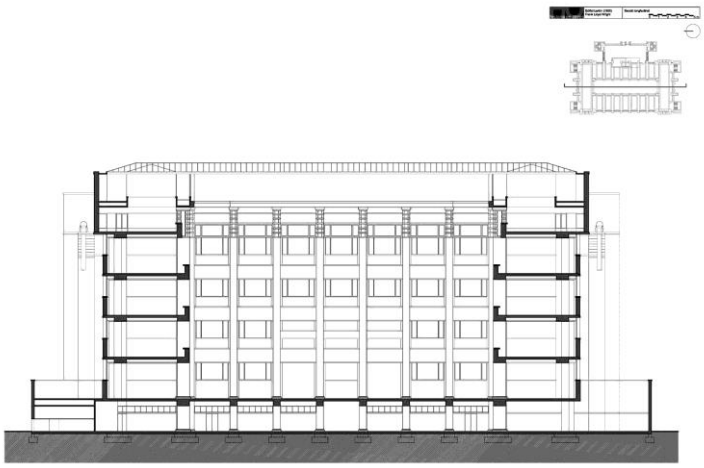


Figure 5: Frank Lloyd Wright Larkin building section (URL1)

Wright locates the stairs and ventilation towers around the corners which influenced Louis Kahn in his theory “servant and served spaces” (Rabifard, 2011). The structure of brick and concrete that wright used for the building helped in locating the stairs and the shafts (Wright, 1932). The plan to section relation in Larkin building reflects Wright’s creativity in dealing with the cube form. The plan shows the main part of the building as two squares, which in section they represented as a two squares office floor. Piers in the plan are located 4.85m on center which in the section it created a square with 4.85m high. Otto Graf once commented on the spatial formation as “a fugue on theme of cube”; Wright developed various characteristics of the building by only the use of square and cube. Including the space, plans, sections, elevations, furniture, ornaments and so on (McCarter, 2005). Wright used a modular grid in his work which he used a certain geometric form in repetition. MacCarter (1997) mentioned that his method was used for formal and economical design. Also Walt Whitman, a nineteenth century poet, wrote a poet using the cube metaphor which inspired by wright use of the cube; “chanting the square deific, out of the one advancing, out of the sides. Out of the old and the new, out of the square entirely divine, solid, four-sided, all sides needed” (Whitman, 1982).

So regarding the above descriptive following is a conclusion summarizing Frank Lloyd Wright thoughts on space, form and structure: Wright from his philosophies and applied wok, as shown, he developed various ideas in many aspects in design which mostly they related to space and form in an architectural project. Regarding the space, his philosophy that space is an individual element that leads architectural development. Also, he claims that a building character comes from the interior spaces. As he discussed "the logic of the plan" in which it contains the features for developing a project. Another concept is the "room typology" which link between space and exterior volume. And for organizing space he used a modular grid. On the other hand, regarding the form of the project, he argued that the exterior is a reflection of the interior and it can be seen in the plan. Also, he believes that form should follow the natural environment and the site. So he developed the concept of organic architecture which meant to unite the different parts of the building together. Moreover, he is against complications but believes that a cube can reflect various significant designs.

2.2 Walter Gropius (1910s)

Walter Gropius is the originator of the Bauhaus art school and one of the few who discussed the rationalism of modern architecture. Gropius aimed to develop thoughts and ideas regarding various industrial logics. His work includes originated ideas of flexibility of construction and assembly line process in which both reflect the rationalism of design process (Seelow, 2018).

The school of Bauhaus is a school of fine arts and crafts which created between 1919 and 1933. The manifesto of the Bauhaus stated for "the unification of all the creative arts under the leadership of architecture". Gropius combined both art and mechanism

of industry for the aim to elevate the level of design's product. Also in educational platform, he believed that a building is collaboration between art, architecture and design rather than individual studies. The school taught the students various design elements such as "design size, shape, line, color, pattern, texture, rhythm, and density". These aspects were transferred and taught throughout the world in which they lead for advanced objects of form and materials. Gropius conveyed the idea of designing a project must follow "systematic practical and theoretical research into formal, technical and economic fields" (Johnson & Langmead, 1997).

The Bauhaus focused in the harmony in artworks and crafts with authentic arts which represents aesthetic in different levels from furniture to urban level (Johnson & Langmead, 1996). In which it tries to keep a unity between art and industry. Industrial and mass production and it aesthetics were redefined by prefabricated elements that used for building in the Bauhaus school. The philosophy of Bauhaus school has been focusing in the function first then form. The buildings in this style during the modern architecture were designed with light structure, and the constructed materials are glass, steel and concrete (Nia & Rahbarianyazd, 2020). As Nia & Rahbarianyazd (2020) mentioned, the architectural characters of the Bauhaus school are "- Order, regularity, and the sense of space, rather than mass predominated, Free-plan interiors, and Use of concrete, glass and steel; stark white cubes".

Gropius (1932) in his article of "The Theory and Organization of the Bauhaus" stated the analytical design process of the Bauhaus school regarding architecture as following: "The objective of all creative effort in the visual arts is to give form to

space. … Although we may achieve an awareness of the infinite we can give form to space only with finite means. We become aware of space through our undivided Ego, through the simultaneous activity. … This conception of space demands realization in the material world, a realization which is accomplished by the brain and the hands of soul, mind and body". The brain refers to the mathematical space and hand refers to the physical tools and machines. "True creative work can be done only by the man whose knowledge and mastery of the physical laws of statics, dynamics, optics, and acoustics equip him to give life and shape to his inner vision. In a work of art the laws of the physical world, the intellectual world and the world of the spirit function and are expressed simultaneously" (Gropius, 1932). Also Gropius mentioned in his article the principles of the Bauhaus school as "the idea of creating a new unity through the welding together of many `arts' and movements: a unity having its basis in Man himself and significant only as a living organism". He believed that "Human achievement depends on the proper coordination of all the creative faculties. It is not enough to school one or another of them separately: they must all be thoroughly trained at the same time. The character and scope of the Bauhaus teachings derive from the realization of this" (Gropius, 1932).

Gropius had to relocate his school to Dessau. He designed a new building which is an asymmetrical composition (1925 – 1926). It includes various blocks for the different parts of the school and they are connected with each other. The blocks contain the school features like administration, offices, classes, etc., and housing for students and the stuff. This building symbolizes the concept of Bauhaus style of modern architecture (Johnson & Langmead, 1997). As shown in the following figures, the building consists of three parts connected with a bridge in which it's a

two story of administrative offices. Gropius designed this school with structural progression as a reflection of his ideas on architecture and for the students, for instance, the use of glass windows, curtain walls, and concrete material throughout the facade. The curtain walls are an important integration part of the building affording a transparency and a new architectural mechanism. Moreover, the exterior appearance and façade of the building is differing from each other according to the various function of each part.

Figure 6: Walter Gropius Dessau Bauhaus, 1926 Arial view (URL2)

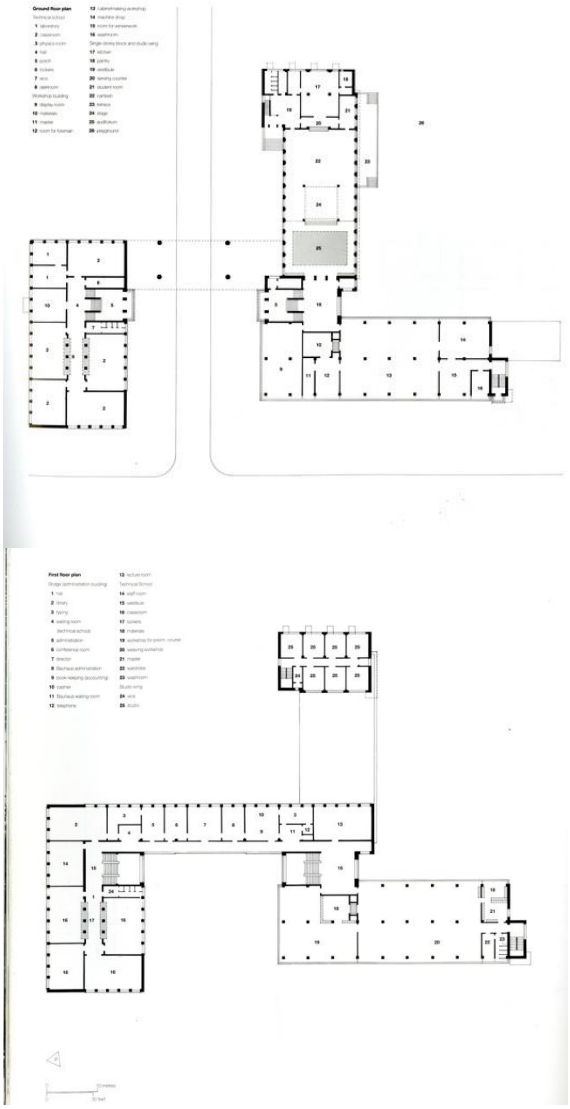


Figure 7: Dessau Bauhaus ground floor plan (left) second floor plan (right) (URL2)

Figure 8: Dessau Bauhaus interior view (URL2)

So regarding the above descriptive following is a conclusion summarizing Walter Gropius thoughts on space, form and structure: Gropius originates the Bauhaus school which he reflects his ideas on art, architecture and design for creating new concepts. He believes in the importance of combining both practice and research for architecture which he had various ideas regarding space, form and structure. Gropius taught his student the importance of collaboration between design elements for advanced form and materials. He considers the different levels of designs from furniture to urban. In terms of space and form, his philosophy was that function defines form. Also he believed in the importance of maintaining sense of space and provides free-planning rather than mass domination. Moreover, he argues on creating a unity between the various features which creates the character of the design. Finally, for the form to be capable of following the space, he developed light structure for example the use of curtain walls.

2.3 Le Corbusier (1920s)

Le Corbusier is one of the most considerable architects and architectural writers during the twentieth century. His architectural works had a major influence on creating the new aesthetic of architecture. On the other hand, his writings were important in architecture; he developed a writing style called “epigrammatic clarity” and wrote his book “Towards a New Architecture”. In his book, he wrote “A house is a machine for living in” and “Architecture is the correct and masterful play of forms brought together in the light” (Rabifard, 2011). Also, he maintained in the book the importance of the idea of “the plan is the generator” and discussed the idea of “Architecture is based on axes” (Le Corbusier, 1927, p.45). As he describing the “Three Reminders to architects” which they are mass, surface and plan. He believes that since architects are no longer creating art but they are using calculations and

mathematics work to create forms. He reminds architects with simpler forms and more meaningful. Surface in which a mass needs a surface. The surfaces are determining by the formation of the mass and how it divided. Architects worries about geometrical surfaces and in modern architecture each problem must solved with geometrical solution. Plan which as mentioned it's the base. The plan for Le Corbusier is the essence of the design. The modern architecture demand a development in the plan but it must consider the importance of the plan in the design (Le Corbusier, 1986).

Moreover, in his book he described creating forms as if the material of a building, like using stones, can speak and send a certain message on the mood and thoughts of the architect. The materials are what used to build building and the architect control the use of them. The materials will shape a harmonious relationship and create a form. As he stated "you employ stone, wood and concrete, and with these materials you build houses and places; that is construction … This is a thought which reveals itself without word or sound, but solely by means of shapes which stand in a certain relationship to on another. These shapes are such that they are clearly revealed in light. The relationships between them have not necessarily any reference to what is practical or descriptive. They are a mathematical creation of your mind. They are the language of architecture. By the use of inert materials and starting from conditions more or less utilitarian, you have established certain relationships which have aroused my emotions. This is Architecture." (Le Corbusier, 1923).

Le Corbusier was leading many other architects. He supposed that new modern architecture required new demands from the architects, and presented new materials

which lead to a new aesthetic in architecture (Doordan, 2001). In regards, many architects influenced by Le Corbusier works and tried to express their work in new forms (Rabifard, 2011). Colin Rowe mentioned that the design strategy that Le Corbusier mostly followed in making form was abstraction. His buildings represent a folded appearance as if it above the ground. It's noticeable in his building the way he works with the mass and solid (Doordan, 2001). Le Corbusier generated five points in creating a new architecture. These points were influenced many architects. The five points are "(1) the structural-formal idea of 'pilotis' (2) the roof terrace (3) the free plan (4) the free façade and (5) The Ribbon or horizontal windows" (Rabifard, 2011). Moreover, Le Corbusier introduced a new structural system called Domino or Dom-ino. This system is created from reinforced concrete structure with columns, slabs and stairs (Millais, 2005).

Le Corbusier works reflect his believe of the outside is the result of the inside. Henry-Russell Hitchcock (1948) mentioned that Le Corbusier stated that "A building is like a soap bubble. This bubble is perfect and harmonious if the breath has been evenly distributed and regulated from the inside. The exterior is the result of an interior" (Hitchcock, 1948). Since 1920s, this "Soap bubble' metaphor inspired many architects. They used it for both repetitive and hierarchical buildings. For instance, the repetitive buildings will present a repetitive façade which will project repetitive in the interior. Moreover, Function and space got a relation with the exterior in Le Corbusier work (Schumacher, 2002). In Le Corbusier work, its noticeable his use of geometry are proportion. He believed in the importance of proportion and Golden Section in the design (Rabifard, 2011).

The building that most influenced Le Corbusier principles of architecture especially in terms of space is the Villa Savoye. The villa is cubic geometrical form standing on pillars for the aim to provide sun lights for the interior. The exterior ways were designed with large openings of glass to combine interior with the exterior and create connections. The interior space combines both stairs and a ramp for improving movement between the floors and the facilities. Also the villa reflects the use of free-planning in which it provides freedom with the use of partitions and larger spaces. Free- plan created a transparency from the façade though the whole interior space which built a strong connection between them. I maximize the internal natural light and the connection with the environment of the Villa Savoye. And as for the structural system, the villa is using the Dom-ino system that he developed (Gudkova & Gudkov, 2017).

Figure 9: Le Corbusier Villa Savoye, 1923 (Gudkova & Gudkov, 2017)

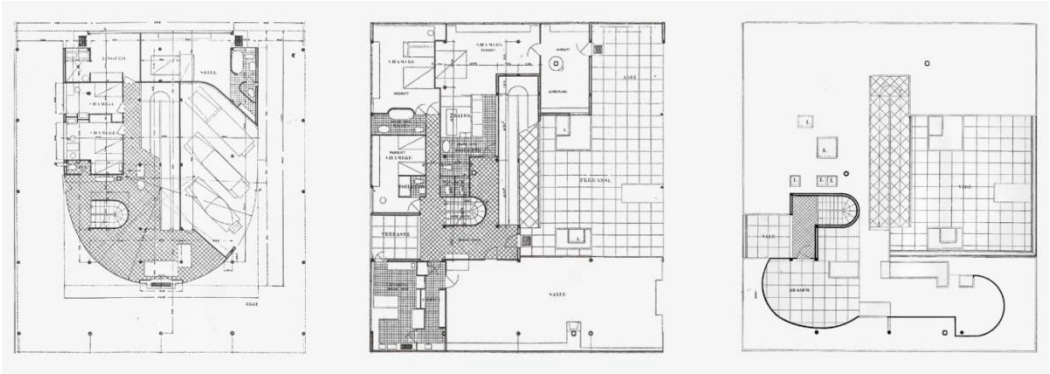


Figure 10: Le Corbusier Villa Savoye, floor plans (URL3)

So regarding the above descriptive following is a conclusion summarizing Le Corbusier thoughts on space, form and structure: Le Corbusier is an architect and writers which they consider references on new aesthetic of architecture for designers and architects. He has many philosophies in terms of developing space, form and structure. On terms of space, he believed that the plan will generate a design and architecture is based on the axes. Also he had a philosophy that outside of e building is the result of the inside and created the “Soap bubble” metaphor; as the function and space are recognized on the exterior. He argued in the importance of three elements: surface, mass and plan and their relationship. In terms of forms, Le Corbusier argued in the importance of simpler forms. He also claims that an architectural problem can be solved with geometrical solution in either space of form. Another aspect is the used material in which it may define the formal appearance. On the other hand, he summarized five points that an architect can follow to create a new architectural design. Regarding structure, Le Corbusier developed a structural system, Dom-ino, which considers the slandered system for buildings.

2.4 Buckminster Fuller (1930s)

Fuller is an architect and also he is a "writer, inventor, engineer, mathematician, philosopher, poet4, futurist, teacher, cartography and resource expert". His work centered on solving the main issues of 20th century and developing a future with rational thinking (Spreiregen, 1975). Fuller (1998) stated that "In his generalized definition of architecture he resolved the concrete and the abstract without regard to aesthetics. Architecture is the organizing of macrostructures from microstructures". He also argued that architects are no longer more than an "exterior decorators" (Fuller, 1998). Fuller's studies were mainly on structure; the gravity resistance and the enclosed spaces. He aimed for less used materials and more tensile materials which lead to longer spans for wide spaces. He introduced light structures, the use of space frames (trusses) and invented the Unistrut system which provided more flexibility in creating the desire spaces regardless the scale or design concept (Johnson & Langmead, 1997).

Fuller get the public attention with his creation of "geodesic dome" in 1940s. He used mathematics to work on engineering techniques, he called it "tensegrity" which its "tensional integrity". It's a large scale implementation with tension elements. It's mostly a series of triangular shape elements which disrupted the weight across the structure and provide free space for the interior. The dome where used onwards; he designed a 70 meter high dome for New York's Manhattan Island. Also in 1970s, The dome was used to cover a floating city with one million inhabitants. This idea represents the collaboration between architecture and engineers (Johnson & Langmead, 1997). As Harvard (1969) stated that "triumphant vindication of this

engineer-architect whose ideas of construction and design threaten to make most modern architecture obsolete".

Dymaxion house is a proposal for a hexagonal house in 1929 by Fuller. Fuller stated about Dymaxion's concept as "constructing ever more with ever less weight, time, and ergs per each given level of functional performance" (Fuller, 1998). The ground level is an open plan and the house is in the upper level. The floor and the roof were supported from the edges with wires connected with the central mass. It's an aluminum building contains of 200 pieces and weight 2721.5 kg. On the other hand it can be moved anywhere (Johnson & Langmead, 1997).

Figure 11: Geodesic dome, 1954 (URL4)

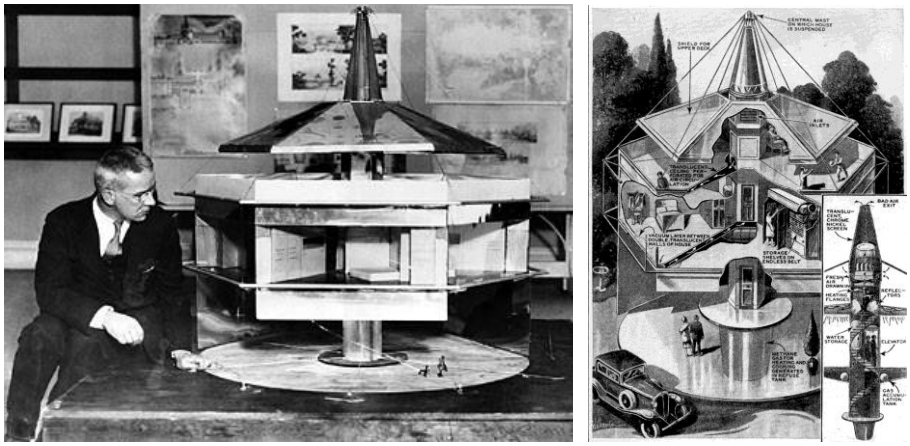


Figure 12: Dymaxion house proposal, 1929 (URL5)

So regarding the above descriptive following is a conclusion summarizing Buckminster Fuller thoughts on space, form and structure: Fuller is known as an architect but he majored in various fields. His ideas and philosophy were mainly concerned structure and engineering techniques which they expanded space designs. He believed that architects are more in the exterior decorations and he worked in resolving this issue by developing structural techniques regarding the aesthetics of designs. His structures have a relation with space. He aimed for providing longer spans for containing large spaces with the use of space frame systems and lighter materials. Another major achievement is his innovation of "geodesic dome" which was applied for various designs. Also, his idea of Dymaxion house offer less weight, time and efforts.

2.5 Louis Kahn (1950s)

Louis Kahn is a professional architect, poet and philosopher. Kahn applied both philosophy and science in his designs. Kahn believed that architecture is kind of art where the user can walk around and through, and interact (Louis Kahn, 1972). Architecture meant for Kahn is the way a building is being build and the spaces organization which relate to the users experience. (Rabifard, 2011). Louis Kahn's design was subjected on creating a dynamic balance rather than symmetry. According to Brownlee and De Long (1991), Kahn designs were insufficient implemented. On the other hand, he builds his experience for the modern architecture by practicing with non-axial planning during 1930s and 1940s (Brownlee D & De Long D, 1991).

He created an applied various concepts in his work including "Order", "Institution", Silence and Light", and "Servant and Served spaces". These concepts are the results

of his understanding design in culture; the relation between form and structure and between form and function. Form for Kahn was an idea of "metaphysical and inspirational insight" in creating physical elements. This insight is served the design for both function and structure with the use of new structural systems and new materials. "Order" concept of Kahn is a guiding standard for his designs. His aim was to find a single standard that can be applied to several aspects of architecture. Kahn did not mention exactly the Order but it's a fundamental aspect for all cultural artifacts and depends on cultural influence for a certain area. Order effect both exist and not-exists objects which it gives the not-exist the ability to come to being. "Although Order is an essential intuitive ability and basically indescribable Kahn could only therefore go so far as to say: Order is". Form is what reflects Order. "Institutions" concept is an understanding of what a building offers in the manner of form. It represents the human desires by contemporary forms. Kahn's philosophy of architecture is the reflection of human institutions through experiencing forms. The form or the building is always an institution for a certain service that created for the desire of culture. "Silence and Light" concept is the source for human for discovering self-expression. Silence represent the not-exist things and Light represent to the exist things. The balance between silence and light is a creative approach which involved architects and artists in which to bring silence into light, from imagination into realization. Kahn believes that the world is a material insight reflection. Finally, the "Served & Servant spaces" concept; Kahn argued that it's not sufficient to just work with the functions and spaces' program of the building but to find the potentials of space. Space is divided into services and serving needs (Rabifard, 2011). Kahn created this concept based on his argument that "It is disgraceful not to supply needs, and it goes without saying that if you are brought

into this world, your need must be supplied. But desire is infinitely more important than need" (Kahn, 1973). Servant spaces include circulation, structure and mechanical system. Served spaces are where people experience the form (Rabifard, 2011).

Structure for Kahn is mainly about providing and controlling lights in the space; he believes that light will create an identity for the space. Kahn argued that "structure is the marker of light. A column and a column bring light between them. It is darkness-light, darkness-light, darkness-light, and darkness-light. In the column we realize a simple and beautiful rhythmic beauty evolved from the primitive wall and its opening" (Kahn, 1969). Kahn used in his designs both structure and nonstructural elements. He believes that "when the building stands complete and in use, it seems to want to tell you about the adventure of its making"; so the structural and nonstructural elements are distinguishable in the design. It must reflect its whole creation and its function in the design must be clear (Komendant, 1975).

An interesting example of Louis Kahn is the Salk Institute for Biological Studies in California. It considers as a major significant structural design which consists of two symmetrical buildings separated with a water flow in the central plaza. Kahn first tried to experience different materials to study the result in various cases. Finally he decides to create the building using concrete material without any layering or painting. Also the designs of the two building are without separated walls between the laboratories. The wide free plaza between the buildings considers an impressive design element of space. The symmetrical design refers to science accuracy. Also the building offers an access for natural lights which create an experience for the space.

For accommodate such science functions and research facilities, the building present stability between balance and dynamic of repetitive design. Moreover, the walls of the building are diagonal which provides the scientists spaces a view of the pacific.

Figure 13: Salk Institute for Biological Studies, 1959 (URL6)

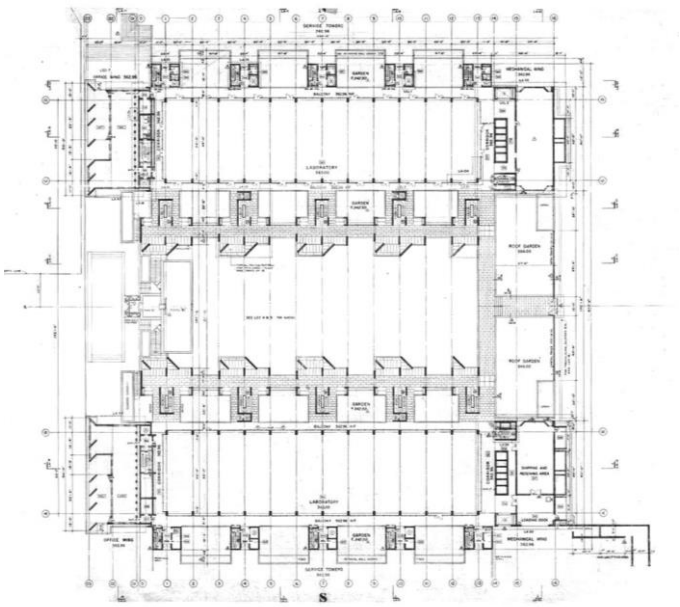


Figure 14: Salk Institute for Biological Studies, floor plan (URL7)

So regarding the above descriptive following is a conclusion summarizing Louis Kahn thoughts on space, form and structure: Kahn is a professional architect which he applied both philosophy and science in design. He had various according to form and structure but most important his ideas were mainly related to form. Kahn studied buildings in terms of what people's needs and the answer revolves around form. Regarding form, he discussed four concepts that as shown they are directly related to from and constructed dimensions which they are order, institutions, silence and light and serve and servant spaces. Kahn focused in the importance of form and described the various aspects with relation to form. He connected the ideas of space, programs, activities and more with the relation of form as it's where people move and interact. Kahn philosophies where more formative in designing a project. On the other hand, in terms of structure, Kahn believes in creating structures that provide light experiences in the space. The structure will build a dark-light relation. Kahn mostly concerned about creating adventures through the design of space by form and structure where functions will be defined.

2.6 Robert Venturi (1970s)

Robert Venturi is a post-modern architect and wrote his book, "Complexity and Contradiction in Architecture", which is the first book about post-modern architecture published 1966 (Doordan,2001). Vincent Schlly mentioned that the book is one of the important books in architecture after Le Corbusier (Scully, 1992). Venturi in his book stated that, "Architects can no longer afford to be intimated by puritanically moral language of orthodox Modern architecture. I like elements which are hybrid rather than "pure," ... I am for richness of meaning rather than clarity of meaning; for the implicit function as well as the explicit function. I prefer "both-and" to "either-or". Black and white and something gray, to black or white. A valid

architecture evokes many levels of meaning and combination of focus; its space and its elements become readable and workable in several ways at once" (Venturi, 1966). Venturi also mentioned in his other book with Scott Brown and Izenour (1977), Learning from Las Vega, that "Many architects find the vernacular of the middle class of America to be so repugnant, distasteful, and unappealing that they have a difficult time in examining it open-mindedly to discover its true functionality" (Venturi et al., 1977). Users prefer the building to reflect a symbolic value that they can recognize. In which Venturi release architecture from staleness and rigidity. He built an understanding to accept variation and differences in design; to provide a design that follows the site or has double coding of traditional and modernism in a way that the structure will remain readable (Kahl, 2008).

Venturi had several concerns in the formal presentation of buildings and neglecting public participation with architecture. He has various contributions for instance windows designs can be vary but connected to the landscape. His designs create a strong connection between functionalism, site and texture and material of the building. He did not relay on aesthetic as a much as the other aspects (Johnson & Langmead, 1996). Venturi mainly starts his designs from the site and accepting the given. Also he believed that a successful project symbolize the certain region; by studying the society, native techniques, styles, constructions and material in that region (Hoeveler, 2004). Venturi used a concept in his designs which is the "layered spaces". He inspired it from Armando Brasini, Italian architect, and it had a historical background. "Layered space" refers to the use of layers of architectural walled and they can be inside each other or behind each other. Their purpose is to provide shade for interior spaces and warm climate (Scully, 1992). Another aspect of Venturi's

design was his perception of façade; he argued that façade are not merged enough with the building. So he used different material and textures in the façade (Owens, 1986).

Venturi in the book, he mentioned his ideas to design his mother's house; his mother asked him to design a house which he used to build a statement. Vanna Venturi House became the first building of postmodern architecture is located in Chestnut Hill, Pennsylvania. Venturi designed the house with the application of his designs ideas. He designed a symmetrical facade to balance fenestration, the arrangement of windows and doors, and chimney disposition. Also he used techniques like shifts in scale and wood molding to be able to read the composition in various possibilities (Doordan,2001). The entrance is located in the middle which emphasizes the symmetrical in the building. However, the windows designs are different according to the function of the space. As the fireplace is the main feature of the house, the stairs are located with the fireplace. The fireplace and the stairs are both vertical elements which merged in the design and it reflected on the exterior as large scale chimney.

Figure 15: Vanna Venturi House (1959-64) (URL8)

Figure 16: Vanna Venturi House, interior view of stairs and fire place (URL9)

So regarding the above descriptive following is a conclusion summarizing Robert Venturi thoughts on space, form and structure: Venturi is the founder of the postmodern architecture in the 20th century. He believed in hybrid and rich designs that interact with the community and society. He developed various ideas related to space and form for providing readable and workable buildings. In terms of space, the function of the space is being reflected on the exterior; it determined the different feature of the façade of the building. Also, he created "layered space" concept; creating two layers of walls to provide shading and warm climate. In terms of form, Venturi preferred to create a design with a symbolic values represent the users and their region; using native styles, textures and materials. The design of the building must follow the site conditions and different styles. The façade needs to be more integrated with the building in which it depends on the functions and using different textures and materials for stronger design.

2.7 Conclusion

Twentieth century had introduced new perception in architecture in various fields. Many architects studied and discussed the importance of developing architecture from the previous traditional styles to create more integrated designs with the users and the different architectural aspects. Table 1 is a caparison between the architects

in their different fields of thinking. The table creates a framework for the different aspects of an architectural project which is extended in the next chapter for further analysis and the base for analyzing the architectural projects.

Generally, they were discussing three different aspects in designing a project: space, form and structure. The architects' perspectives of these aspects were the base of the 20^{th} century architecture onwards which they discussed the importance behind them in design.

Table 1: Analysis on the architectural and interior architectural elements which developed by various architects during the 20th century: Source: author

	Space			Formal appearance				Formative Structure
	Interior spaces	**Plan**	**Function**	**Exterior**	**Form**	**Geometry**	**Urban/Site**	
Frank Lloyd Wright (1900s)	- Organic architecture: harmony and unity - Create the house character	- Generate the design - Ground plan reflects creativity - Ground plan link the outer space with the interior space - Define the spacing with the structural system - Room concept connects interior space with exterior volumes		- Outside reflect the inside	- Organic architecture: Forms inspired form nature	- Mostly square and cubes - Modular grid	- Organic architecture: the building is growing naturally from the site	

Walter Gropius (1910s)	- Bauhaus: sense of space	- Bauhaus style: Furniture - Free-plan interiors	- Function is the base of the design		- Follows function	- Mostly asymmetrical	- Bauhaus style: Urban study	- Light structure
Le Corbusier (1920s)	- Interior spaces are related to the exterior	- "The plan is the generator" -Free-plan	- Function is related to the exterior	- The Ribbon or horizontal windows - Free façade - Repetitive façade - Façade is display on the internal spaces - The outside is the result of the inside	- Forms created using calculations and mathematics - simpler forms and more meaningful - The form is created from the harmonious relation between the materials	- "Architecture is based on axes" - Geometry solved modern issues - Geometry is proportion		- The structural-formal idea of 'pilotis' - The roof terrace - Dom-ino system

Buckminster Fuller (1930s)					- Geodesic dome			- Mostly focused in structure - light structures space frames and he invented the Unistrut system - Geodesic dome - Dymaxion house
Louis Kahn (1950s)	- Servant and Served spaces - Space organization relation with users	- Non-axial planning	- Developed the idea "metaphysical and inspirational insight" which serves function - The idea of function must reflects in the design		- Form foe Kahn is where a design begins - Form define structure	- Dynamic balance	- Providing and controlling lights in the space	- Developed the idea "metaphysical and inspirational insight" which serves new structural systems - Provides balance and order between spaces

Robert Venturi (1970s)	- Readable spaces - Layered spaces		-Function creates forms and façade	- Symbolic façade -Native materials and textures	- Follow function -Follow site -Symbolic values -Different styles in one	- Hybrid -Richness	-Building integrated with site	

Chapter 3

ARCHITECTURAL PROJECT SPECIFICATIONS DURING 20TH CENTURY ARCHITECTURE ONWARDS

Architects of twentieth century used to reflect a certain language to the exterior and they realized the importance of maintaining a connection with the internal spaces. Architects developed the perception of space, volume and structure; they gave each element an independency in creations which allow improvements in plan organization, making of rooms, expressions and the design of the façade. On one hand, it conducted to the appearance of free-plans, free-flowing space and free façade (Rowe & Slutzky, 1963).

An analysis was conducted on the influential architects of 20th century onwards to summarize their perceptions of design elements in different fields of architecture and to understand their ideas of space, form and structure (fig 15). These different fields will be mentioned in this chapter with further study. The previous chapter shows the architects interest in space (interior space, planning and function), form (forming, exterior façade, site and geometry), and structure in building's design. This highlighted the significant terminologies and fields that the architects developed which built an understanding on the importance aspects to construct and design a building that serves the community and interact with the users. The architects had different ideas on their relation and each had a different perspective on the most significant aspect related to the others. Regarding, this thesis will focus on the

relation of space with form and structure (fig 16); the interior space characteristics and whether form and structure are related to them.

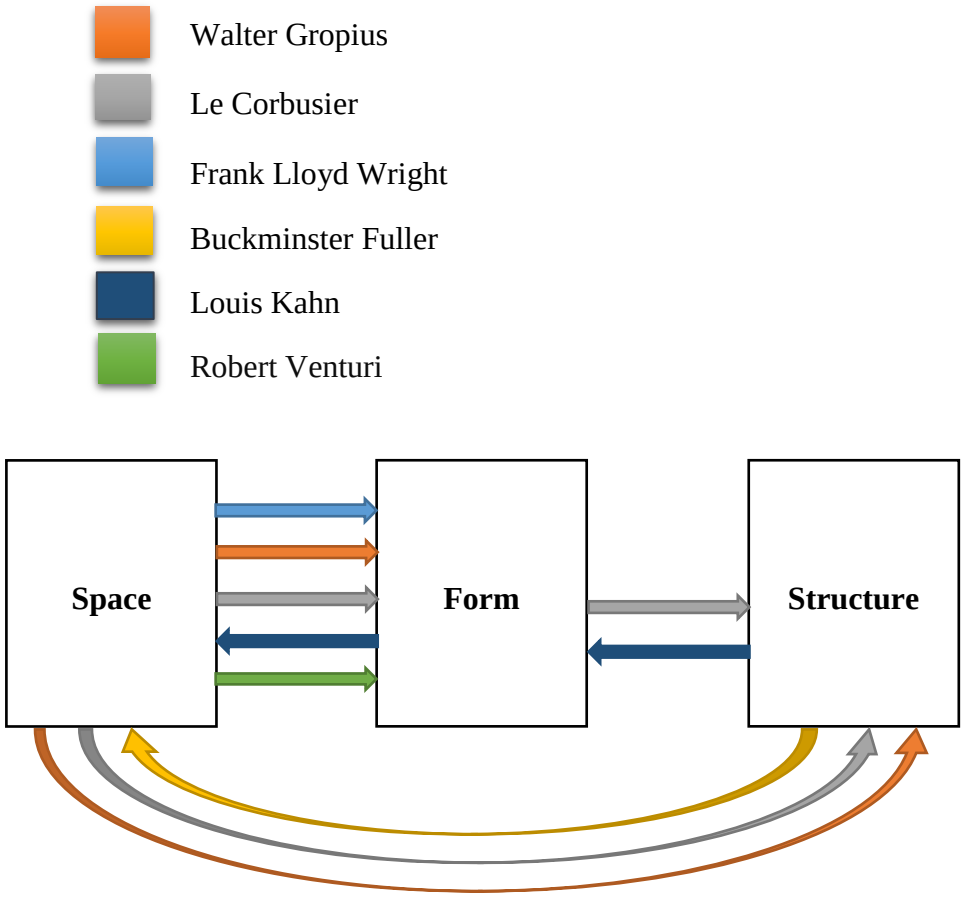


Figure 17: The relation between space, form and structure in the perspective of the selected architects (Author)

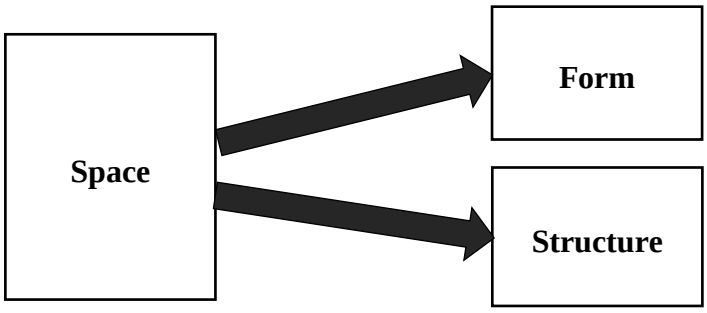


Figure 18: The studies relation in this thesis (Author)

3.1 Space in interior architecture

Space is a main element in interior architecture and consider as the motherboard for designers, interior architects and architects. It's where users move through, interact, and have different senses experience (Isaac, 1971). Space is an element which comes free and considers the most significant feature in interior architecture. Space in design is what creates volumes and experiences. Many architects tend to focus more in the physical elements like walls and floors and ignore the space, when space is what gives perspective to design. Space and boundaries and connection are together creating an experience (Furnell, 1998).

In the mid-twentieth century, the internal spaces role is to offer a standard for the exterior expression. Architects consider any diverse from this standard as a sarcastic deviation (Schumacher, 2002). In order to create a space, interior architects need to emphasize their spatial enclosure. The spatial enclosure harmonizes with the architectural elements. Elements including windows and doors perfectly indicate the interior spaces. Moreover, the details of the interior space, character that wanted to reflect, access to the space and the light and air circulation to the space (Corona-Martínez, 2003).

Spaces in interior architecture have various physical characteristics which rely on human's perspective and awareness. Characteristics include shape, size, entrances and exits, rooms and paths, dimensions and topography of rooms and paths, number of floors, light, surface's quality such as color, texture, etc., temperature, humidity, stability of floors, and others (Montello, 2014). Researchers suggested that architectural spaces are legible if they have three characteristics. The characteristics

are “differentiation of appearance, visual access, and layout complexity”. “Legibility” is a concept that creates a clear image of the place. The three characteristics serve people experience and route orientation. Moreover, they serve space layout, people’s ability to remember it, sense of space, sense of privacy, and spaces authentic and emotions. (Gärling, et al., 1986). First, the concept of “differentiation of appearance” indicates the various appearances of the parts of the building in terms of style, size, shape, color, etc. Differentiating between the spaces allow the users to distinguish and memorize them which in result create landmarks. Second, “visual access” is the ability to visualize the exterior and interior parts of the building from different locations. The users will be able to recognize directions, entrances, structural features and landmarks. A high visual access will maintain people’s orientation and comprehension. Third, “layout complexity” is not fully understood feature in architecture. Complex layout depends on the objective of the building, human perception and perception of each individual user. Geometric patterns create complex layout in various levels; straight and orthogonal paths are less complex than oblique paths (Gärling, et al., 1986).

3.1.1 Planning and geometry

Plan is a core element in an architectural design. Forms are created from the plan and inspired by the former architectural styles (Corona-Martínez, 2003). Le Corbusier (1989) stated in his book “Towards a New Architecture” that “The plan is the generator. Without a plan, you have lack of order, and willfulness. The plan holds in itself the essence of sensation. Modern life demands, and is waiting for, a new kind of plan both for the house and for the city”. The plan is the basic; the plan can provide richness to the building, shapelessness, various abilities, and order. The plan can serve any type of imagination and discipline. Architects give the plan a major

consideration because it's what defines all the other architectural divisions. The plan arrangement is like the rhythm of the building. The two-dimensional plan is the primary of the work; the work rises from the plan with height and the result can be either simple or complex (Le Corbusier, 1989).

Nathaniel Cortlandt Curtis (1923) in his book, Architectural composition, mentioned that the role of the plan is to determine the elements needed for the composition. These elements are separated from the elevations or facades but they must relate to them (Curtis,1923). Another writer had a similar opinion, Arthur Stratton (1925) in his book, Elements of Form & Design in Classic Architecture; A good design is when the plan being reflected on the exterior and the general outline of the building being brought to the plan (Stratton, 1925).

Geometry is directly related to mathematics which creates shapes and forms. Geometry are created from three main elements: Points, lines, space and planes. The basic geometric shapes are circle, square, oval, rectangular, octagon, parallelogram, trapezoid, pentagon, and hexagon. Free-forms are a modification of these forms. Shapes are these basic geometries and form is shapes with added height/depth. For example, the square is a geometrical shape and the form is the cube or cone. Architects use geometrical shapes and forms to originate all sort of new shapes and forms in buildings (Ching, 2007).

3.1.1.1 Regular geometrical plans

Regular plans are various parts connected to each other in a certain order. They are stable and symmetrical in one or more axes. The basic geometries of regular plans in 2-dimensions are triangle, square, and circle. Regality can be maintained even with

subtraction or additive transformation elements of the basic geometry (Faravar, 2010).

Basic geometries of a regular plan are triangle, square and circle. Triangle is a polygon with three sides and three corners. Square is a quadrilateral with four equal sides and four corners. It's a stable and static shape with no preferred side. All other quadrilaterals are variations of the square in terms of height and width. Circle is an arrangement of series of points in equal distance around a point. It's a stable and centralized shape. The circle can be attached with a angular or straight elements (Ching, 2007).

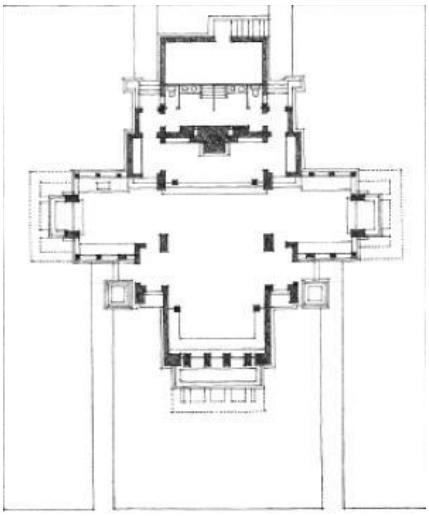


Figure 19: Example on regular plan (Ching, 2007)

3.1.1.2 Irregular peometrical plans

Irregular plan is an asymmetrical plan without any well-defined and consistent similarity. Asymmetry provides flexibility and dynamic for the plan design. The basic regular geometries are part of the irregular plans (Ching, 2007). The plans of the free-from architecture are mainly irregular plans. Free-forms include Blob, Liquid and Formlessness architecture. The main concept of these forms includes

curved lines and with fewer straight lines; their plans are mainly irregular with curved lines (Ghadim, 2013).

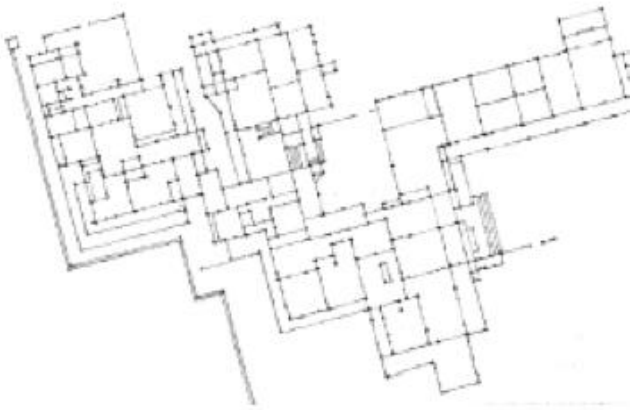


Figure 20: Example on irregular plan (Ching, 2007)

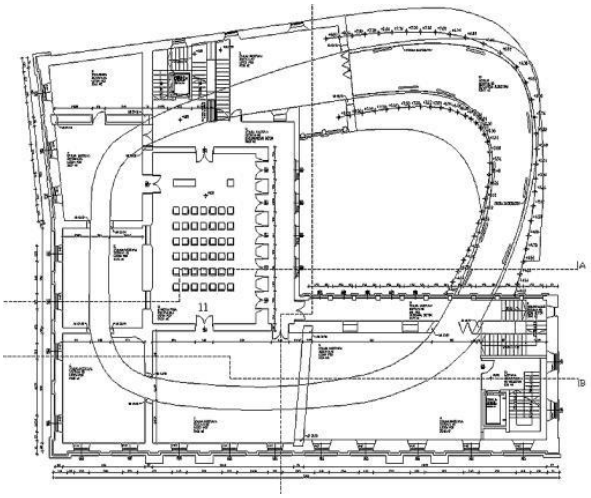


Figure 21: Example on irregular plan (Liquid architecture) (Ching, 2007)

3.1.2 Spatial relationships

Spatial relationships are directly linked to space organization which in result creates form. Spatial relationships are concentrated in the plan; representing the patterns of void and solid that connect spaces. There are many basic ways to integrate building's spaces together and organize them as defined by Ching (1979) in his book

“Architecture: Form, space, and order” as following including: Space within a space, interlocking spaces, adjacent spaces and spaces lines by a common space.

3.1.2.1 Space within a space

“Space within a space” concept is when a large space is containing a smaller space (Fig). There is a spatial and visual continuity between these spaces. The larger space depends on the outer space. On the other hand, the smaller depends on the larger space. The smaller space can be either in a different grid from the larger space or it can be in a different form from the larger space. This could be regard presenting different functions or varied symbolic meanings (Ching, 1979).

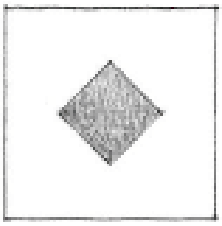


Figure 22: “Space within a space” concept (Ching, 2007)

3.1.2.2 Interlocking spaces

“Interlocking spaces” concept is when two spaces are overlapped and create a shared area. Even though these spaces are interlocked but each one of them have its character. Also the shared area can be under different interpretations. The shared area could be either equally from both of the original spaces, it can merge with one of the original spaces or it can be separated independently and still connected to the original spaces (Fig) (Ching, 1979).

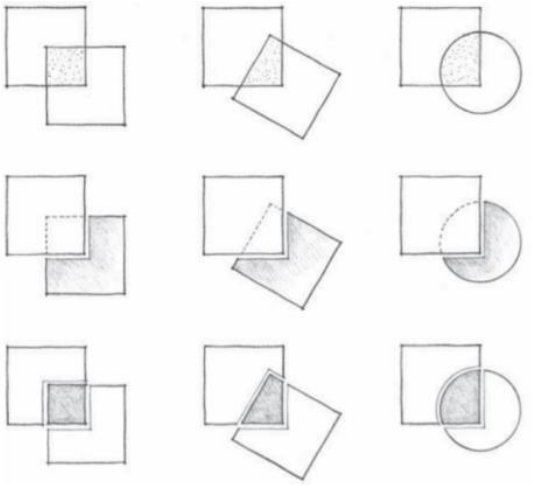


Figure 23: “Interlocking spaces” concepts (Ching, 2007)

3.1.2.3 Adjacent spaces

The most used concept of spatial organization is “adjacent spaces” concept. This concept will let each space to present individually; each with its own function or perspective. These adjacent spaces can be separated and at the same time connected together, it will depend on the plane and can visually recognize. The separated element can be defined by different ways. It can be a wall with a small opening which will limit physical access between spaces. Also it can show as a plane separating the space into two. A row of columns can be a separating element and it will provide more visibility. Or the spaces can be defined by changing with the level of the surfaces; the space is visible as one volume but they have different and related functions (Fig) (Ching, 1979).

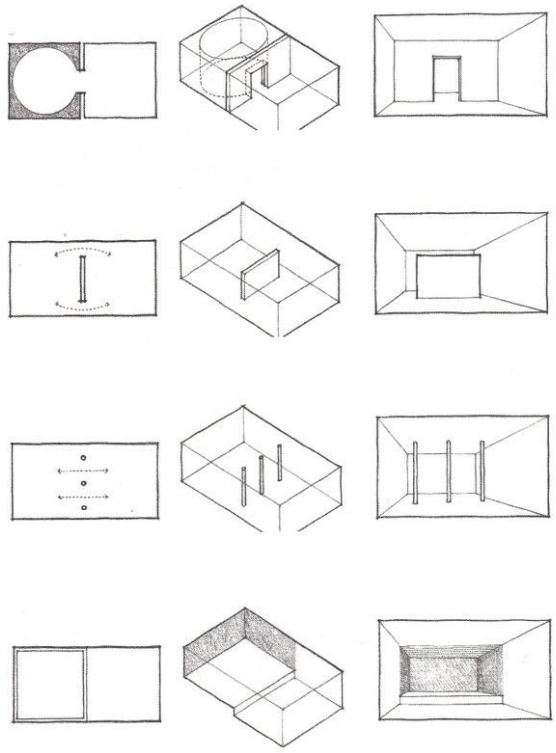


Figure 24: “Adjacent spaces” concepts (Ching, 2007)

3.1.2.4 Spaces lines by a common space

“Spaces lines by a common space” concept is two spaces that are separated and linked together by a third space. The nature of the third space has a major role in determine the relation between the original spaces. Mostly the third space is a different form from the original spaces to present its purpose. However, they all can have the same form. The intermediate space can be linear between two distant forms, or it can join many different spaces together. Moreover, the intermediate space can be larger than the original spaces which will make it the dominant space. Also, it will follow the shape and orientation of the original spaces and linked them (Fig) (Ching, 1979).

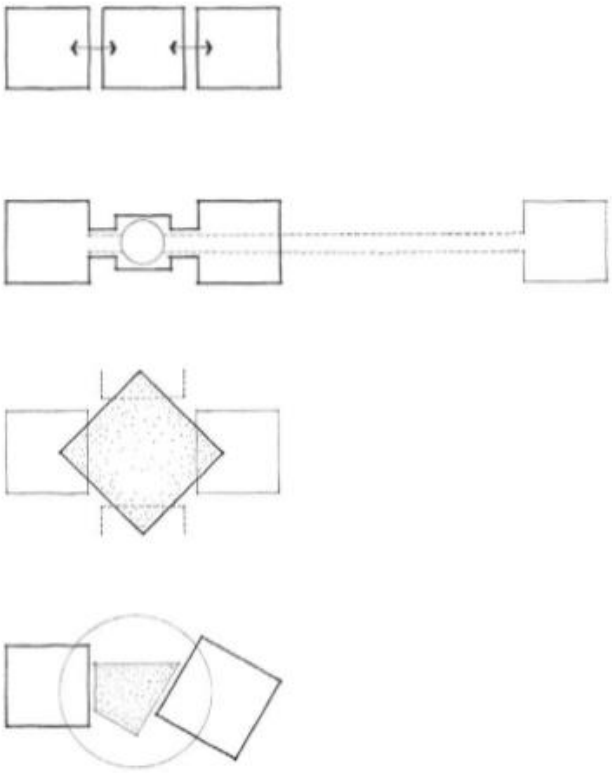


Figure 25: “Spaces lines by a common space” concepts (Ching, 2007)

3.1.3 Circulation

With the increase of the number of relations in a building, the use of circulation became significant. Circulation is a new concept during the beginning of the modern era. However, it’s a major part of the design because the building design is following the internal circulation network. The main spaces are designed to locate around the circulation network. For instance, rooms can be located in both sides of the corridor (Corona-Martínez, 2003).

Circulation or circulation network is an element that can be used to define the formation of the building. Different kind of building will have different kind of circulation which will create a new typological function. Circulation system is developed gradually; an idea that presented by Louis Kahn in his theory about servant and served spaces. In the process, it starts as parts in the general plan layout.

With progress, the system gains continuity and geometrical identity. Finally it improved and became a certain typological circulation system. The system is now ready to be implemented in the design or any similar program. Between 1960s and 1970s, a circulation system was developed for the plans of flexible hospitals. This system was later performed for many other buildings (Corona-Martínez, 2003).

3.1.3.1 Exterior circulation

Circulation represents users' movement in the space. Ching (1979) mentioned different types of circulation elements including "the building approach, entrance, configure of the path, path and space relation, and form of the circulation space" (fig 26). "The building approach" is the path leading to the entrance which considers the beginning of the circulation system of the building. This approach introduces the building's spaces to the users and prepares them for the experience. The path towards the entrance is diverse in terms of length and route; it can be in a straight or oblique line. The approach to the building can end with the entrance or it may continue as part of the interior paths which creates an interior – exterior relation. "The building entrance" is a circulation element, a vertical plane that provides an entrance to the building or a room. Also it defines an area within the exterior space which separates between two spaces. The entrance is aimed to connect or separate between two spaces and it can be a simple hole or a unique gateway. The entrance is determined in perpendicular angle to the path approach regardless the enclosure form or the interior space. The entrance mainly designed to be distinguished and recognized from rest of the building. "Configuration of the path" is state that all paths are mainly straight lines and it represents the paths for people or even cars. This path consists of sequence of spaces and starting and ending point. Intersected paths will have features that determine the main path and the secondary paths. The path followed the

organization of the spaces and linked them together which orient users within the building. Configuration of the bath can be in various shapes such as, linear, radial, spiral, grid, network, and composite. “Path and space relation” discuss the direct relation between paths and spaces in which they are linked to each other. They are connected in various ways including “pass by spaces, pass through spaces, and terminate in a space”. Finally “form of the circulation space” is the significant of the circulations in the building; it’s a major part of the building organization and occupies a percentage of the total space of the building. The circulation can be a path linked between functions. Its purpose is for movement or to pause and rest (Ching, 1979).

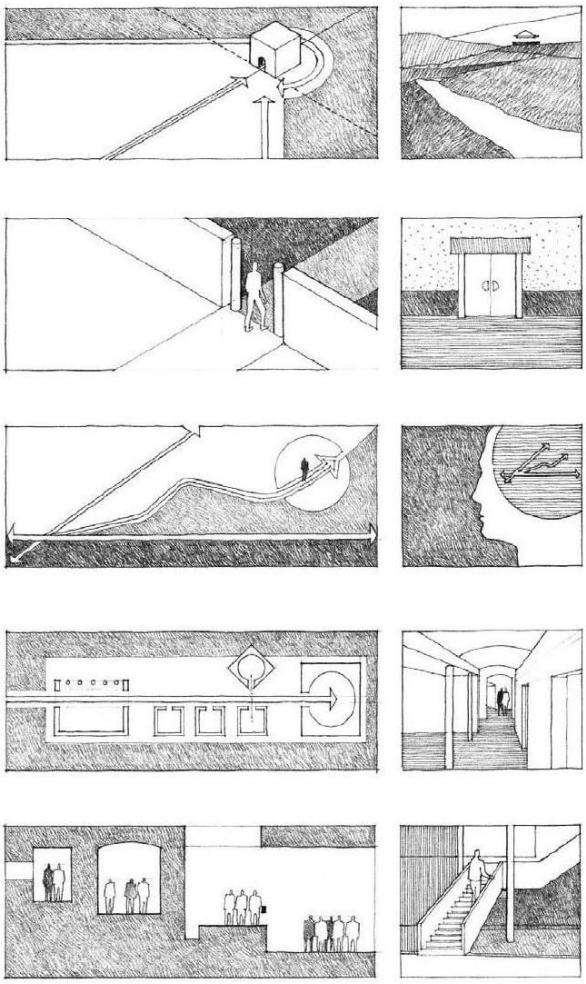


Figure 26: Circulation elements of architectural space (Ching, 2007)

3.1.3.2 Interior circulation

Interior circulation shows the path in the interior of the building and links the spaces together. With circulation, users experience space in relation with space and place. Interior circulation can be represented in to two concepts: horizontal and vertical circulations. Horizontal circulation is the corridors. Corridors are mainly linear paths that connect the various spaces in the building. Basically corridors define the movement routs for users; the internal doors open to the corridor which leading to another space. Designers avoid narrow and long paths because they may confuse the users. On the other hand, wide and short paths are more functional in the space. However, the width of the corridor is related to the users; the path for wheelchair person is wider than healthy person, also a public space with many people need a wider path than a private home with fewer people. There will be signs that define the direction in the beginning of the corridor. The paths should be designed simple, safe and empty (Kocabaş, 2013).

Vertical circulation is another type of internal circulation; it provides vertical movement in the building. The elements of vertical circulation connect between two space and link two floors together. "... all walking areas and mechanical tools installed in all floors of a building required for vertical physical access to some space including staircases, ramps, elevators and escalators" (Elottol & Bahauddin, 2011). For instance, stairs are vertical element to move from one level to another in the building. In order to for the stairs to be accessible for users, the stairs need to follow certain standard measurements that developed through the history. Stairs are the preferred vertical element in case of danger so they should be well-designed (Siedle, 1996).

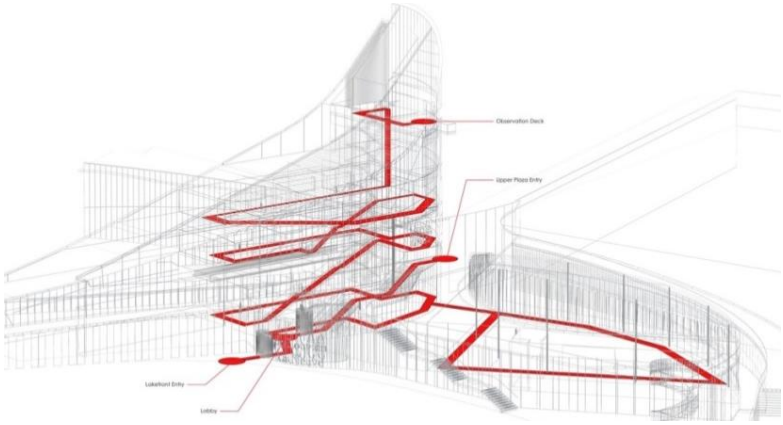


Figure 27: Example shows the horizontal and vertical circulation in the building (URL10)

3.1.4 Function

Function is defined as the “institutional identification” or “social activity purpose” of a building. The term “Function” (singular) is referred to the comfort requirements. On the other hand, “Functions” (plural) is referred to the programs of the spaces in the building (Schumacher, 2002). The function subject is determined by social principles and not by individual person with stable nature. Functional architecture meant to serve the needs for the current place and time (Leach, 1997).

Renato de Fusco (1967) in his text described the design process between 1920 and 1930. Functionalism is a major factor in the design as architecture is created from the function. The text also talked about the “functional scheme” which helps on creating many formal possibilities by the various hypotheses and alternatives offered by function. This process of schemes transfers the function into form. Moreover, typology of architecture is also determined by the different schemes. Function has a major role in the field of typology while form is more variable. De Fusco also mentioned the use of bubble diagram of function to transfer it to a plan. In this procedure, he considers the scheme as a practical instrument for the function to

transfer to form. Moreover, the typology consider as a thematic instrument for the design (De Fusco,1967).

Functional typology can be determined by various factors. Circulation can create a certain typology of function depending from one building to another. Another functional typology can be created from the shapes of elements of composition regarding the internal spaces (Corona-Martínez, 2003).

3.2 Form in interior architecture

Space is a general idea while shapes and forms are the specifics that make the space more readable. The space cannot reflect a definition without these factors. These factors, the form and space, are categorized in many ways regarding their dimensions. Form is a three dimensional but shape is a two dimensional with width and length (Ching, 2007). Ghadim (2013) defined form in his research as "is the shape, visual appearance or configuration of an object. Form means having framed and geometric regulations which is potentiated to translate to mathematics. In architecture when we are talking about ordered form it means that we can fit this form in an ordered frame".

Formal revolution took a significant place for architecture during the modern architecture. It's the factor to words a new architecture. From the late nineteenth century, forms creation took a new path with the new materials and the new techniques. Also a new openings and visual connections were introduced which created a new topologies of architectural forms (Corona-Martínez, 2003). Form of an object is defined regarding its shape, visual appearance or deposition. Moreover, form has a frame and geometrical organizations which also can be indicate

mathematically. Ordered form in architecture means that the form can be put in a certain ordered frame (Ghadim, 2013).

Different forms in buildings can reflect different experiences and emotions to the users. For instance, curved surfaces can present smoothness and harmony but they can feel inconvenient. A building can be designed with geometric shapes which can reflect organization, but it will display a lack of sentiment feeling. Also intensive materials project strength and safety. On the other hand, lighter materials will project comfort. As an example, An open form with sofa can be welcoming to the space but closed and windowless space will feel inconvenient. Moreover, active shapes like diagonal can be more energetic and static shapes are more horizantal which reflect peace (Allen, 2003).

3.2.1 Facade and exterior skin

The façade is the face of the three dimensional volume of a building; this face is indicated by the modulation of the volume or by columns appearance (Corona-Martínez, 2003). The appearance of the façade reflects the building characteristics and aesthetics. Many features of the building can be recognized from the façade, for instance, culture and climate of the city, the plan of the building, and history of the building. Moreover, they are the factors that create the façade (Davarpanah, 2013). During 20th century, architects came to the use of plain walls. Also they used to apply the same materials of the exterior on the interior. Various historical examples inspired 20th century architects to project the interior spaces on the exterior walls/façade (Schumacher, 2002).

The interior and exterior of the building define the character of the façade; the character of the façade changes if any modifications acquire in the interior plan. The elements of the façade such as form, structure, materials, colours, openings, balconies, and roof type are directly related to the character of the building. The main focus of façade and elevation are the entrances, porches and balconies with their functions which also define the character of the building. Moreover, the exterior conditions such as, location, culture, history, climate, and economy affect the character of the façade (Zionsville, 2012).

3.2.1.1 Materials

During 20th century, the construction of the façade design developed with the achievements in industry and design fields. The façade can be related to the current era or to historical architecture. The main elements of the façade and wall construction are natural local materials in that area such as, stones and woods. Although, the façade design become simpler with less openings on the wall and roof. The openings of the wall are related to the natural lightning. So designers used glass to fill these openings and also as a construction material. It provides visual and light access to the space. Also with the development of architecture, the glass techniques improved to serve the various needs (Oesterle et al, 2001).

3.2.2 Formative elements of space

The basic formative elements are defining interior spaces in the aim to maximize performance. On the other hand, these elements create structural systems.These elements control the interior spaces in terms of developments, structures, decorations, interior designs and transparency. The role of the interior architect is to distinguish various functions, create attractive designs and comfortable

environments. Formative design elements include walls, floors, ceilings, stairs, and apertures (Eisner et al., 1993).

3.2.2.1 Walls

Walls are the most fundamental vertical element. They are the most effective element that define a space and separate between two spaces; control both visual and physical access between spaces (Beddington, 1982). Non-bearing walls are defining elements of the space but are not structural related. They can be fixed or moveable as partitions. These walls maximize the use in limited spaces. Moreover, they provide more flexibility for the interior spaces and can be in any form such as, straight, curve or dynamic forms (Ching & Binggeli, 2004). The walls also usually contain different openings to connect the space with the exterior or other spaces. Openings include windows and doors (Ching, 2001).

3.2.2.2 Floors

Floors are horizontal elements. They are the basic designing element in defining interior spaces for any constructive building. Floors are planes were users move above; above floors acquires any kind of events and activities. Since the floors carry all the weights, including people, furniture, etc., they constructed in safe standards to handle the weights. With the technological development, it became possible to have floors from glass and it became easier to control transparency. The glass became strong enough to be used as a floor and bear all the weights. Floors can be in various materials and characteristics. Their purpose is to control the space and proportion of space, can be used for artificial lightings, or using different layers of floors (Ching, 1987).

3.2.2.3 Ceilings

Ceilings are horizontal elements. They are parallel to floors with a certain height from to the floors. Ceilings determine the height of the interior space in terms of the scale of the space. They have an essential role in defining the function of the interior space. The interior architects can control the interior space formation by using secondary roofs with the use of artificial lighting. The different variations in height will identify different spaces (Ching & Binggeli, 2004). Ceilings have the ability to be visually accessible and offer transparency which has many psychological expressions. The non-structural ceilings are a secondary roof and it can be in various form and scale according to the designer. They are in different layer from the structural ceilings for different reasons (Ching, 1987).

3.2.2.4 Stairs

Stairs are mainly vertical and they are used to connect two levels of floors together. The stairs are nonstructural and they are added to the design after the space is constructed. They can reflect different perspective of views. The different layers of the stairs will have different images to the users; new images appear and others disappear. The interior architects can design the stairs in different features such as, simplicity or complexity, functional aspects, and level of recognition (Abercrombie, 1990).

3.2.2 5 Apertures

Apertures are openings that connect between spaces and especially between exterior and interior such as, doors, windows, gates, etc. They are mainly openings in the walls and they have the role of defining the interior spaces and its characteristics. These openings create visual and physical connection between adjacent spaces. Apertures are sources of transparency in interior spaces (Ching & Binggeli, 2004).

3.2.3 Geometry and form

Geometry is the essence of the design process which contains the initial stages of forming the building until the final formation. Geometry in 20th century provides different ways for sufficient design, analysis and creates complex forms. The idea of geometry of architecture is to propose new designs. Also architecture introduces different problems to geometry which opens up research opportunities in the field of architectural geometry (Mungan, 1988).

Helmut Pottmann, a professor of Applied Mathematics and Computational Science (AMCS), argued that the way to achieve free forms in design is by the study of geometry with the needed structural consideration. The digital design and new technological software provided possibilities in creating various geometrical forms and free-forms design in architecture. Architectural studies in geometry developed more with the use of new software which allow build digital models. However, digital models had to follow the standards of design creation. It's important to include different features of construction such as materials, industrialization technologies and structure (Pottmann, 2007).

Geometry can control the visual perspective of people. In buildings, the geometry has an effect in the internal spaces, which it can emphasize or hide an element of space and it can control the light and temperature of the interior spaces. The complex geometry tends to get visitors attention and curiosity to figure the building concept. It creates an attraction. On the other hand, simple geometry may not get visitors attention on the geometrical elements and loss the advantage of visual attractions;

visitors will pass through without any concern. This indicates the role of geometry that architects and designers can use in their work (Ghadim, 2013).

3.2.3.1 Regular forms

Regular forms are referred to the different parts of the building with an orderly relation to one another. The nature of the regular forms is stable. Also, they are symmetrical in one or more axes. The basic examples of regular forms are including cube, sphere and pyramid. Regularity of the form can still be maintained even with subtracting elements, adding elements or transforming dimensions. The similarity between the forms can build a mental image for the users on the whole formation even with the missing or additional parts (Faravar, 2010).

Figure 28: Example of regular form (URL 11)

3.2.3.2 Irregular forms

Irregular forms are variable and not well defined forms, also they are asymmetric and unstable in nature. The lack of symmetrical principles in irregular forms provides flexibility and creates more dynamic forms and they can be integrated from regular forms. Architecture deals with both solid and void features. Irregular forms can be part of the regular forms. Irrigular forms can be surrounded with closure elements to become regular forms (Ching, 2007).

Figure 29: Example of irregular form (URL 12)

3.2.3.3 Transformation form

Forms in reality are a transformation of the original solids in terms of shape, size and structure. Transforming forms are original forms modified in height, width or length but they still in the same family. The transformation can be either subtracting or adding. Subtractive form transformation is done by reducing the volume size of the basic solid forms. The new form can be in the same initial family or transformed to a different one. For example, the cube can be transformed within the cube character or changed to a new family like polyhedrons. On the other hand, Additive form transformation is the basic solid forms with adding elements. The initial form can also be maintained or changed according to the type of additive transformation, amount and size of the adding elements (Ching, 2007).

Figure 30: Example of subtractive form transformation (Pazooki, 2011)

Figure 31: Example of additive form transformation (Pazooki, 2011)

3.2.3.4 Free-form

The field of geometry became more recognized during the 20th century when architects start to create free-form shapes. The creation of free-forms led to create a more complex and demanding designs which seek more studies in this field (Ghadim, 2013). Free forms designs were expand and developed with the new digital technologies which create new experiences and aesthetic designs. Free-forms include different concepts such as, Blob architecture, Liquide architecture and formlessness (Pottmann, 2007).

Blob architecture is an organic invention and the buildings are inflatable. They show curved and soft rounded dimensions. These forms are created by using different software of digital design to produce new and unique forms The Geometry of Blob architecture are categorized as free-form and irregular. The Blob forms are not based on a Euclidean geometry but they are defined by external forces (Ghadim, 2013).

Figure 32: The Bubble Pavilion, example of free-form (Blob architecture) (Biondi, 2006)

Liquid architecture is a concept first developed by Marcus Novak in digital design for the invention of liquid landscape. Liquid forms are unique as they are not restricted with the idea of Euclidean geometry and do not respond to the laws of gravity. Time and space are the main elements of liquid architecture. Liquid architecture is designed to integrate and respond to the users' needs and it varies accordingly. A poetics of space describe the liquid of architecture as "science and art, the worldly and the spiritual, the contingent and the permanent" (Ghadim, 2013).

Figure 33: The Selfridges Birmingham building, example of free-form (Liquid architecture) (URL 13)

Formlessness is a new concept in architecture and it became used more frequently. Formlessness can be recognized in obvious quality or in the building's atmosphere, structure and dematerialization of architecture. Formless surfaces are firstly used by the architect Frank Gehry; which also his designed called as single-curved surfaces

(Klingmann, 1999). Formlessness buildings are not abandoning the use of structure or contain more openings. But it's a concept in which architects tend to became more international and eliminates individuality (Ghadim, 2013). Initially architects inspired Formless object from the nature. Formlessness is inspired from the free fluidity like water and the way it moves; it does not have any certain order. It has an unlimited growth and changeable soul (Mostafavi, 2002).

Figure 34: The Experience Music project, example of free-form (Formlessness) (URL 14)

3.3 The integration between form and space

Form and space are related to each other in various elements and aspects. This section is a descriptive discussion on the standards of where form and space are defined in related to each other. In which defining a space required certain philosophies and physical elements and on the other hand, for transferring form into being it transferred into these physical components and presented in to various visual designs.

3.3.1 Architectural elements of defining space

The term "elements" is recognized as all the parts of the built project. Elements of architecture are the physical material in the space which completes the role of elements of composition. Elements of architectural are materials with a virtual image

and existence. In modern architecture, it's the elements that a user can see, use and buy including windows, doors and furniture. With progression of these elements the space became more physical and assigns a certain function. Architectural elements are the elements of the whole completed building. These elements include the exterior appearance, materials and the skeleton of building. In order to bring the project into being, these elements need to be arranged. (Corona-Martínez, 2003).

3.3.1.1 Horizontal elements

Horizontal elements are elements that used to define space in the horizontal plane. As defined by Ching (1979) in his book "Architecture: Form, space, and order" as following. There are many horizontal elements that can be used, such as, the base plane, the base plane elevated, the base plane depressed and the overhead plane.

"The base plane" is a defined zone in the surface (Fig 33). This concept is used in architecture to articulate a surface or floor plan to define a zone in the larger space. These planes can used in distinguish between the platform of the building, a path, a living space or a separated space within a room. The base plane is defined and recognized with using a different color or texture than the surface.

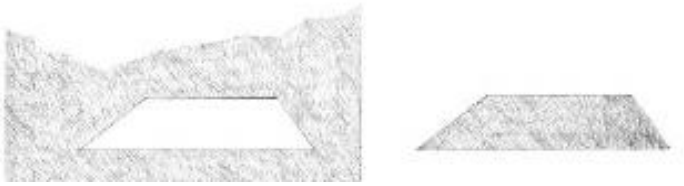


Figure 35: "The base plane" horizontal element (Ching, 1979)

"The base plane elevated" is the base plane and lifted up above the surface which will create a zone in the larger space. Then this zone will be visually recognized as a separate space from the surrounding (Fig 34). The elevated surface can be to form a

platform, a structural base, part of the site condition, separating the building from the surrounding, presenting a unique image to the building than the rest of the surrounding, or emphasizing the interior from the exterior.

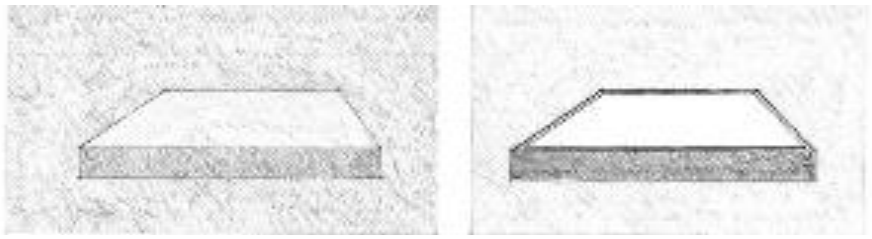


Figure 36: "The base plane elevated" horizontal element (Ching, 1979)

"The base plane Depressed" is a base plane with a depth beneath the ground. The boundaries are defined by the edges of the depressed surface. The depth of the surface can be in any value regarding a certain function. The depression it can from the topography or it can construct to serve a purpose (Fig 35).

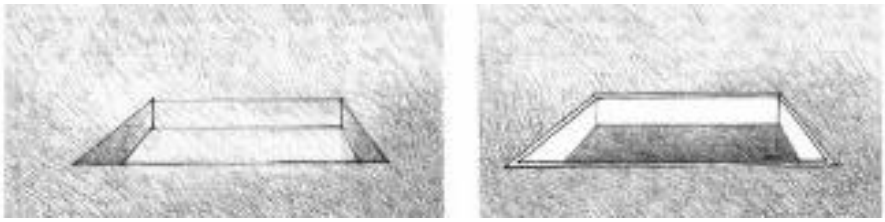


Figure 37: "The base plane depressed" horizontal element (Ching, 1979)

"The overhead plane" is a shade surface over the heads that define a certain area between the ground and the plane. The edges are defined by the distance between the ground and the plane. The overhead plane can define the whole volume of the form; it depends on the plane shape, size and the height (Fig 36) (Ching, 1979).

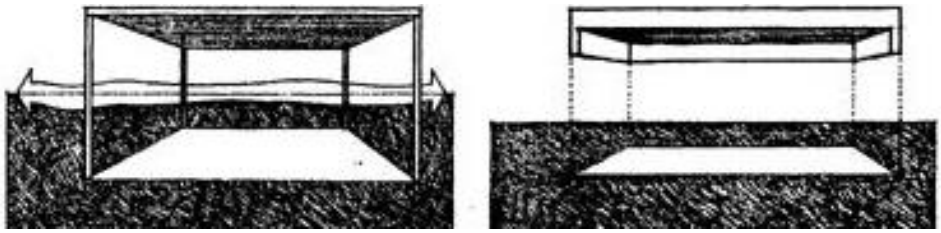


Figure 38: “The overhead plane” horizontal element (Ching, 1979)

3.3.1.2 Vertical elements

Vertical elements of design are for defining a point or emphasize a space. To define a volume, it must have edges and corners. The standard vertical element in design is the linear vertical element which is the column. Two columns can define a vertical plane. Three columns or more can define two planes intersected and create a coroner. To create a volume, the base plane is well defined using columns in the vertical plane and beams on the overhead plane. Defining a space using vertical elements can be in various methods as defined by Ching (1979) in his book “Architecture: Form, space, and order” as following. It can be by using columns, single vertical plane, L-shaped planes, Parallel planes, U-shaped planes, or closure (Ching, 1979).

“Columns in space” can define a space; four columns can define a space or a room. The columns are working as a structure for the ceiling and as to define the dimension of the room. Moreover, a grid of columns can be either to support the roof, articulate the volume of space, or to divide the whole space into many zones (Fig 37).

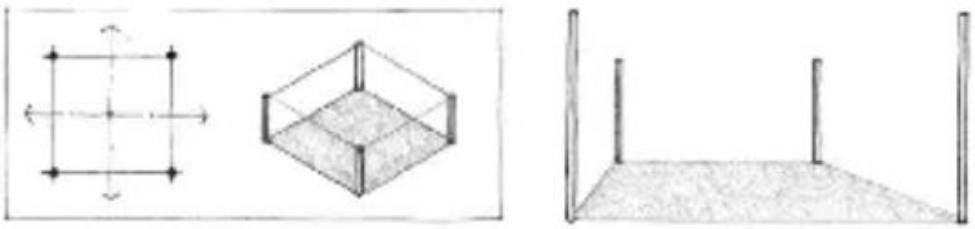


Figure 39: “Columns in space” vertical element (Ching, 1979)

“Single vertical plane” is one plane standing freely in the space and have a visual appearance. It can be a part of a larger plane to divide a space. The plane has two faces which will create two separated volumes. This single plane cannot fully define a space; it must interact with other elements (Fig 38).

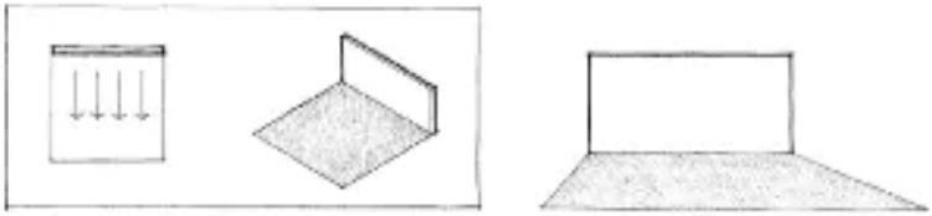


Figure 40: “Single plane” vertical element (Ching, 1979)

“L-shaped vertical planes” define a space starting from its corner. The space is defined strongly beside the planes and corners but the other edges will remain freely. So it can be used a vertical element or an overhead plane to define the whole space. If the two surfaces where not connected, it will create a void which will weaken the boundaries (Fig 39).

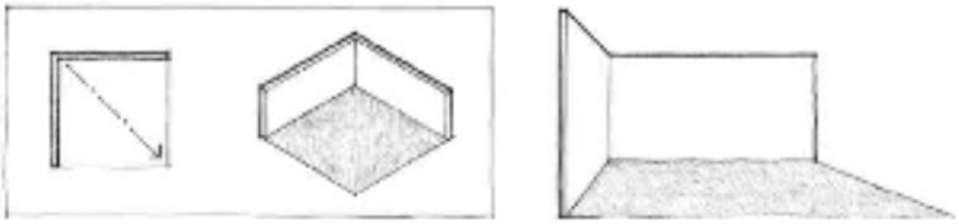


Figure 41: “L-shaped planes” vertical element (Ching, 1979)

“Parallel planes” are two parallel planes with a defined space in between. The edges of the plane establish a strong path direction.. The space between the planes is extended to the nature. The space can be more emphasized by adding a base plane and an overhead element. The parallel planes can be different in form, color,

direction or texture. Moreover, the planes can contain an opening which in result a second axis will be created and change the space flow (Fig 40).

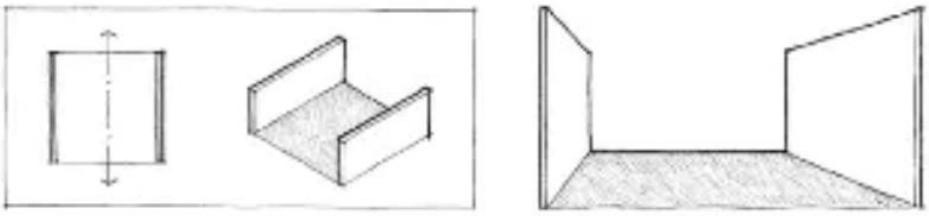


Figure 42: “Parallel planes” vertical element (Ching, 1979)

“U-shaped planes” are three planes defining a space with a certain focus to the nature. The space in this manner is well-defined with an open end. The main side of this configuration is the open side with its relation with the other planes. This configuration can be extended from the open side and be connected with another space. The planes can be strongly defined with joining with an overhead plane or columns (Fig 41).

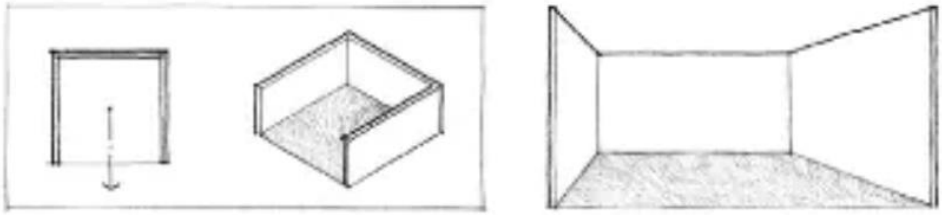


Figure 43: “U-shaped planes” vertical element (Ching, 1979)

“Closure” is four vertical planes that define a space and completely closed. Is the most solid and used configuration in architecture. The closure configuration does not provide any visual continuity with the nature. Also these planes can have openings and provide connection between the defined space and surrounding spaces. Openings on the corners of the planes can give the planes an individual identity and enhance

lightening, use and movement. Moreover, the interior space of the enclosure can be more defined by differentiate the various plane faces using a different size, form, texture, or an opening regarding the function (Fig 42) (Ching, 1979).

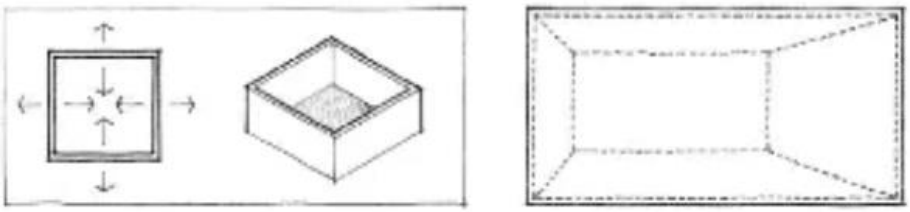


Figure 44: “Closure planes” vertical element (Ching, 1979)

3.3.2 Space and form organization

Building’s spaces are being organized in many ways. Spaces in a typical building have many requirements which develop its own organizational system. Requirements such as, spaces with a certain functions, space with a unique function, spaces with flexibility in use, spaces have similar or different functions, openings and closures of the building, the need for privacy, and finally accessibility. Building organization is reflecting the spaces importance and functionality. The type of organization will depend on: building program including functions, dimensions, spatial hierarchical, and access requirements. On the other hand, the site’s condition which might limits the organizations options (Ching, 1979).

To define a space and form, there are basic geometries including point, line, plane and volume. These geometrics are created many elements of architecture such as, columns, walls, floors, and roof. They all collaborate together to create forms as followed: Columns are visible in space in three-dimensions. Two columns together will create a spatial membrane as a path. These two columns and a beam will form a

transparent plane. Another element is wall; which is inserted in a shapeless space and divides that space. Floor is a horizontal area with assigned limits. Last but not least, roof is an element used to cover the underneath space (Ching, 2007).

Additive forms in design are connected and developed with other forms by using separated elements. On this issue, harmonious relationships between the various forms are required to combine them together as one (Ching, 2007). There are many ways to integrate of the additive forms as followed: Linear organization, Centralized organization, Radial organization, Grid organization and Clustered organization. The concept of these organizations of forms is similar to what was mentioned in the space organization (Ching, 2007).

3.3.2.1 Centralized organizations

"Centralized organizations" consist of a large, main, centered space and several of secondary spaces around it. The form of the main space is large and uniform in a way that the other spaces can be organized around it (Leonardo, 1998). The secondary spaces can be either at the same size, form and function with a symmetrical organization around axes or they all can have an independent functions which will made them in different sizes and forms (Fig 43) (Ching, 1979). The movement of the central forms can be in radial, loop or spiral form. Also the sequence of spaces ends in or around the center (Kornberger, 2007).

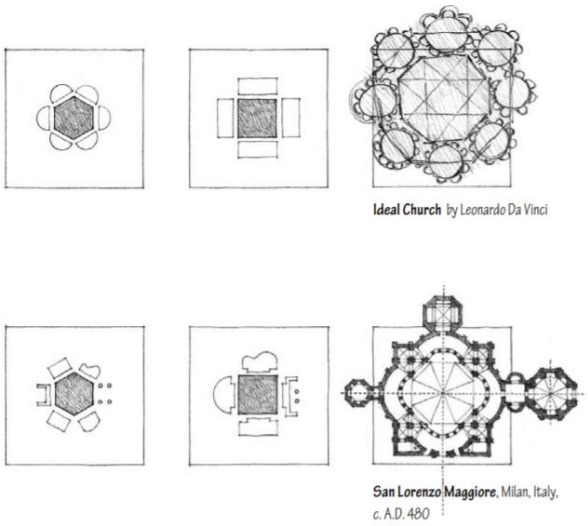


Figure 45: "Centralized organization" concepts (Ching, 2007)

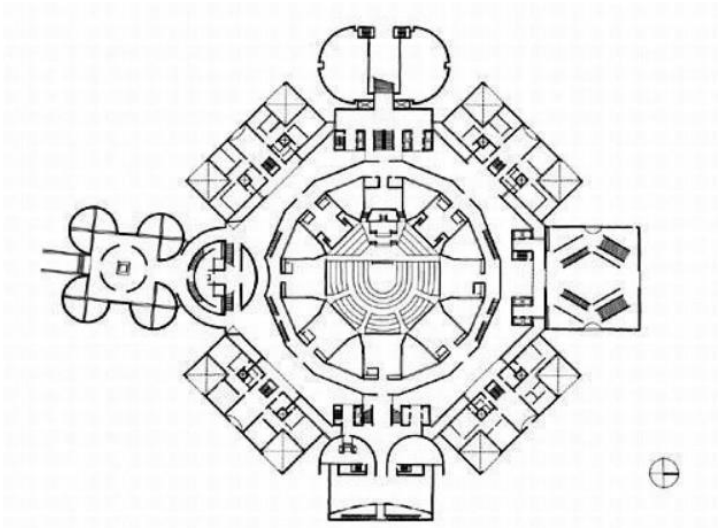


Figure 46: National Assembly building, central organization plan, 1962 (URL15)

Figure 47: National Assembly building, central organization form, 1962 (URL16)

3.3.2.2 Linear organizations

“Linear organizations” is a series of spaces. The spaces are arranged in repetitive sequence either straight or curved. Also the sequence can be cut into parts (Chen, 2011). The organization is contains of spaces sequence can all be in the same size, shape and function. On the other hand, the spaces can be diverse in their size, shape and function, and an exterior exposure linked the different spaces together (Ching & Eckler, 1982). The spaces can be either related to each other or they can be connected with a separate space. All spaces can have their individual exposer. The most important functional space of the series is located in the same sequence but have a different size and form. The significant space can be recognized also with its location in the sequence (Fig 46). The series of spaces as Ching mentioned, they “express a direction, movement, extension and growth”. The growth of the series can be stopped by using a controlled form or space such as an entrance or the topography of the site (Ching, 1979). The best feature of linear organization of linear plans that it can be modified to fit any site and follow the conditions. The linear sequences is flexible which can be adjustment either by extend it or by change orientation according to the situation. So the plan can fit any site with larger landscape and create a modern design (Ghadim, 2013).

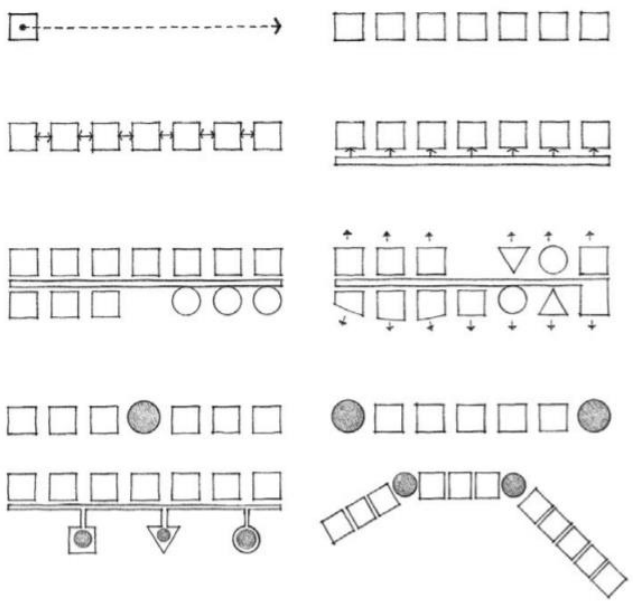


Figure 48: “Linear organization” concepts (Ching, 2007)

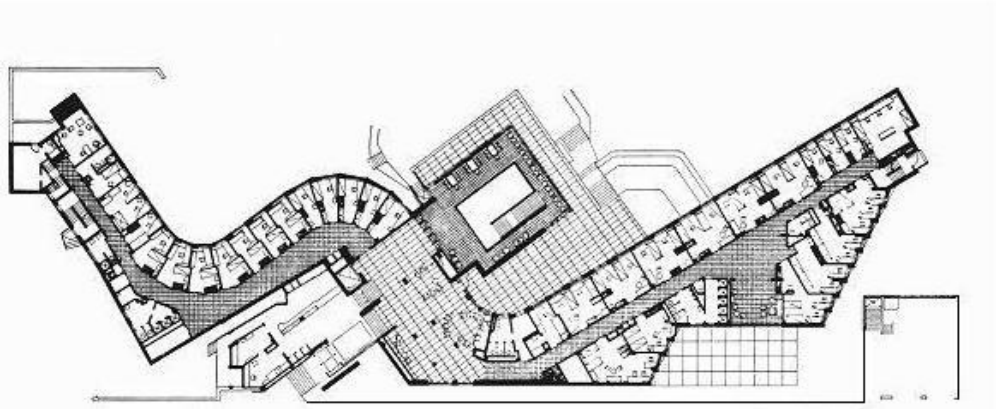


Figure 49: Baker House Dormitory, 1946 (Perez, 2010)

Figure 50: Baker House Dormitory, linear organization form, 1946 (URL17)

3.3.2.3 Radial organizations

"Radial organizations" is a composition between central and linear organization. It consists of a main space in the central with the linear series of spaces arranged in a redial distribution. The difference between central organization and radial organization is that radial organization with its linear arms can extent and function in a certain way with the site. The central space is usually regular in shape. The arms, the linear organization, can all be either similar in form and length which will represent a regular final form or they can be different in form regarding their individual function and requirement (Fig 49) (Ching, 1979).

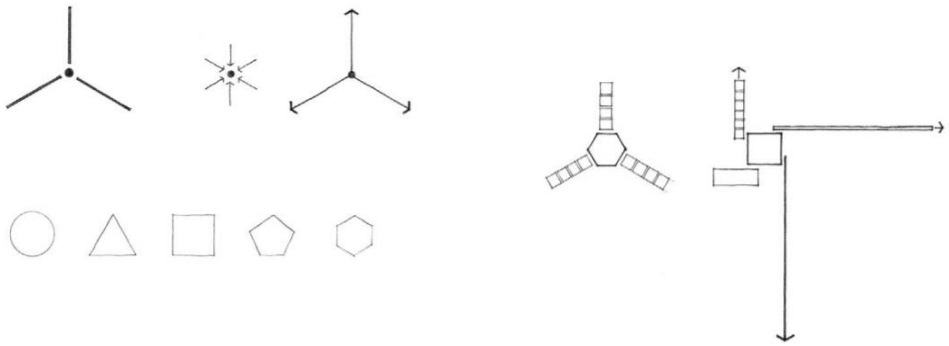


Figure 51: "Radial organization" concepts (Ching, 2007)

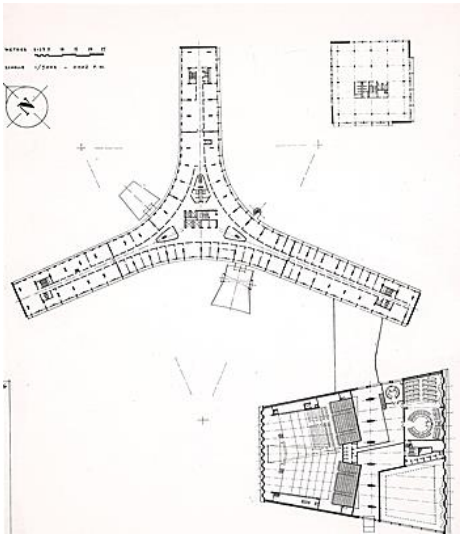


Figure 52: Secretariat Building, UNESCO headquarters, radial organization plan, 1953 (URL18)

Figure 53: Secretariat Building, radial organization form, 1953 (URL19)

3.3.2.4 Clustered organizations

"The general definition of cluster is to extend over so as to cover partly or cover part of the same area like other concepts and techniques in architecture" (Ghadim, 2013). "Clustered organizations" is a concept use to relate spaces together. This organization consists of many spaces that have similar function and they can be recognized by their shape or orientation. However, it can be different in size, form and function, but merge them with visually or organized them in axis. The clustered organization is flexible and does not follow a certain pattern which makes it able to grow and change (Fig 52). Clustered spaces in building are arranged around an entrance or a path. The organization of spaces does not have a regular geometry. They also can be organized within a specific field. Since the clustered organization have no certain patterns, it gain it's significant from by the use of size, form and function. In some cases, it can be used a symmetrical axial to give the spaces more strength and stability (Ching, 1979).

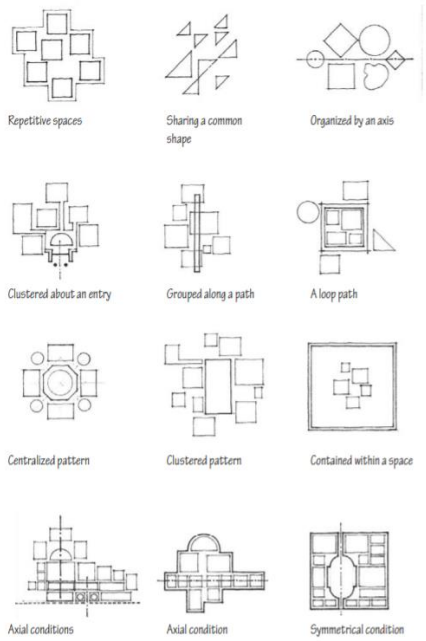


Figure 54: "Clustered organization" concepts (Ching, 2007)

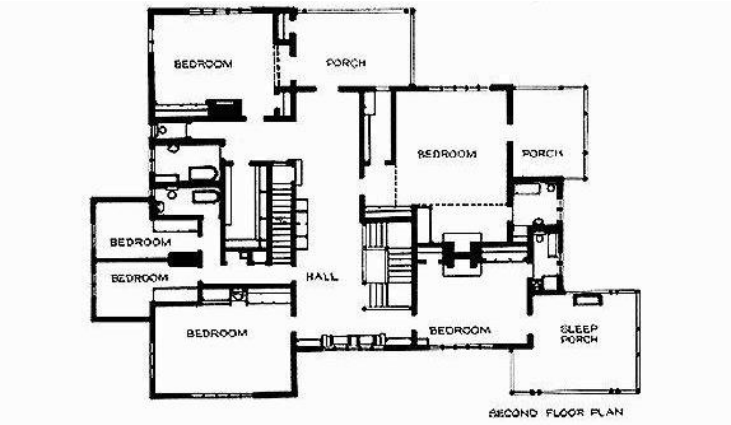


Figure 55: Gamble House, clustered organization plan, 1909 (URL20)

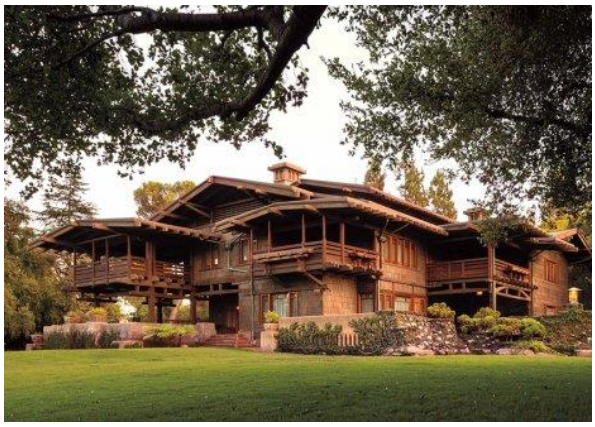


Figure 56: Gamble House, clustered organization form, 1909 (URL21)

3.3.2.5 Grid organizations

“Grid organizations” is consists of spaces that organized within a grid pattern. The grid is made by basic patterns that are intersections of lines. The grid is built from the continuity of patterns and it give to this type of organization strength and simpler way to organize spaces. The spaces in the grid can be dissimilar in size, shape and function but they share a relationship. The point and lines in the grid will be as a reference for creating spaces (Fig 55) (Ching, 1979). The other grid shapes are rectangular, triangular, polar, and it can be any other shape. These categorizes of the architectural grids will be an explanation for any model in a grids perspective. However, this grid is more used in the urban design than the building formation (Leonardo, 1998).

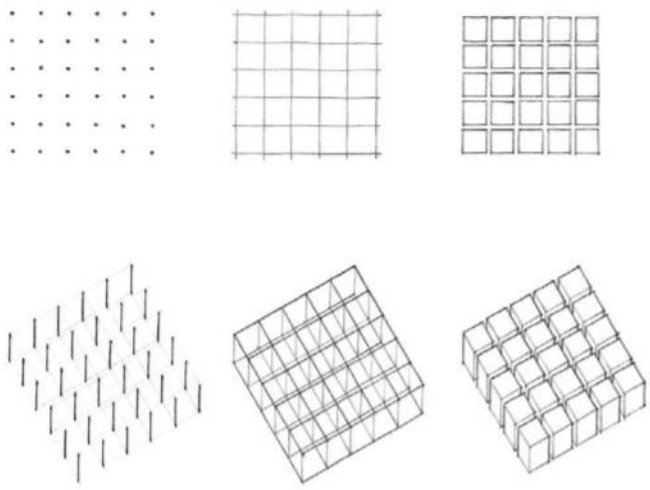


Figure 57: “Grid organization” concepts (Ching, 2007)

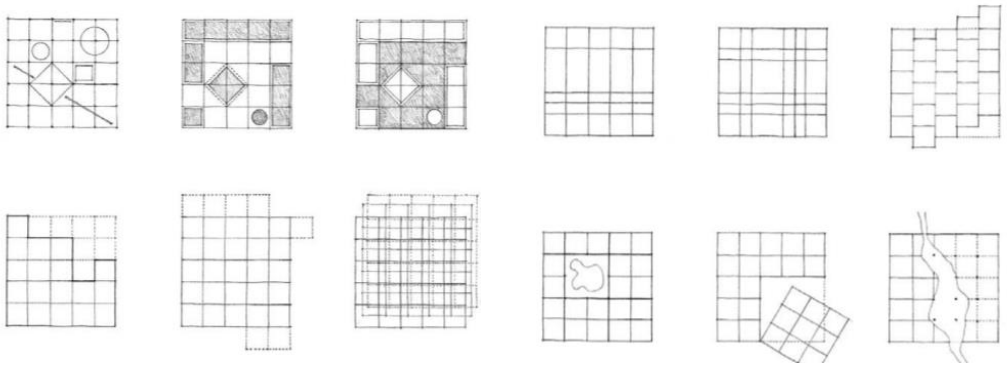


Figure 58: Types of "grid organization" (Ching, 2007)

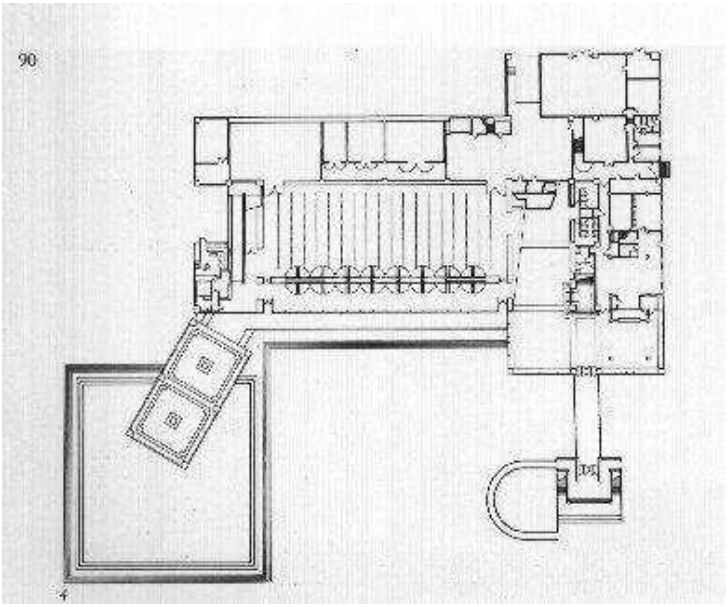


Figure 59: The Gunma Museum of Fine Arts plan, grid organization plan, 1974 (Gunma Corporation, 2008)

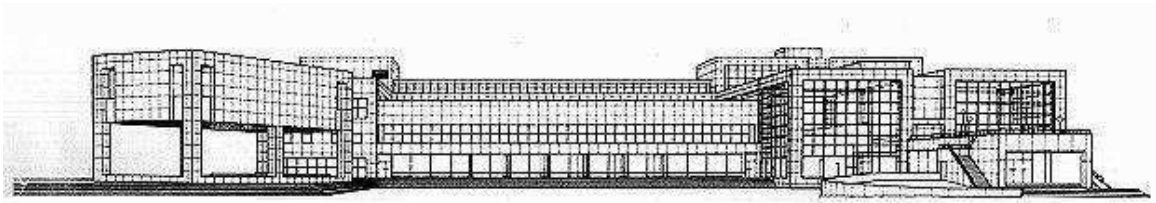


Figure 60: The Gunma Museum of Fine Arts, grid organization form, 1974 (URL22)

3.4 Structure in interior architecture

The form and free-form of space is related to various elements and mainly structure (Ghadim, 2013). The previous philosophies of interior space and from organization

are related to various factors including the use and aesthetics space. But another important related factor which is the strength, cooperation, durability, and security of materials. The field that was recognized by the design in architecture from only the simple strength and function in buildings is “engineering structure” (Salvan & Thapa, 2000).

The elements of architecture provided to reflect an expression for the building. Although these elements provided materialization and expression, the form can’t be controlled without the medium representation. For any building, a supporting parts need to hold the building. And a basic constructional system will contain at least columns. This proves the relation between structure, interior and architecture. With the all the new formational technique in the 20th century architecture, new construction strategies were implemented. They vary between simple columns and beams system to a more complex system according to functions (Corona-Martínez, 2003).

Many architects became more committed in the presentation of space, function, and volume during the modern architecture. It became feasible to reflect function on the exterior of the building. Various ideas were needed to be developed for the new construction including stability, masonry construction and larger spans. For instance, before modernism, long spans required thick walls, columns, buttresses and side aisles. However, these issues were solved with the new achievements in structure and new materials. Large spans became much easier to apply with any distance and thin walls (Schumacher, 2002). Architects by the end of the 20th century were designing

bridges since the engineers have no aesthetic aspects in designing bridges (Millais, 2005).

3.4.1 Structural design aspects in buildings

Structural design or structural engineering is the study to create a structure that can hold the loads on a certain surface. A building is a space separated from the surrounding environment and it serves a specific use. The structure is part of the constructed building. The role of the structure is to support the building and give it the strength to stay standing and sustain the subjected load to it. These loads are calculated by consider many factors including the weight of the building, any physical features used on and in the building, the proximity of the users' number, and natural load such as wind. Since a building cannot stand without a structure, the structures consider as a part of the building and should not be treated as a separate element in the design (Millais,2005).

Usually, architects tend to start designing without conforming a specific structural concept, and they can determine the size of the structural members without the need to the whole system. However, the structure that will be used for a building, it can be effecting the design and require modifications. Structural design is more concerned in the size of structural elements rather than the design itself. Creating a design and then decide on a structural concept will cause difficulties on the structural designers. Structural designers need to consider two points: "There is no correct structure" and "All loads must have a load path" (Millais,2005).

The use of the spaces is what determines the used structure. Architects design spaces for a specific use and according to a structural concept that will be applied. The

requirements of the internal space will determine the span of roofs and the positions of vertical structural elements. For instance, a space requires walls but columns will present more flexibility to it. An auditorium will need a large span with no internal supports and using thick walls for sound isolation. A tall building will need a vertical circulation using stairs and lift towers which designers used them for prevent wind loads. During design history, the most concerned matter was the long spans. But with the modern architecture and technical development, designer were able to create long span spaces which in result innovate many new creative forms (Millais, 2004).

Le Corbusier was a significant influence on the modern movement. He proposed the importance of studying the mass principles. In 1915, he created a system called “Domino” or “Dom-ino”; it based on a reinforced structure. This system became the icone of the modern architecture (Millais, 2005).

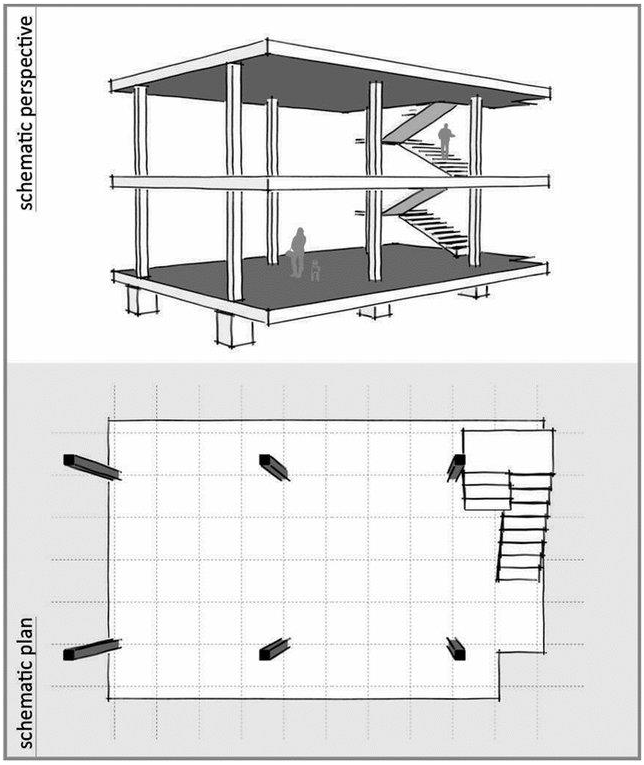


Figure 61: The Dom-ino system, Le Corbusier, 1915 (Nogueira & Kong, 2019)

On the other hand, Le Corbusier also mentioned his idea of “Five points of a New Architecture”:

1. “Pilotis, plan libre, facade libre, fenêtre en longer, and toit jardin”.
2. “Pilotis” are columns that lifting the building above the ground.
3. “Plan libre” is a free plan.
4. “Facade libre” is a façade without any loadbearing features.
5. “Fenêtre en longer” is horizontal windows.
6. “Toit jardin” is a garden on the roof as a replacement for the used land.

These are the basics to create a structural system for any formation. Architecture is no longer needs a craftsman but it required structural engineers. Le Corbusier used structure as a source of engineering aesthetic. Also many other architects used engineering aesthetic in their design including Mies van der Rohe and Walter Gropius suing steel structure (Millais, 2005).

3.4.2 Importance of structural systems

Structure in interior architecture is when a loadbearing element is the same as the physical element of architecture which give more reasons for formation. An architect will be able to distinguish if the wall is or not a loadbearing. At the same time, the features of the wall also can be part of the structure and form such as, the thickness of the wall, its openings, and the connection between buildings. An important thing to consider is the used material and its characteristics. It’s significant to know the loads subjected to a wall in order to determine forms and proportions. The making process also controlled with the shape and texture of walls in many ways; the manufacturing and construction of walls and the way to deal with raw materials. The

mechanical aspects of structure defined such characteristics by science and technology (Sandaker, 2008).

The structural element can be used to limit and form architectural spaces and to provide support. This also will influence the spatial functions such as thickness, shape, and openings. When architectural elements are also loadbearing elements, the form of these elements is as important to define their use. The structural element is considered as a separated object and it connected to the utilities of functions of the architectural spaces. Structure in architecture is consists of the mechanical objects and the spatial objects which creates both the visual elements and spaces. The analysis of structural form should consider two main points: mechanical and spatial functions. These aspects will present the complexity and richness of architectural form (Frampton et al., 1995).

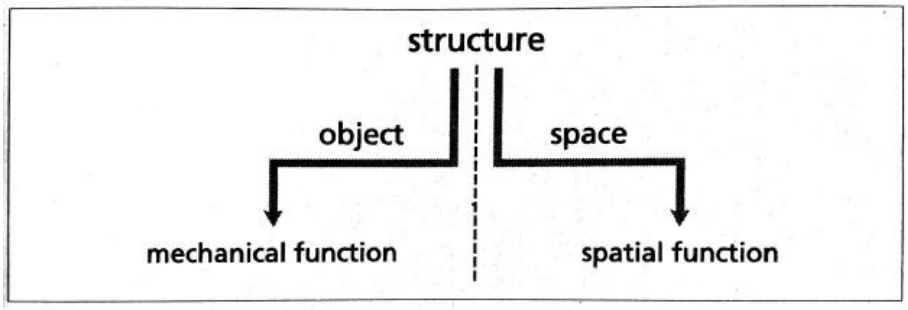


Figure 62: The main aspects of structure in architecture (Sandaker, 2008)

“Contextuality” is a term defined the structural form in terms of architecture and spatial context. This concept is important in structural design in relation with architecture. Structure and space are work together in creating forms but it does not have to be harmonious. But the more suitable case is to have a harmonious relation between structures and form (Fairweather & Tomasetti, 2004). So the significant

aspect of architecture is to decide a structural strategy according to the spatial organization (Simon, 2003).

Structural frame has the ability to carry loads in terms of its mechanical and geometrical aspects as well as the structural materials' strength and elasticity. The frame procedure is to carry the loads on the beams, through the vertical structural elements and into the foundation and other rigid parts. The strength of the frame can maintain the horizontal stability. It's important to avoid any collapse. The aspects of structural form are recognized as mechanical features. These might not decide a certain design but it can minimize the options. The mechanics features will provide various proposals and the final design will have a clarified reason for selection (Addis, 1990).

There are significant differences between the technological and science of structural form. Loadbearing structures are related to mechanical aspects under the field of "technology". Structural forms are considered scientific because it follows the laws of nature (Mark & Billington, 1989). The framework of structural strategies is defined based on the nature conditions which defines the form. The mechanical objects of structures required a study on mechanical sciences such as statics, equilibrium and materials' properties. Bill Addis stated that "something rather worrying about the engineer who believes that all aspects of a design are capable of mathematical formulation according to scientific laws" Addis, 1997).

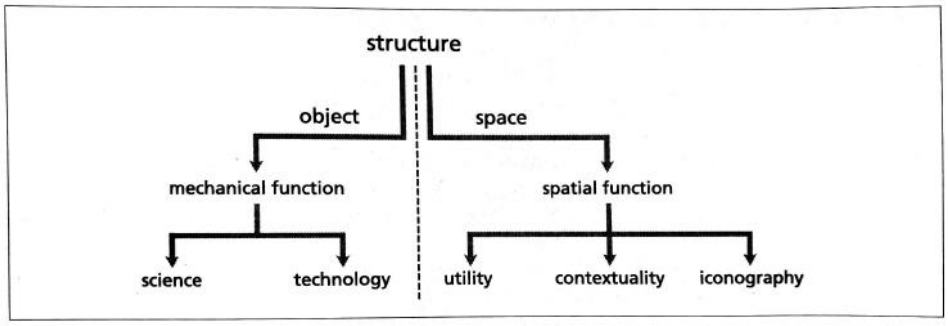


Figure 63: Taxonomy of aspects of structural form (Sandaker, 2008)

Structure as a whole concept refers to the visible structural system. Structural system contains the structural type, the shape of the structure and its mechanism. Furthermore, this is known as the global form. For instance, dome, arch, structural frame, columns, beams and other structural elements consider as a global form. Global form may also contain geometrical aspects such as, shells (Sandaker, 2008). On the other hand, global form determines the behavior of the structure. Structural system in global form can be categorized in three categories: “form-active systems”, “semi-form-active systems”, and “non-form-active systems” (Engel, 1967). Structure systems belong to the carried loads, geometry and support elements. On another matter, the details of the structure are called the local form (Sandaker, 2008).

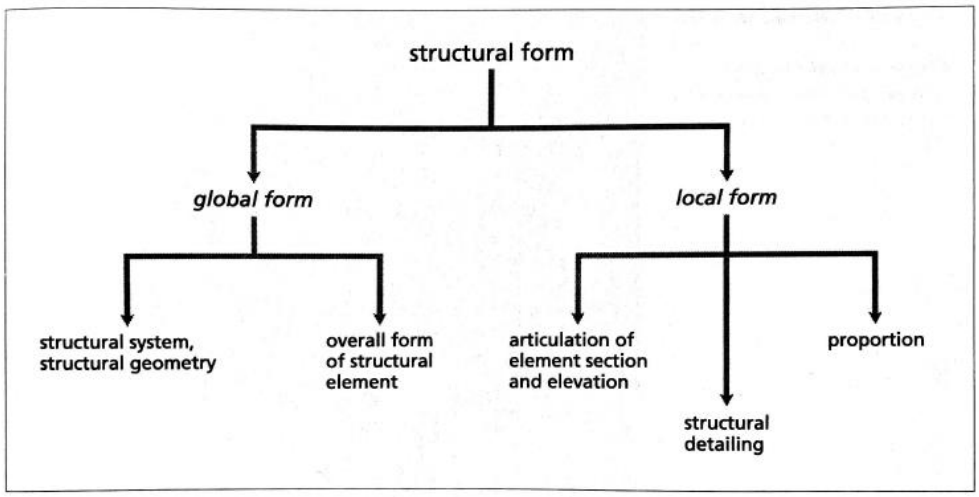


Figure 64: Levels of structural form (Sandaker, 2008)

Form as a general refers to architecture but the details of the form are the structure. Edward Ford once stated that “structure equals architecture”. His theory was essential in architecture in the last two centuries. Ford also stated that “For the most part the ideal constructional principles of the twentieth century conform to the idealized theories of the nineteenth” (Ford, 2003). “The result of structure” is the form as Ford discussed. On the other hand, architecture can also form freely form the essential structural form (Sandaker, 2008).

3.4.3 Structural proportions

Structural elements are significant in construction; span in the overhead plane is supported with vertical structural elements which transfer the load into the foundation in the ground. The structural requirements of a form are determining the size and proportion the used structural elements. In result, these structural elements can determine the size and scale of the contained space. The basic structural elements are used in building are beams and columns. Beams are horizontal elements which transfer the loads above to the vertical elements. Beams can be collapse in case of using a larger span or doubled the weight that this beam can handle. So if the span was doubled, the depth of beam should be increased. Depth-to-span ratio is important to consider. On the other hand, columns’ width becomes thicker with the increasing load or the height. Beams and columns together generate a structural skeleton that defined space and form. Beams and columns can differentiate space and give it scale according their size and proportion (Ching, 2007).

Structural elements of architectural form are various between different loads and different scales. The structural elements can be in a simple solid form, I section shape, ribbed, hollow or truss and they preform sufficient in tension. The elements of

form with similar loads and scales will have similar proportions in terms of ratio, depth, thickness, span dimension or axial dimension (fig 63). These will vary with the variations of form. Beams and columns structure have the ratio of 1/20 of the order. Analogue trusses have the ratio of 1/10. Trussed analogue slab with expanded in two directions have a low ratio of 1/40 to 1/20. Structural element of arch has more proportions according to the thrust line and the resistance strength of the material. The materials with strong tension resistance have a ratio between 1/40 and 1/80 if it's integrated well with the thrust line. But if the structural materials are distorted from the thrust line, the ratio will increase to meet the values of beam and column system. Vaults and shells can be from thin layer. Domical shells have a ratio of 1/400 of the order, except in the edges and single shells. Large spans are for creating continues surfaces with single layer of structural elements. The structural system for large spans is a repetitive triangles analogue. Moreover, the thickness of large spans can be more sufficient with using a double-layered system. On another matter, a single flat panel of a structural system can act as a wall (fig 64 (d)) if it's ratio thickness around 1/20. The wall can be a shear wall (fig 64 (c)) or tensile membrane (fig 64 (b)) also it can form a slab (fig 64 (r & u)) (Mainstone, 2001).

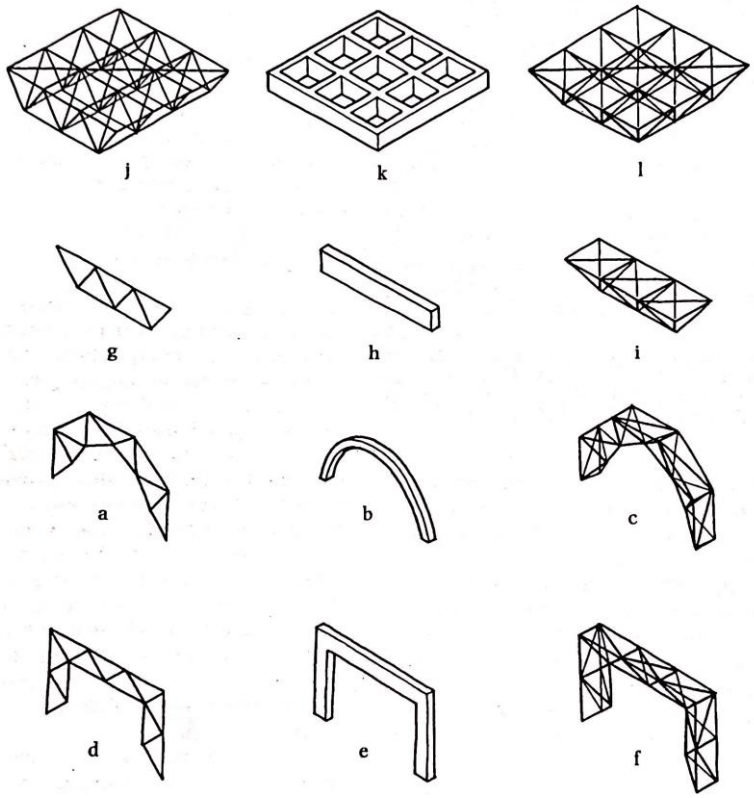


Figure 65: Structural elements forms of frames and trusses (Mainstone, 2001)

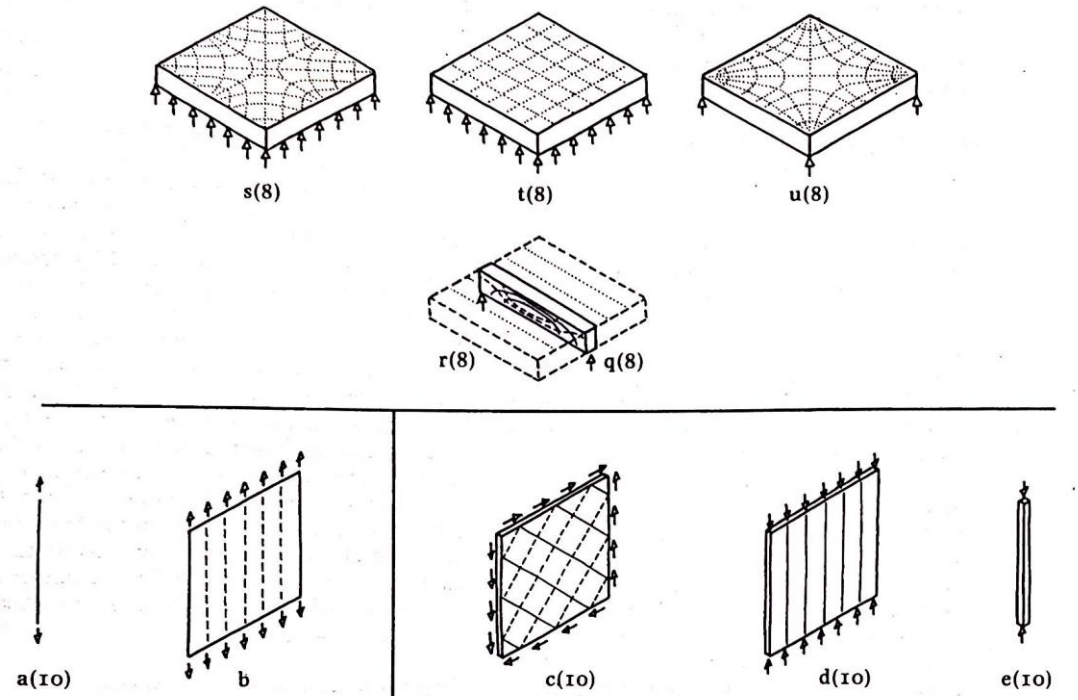


Figure 66: Structural elements of panels (Mainstone, 2001)

3.5 Formative structural elements of space

The formative elements can be also structural elements. They define interior spaces and maximize their performance. Structural elements are connected with the surroundings, such as, columns, beams, wall, floor, etc. Structural systems are aimed to control the interior design and its transparency. Formative structural elements to define space are including walls, floors, ceilings, stairs, etc. (Eisner et al., 1993).

3.5.1 Post and beams

Columns and Beams in buildings are post-and-beam structural system forming frames-structure. This system is the most common used in buildings and represents the structure of the basic forms. The system can modified with various structural arrangements. The beam (horizontal element) subjected to internal vertical and bending forces and the columns (vertical elements) are subjected to axial forces with gravitational loads. They are connected with each other with hinge joints. Two columns and beam form a panel which led to construct a wall; the wall can be loadbearing or non-loadbearing. The spans between the columns in this system are usually small (MacDonald, 2001).

3.5.2 Walls

Walls as mentioned before, they are vertical elements that have a fundamental role in defining space. Walls feature as separation between two spaces, both physically and visually (Beddington, 1982). The structural walls are bearing walls. Bearing walls are walls that have the ability to support other elements to define a space and bear the load (Ching & Binggeli, 2004). Loadbearing walls are post-and-beam systems which carry the weight of floors and roof. Generally, the walls are located parallel to each other with a separation of equal distance. Also the distance is determined according

to the planning requirement and in case of columns and beams system, it's preferred to minimize the span (MacDonald, 2001).

3.5.3 Floors

Floors in structure are also defining an interior space. Floors are where users move and carry the physical feature of space so floors need to bear all the loads above. The floors are designed with safe standards to be more efficient. With the technological development, it became easier to create different types of floor with the ability to bear loads. The floors of the interior space are considered structural floors constructed in a way to carry the loads (Ching, 1987). Slabs and beams are part of the floor systems of loadbearing structure (MacDonald, 2001).

3.5.4 Ceilings

Ceilings are parallel to floors with a certain height of the interior space according to the wanted scale. They are important to define the interior space function with its vertical dimension. The main element that covers the interior spaces are the structural ceilings. Structural ceilings are essential part of the constructed building of the structural system. Also, they are directly related to the materials of the exterior building (Ching, 1987).

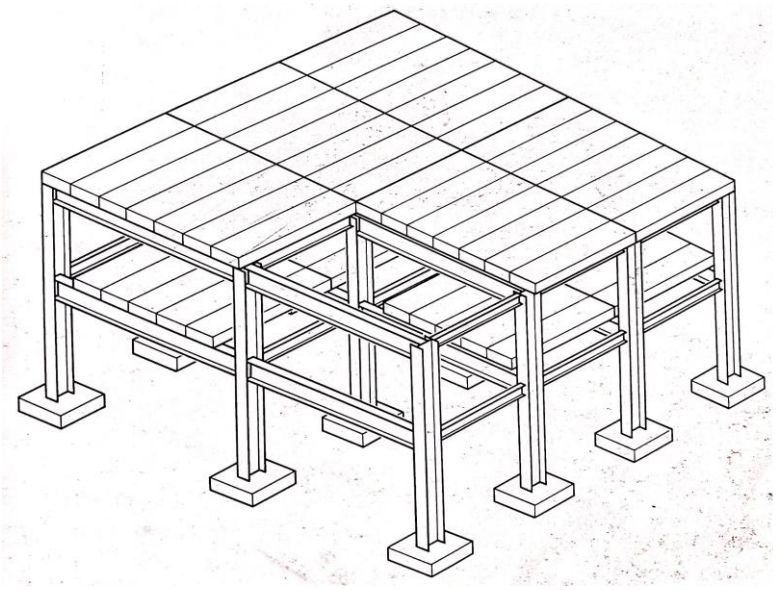


Figure 67: Structural figure shows columns, beams, roofs and floors arrangements (MacDonald, 2001)

3.5.5 Stairs

Stairs are vertical movement feature between different floor levels; transition between floors. Stairs and escalators are structural elements and they can be part of the structural system of the building (Abercrombie, 1991).

3.5.6 Trusses

Trusses are structural system used for horizontal elements of roof structure. The most lightweight type of roof trusses is the timber trusses (MacDonald, 2001). Roof trusses are parallel to beams and arches in terms of visual aspects; roof trusses can be either straight or curved. Trusses were first used for bridges and then architects and engineers begin to use them in buildings for longer spans. Truss frame are less efficient in tension than the solid frame structure, however truss can be more efficient in the form of slab or beam (Mainstone, 2001).

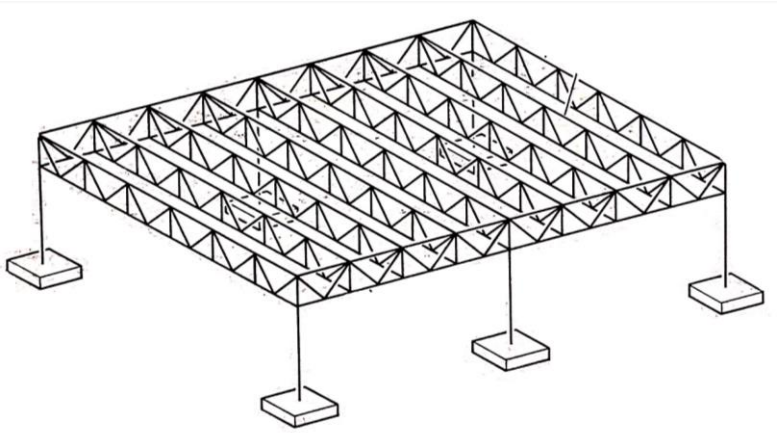


Figure 68: Struss frame of structural system (MacDonald, 2001)

3.5.7 Membrane structure

Membrane structure is a structural system formed in the 20th century which is more flexible, lightweight and easy to form. It also called as fabric structure because of its thin and flexible surface. It designed from rigid materials such as PTFE, PVC or ETFE. These materials are supported by tension, compression or bending structures such as steel columns, strong cables or truss structure which creates a unique three-dimensional shape. The membrane structure is mainly used as a roof with the advantage of lower cost and larger spans. This system used in many buildings such as theatres, stadiums, exhibitions, lobbies with large areas, entertainment centers, etc. (Supartono, 2011). The membrane structure serves as shading device, skylight or a shelter which it have the role to maintain wind pressure, natural ventilation, and solar radiation for the building (Pottmann, 2007).

Figure 69: Example on membrane structure (Schlaich, 1989)

3.5.8 Dome

Dome is structural formation that been used since ancient history. Dome is formed as a half sphere in flat surface and it built with various materials. Aesthetic form of dome can be on circle or polygon shape; it can have either curve or straight ribs. The shape of the plan defines the form of the done (circular or polygonal form) and the supporting rings in the upper and lower of the dome (Sinan, 1988). The basic form of the dome is half sphere also it can be as an ellipse, parabola or hyperbola. Moreover, the dome can be single curved or double curved shells. The weight of the dome is directly related to the ratio of thickness to span (Schueller, 1996).

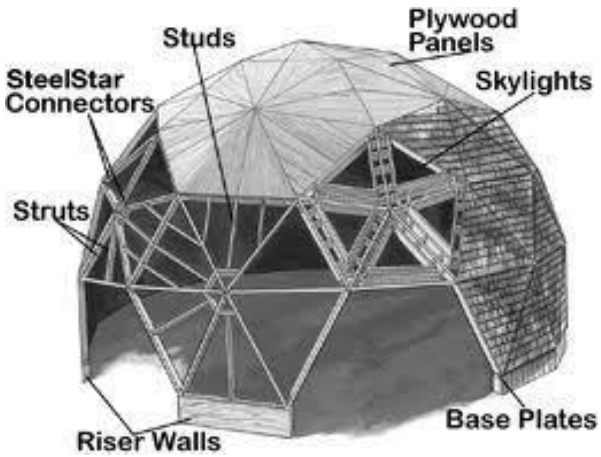


Figure 70: Skeleton of dome structure (Sinan, 1988)

Figure 71: Geodesic Dome (URL 23)

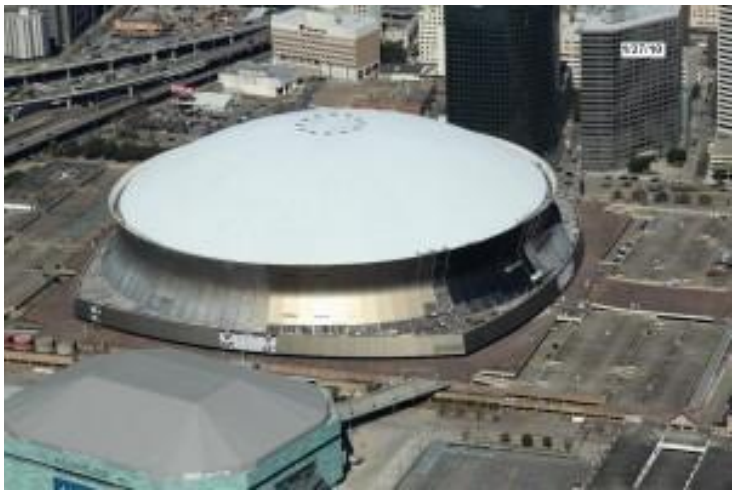


Figure 72: Lamella Dome (Schueller, 1996)

3.5.9 Shell

Shells are very thin curved membranes and structural systems. It designed with tiny bending stresses in the edges. The shape of the membrane or the shell is related to its thickness (Stroud Foster, 1976). Shells are efficient and economic structures that used in the field of engineering and architecture. Reinforced concrete shells can be used as a cover for large spans and they have two-dimensional curves and various geometrical aspects (Lozano Galant, 2009). Shell can be in various materials such as, wood, steel,

aluminum or concrete. Concrete consider as an ideal material for shell structure because they can be easily shaped and do not need for covering material (Schueller, 1996).

Figure 73: Example on concrete shell structure (URL24)

Figure 74: Example on hyperboloids of revolution, shell structure (URL25)

3.5.10 Pneumatic

Pneumatic structures are like an air balloon with pressure and compressed air. Pneumatic are skins with thin and lightweight membrane structure. The types of pneumatic structure are various including air-inflated structures and air support structures. The structure's shape can be in half cylinder or hemisphere (Yellapragada, 2010). The structure is determined by using two mechanisms: compresses air and airtight membrane. It contains carbon dioxide, nitrogen, and oxygen. Also it can be

determined by its volume, temperature and pressure. The pneumatic structure is a solid form and it can be defined with different characteristics of material and geometry (Wouters, 2010). The advantages of this structure are that it can be applied without columns and it has a low cost efficiently. On the other hand, it can reflects natural lights with the use of glowing plastic sheets which it used for the sake of simplicity and fabrication free space (Yellapragada, 2010).

Figure 75: Example on Pneumatic structure, exhibitions reached a peak the EXPO'70 in Osaka (URL266)

3.6 Conclusion

The three elements that construct a building are space, form and structure. In which space where users move through, experience and interact. Space is an invisible element that the architects and interior architects give it character based on various factors. Interior space of a building is where the building maintains its activity for the users and reflects building's typology and characteristics. Form is the exterior appearance of the building and the defining elements of the space. Finally, Structure is the system used for give the building the ability to bear loads, support defining spaces and define irregular and free-forms. Any design contains these three aspects

for providing a reliable constructed building. However, the relation between these aspects was varying between the architects. In this thesis, it will be studied the relation of space between form and structure.

This chapter contained descriptive discussion on elements of architecture and interior architectural project including space (interior space), form and structure in which they were the main considerations for major architects of the 20th century. Each element was studied in terms of its characteristics and defining elements in order to develop further analysis for the case studies. First, an analysis was based on the different aspects that the architects concerned which they are the space, form and structure. After that, extending the analysis of each aspect of each case in presenting their features and defining elements based on this chapter descriptive. They are the main points in studying the relation of interior space with form and structure. Following is the tables (table 2 & 3) that will be used for the comparison between space, form and structure for each case and between all the cases; table 2 is for analyzing the interior spaces, formal appearance and structural formation characteristics in terms of views and 2D and 3D dimensions perspective. On the other hand, table 3 is a checklist represents all the discussed aspects and for the analysis to check the related aspect for each case.

Table 2: Analytical table for analyzing case studies in terms of interior spaces, formal appearance and formative structure: Source: author

<table>
<tr><th colspan="2">Interior space</th><th colspan="2">Formal appearance</th><th>Formative Structure</th></tr>
<tr><td>Interior Views</td><td></td><td rowspan="2">3D-formation</td><td rowspan="2"></td><td rowspan="4"></td></tr>
<tr><td>Functions</td><td></td></tr>
<tr><td>Plans</td><td></td><td rowspan="2">Elevation</td><td rowspan="2"></td></tr>
<tr><td>Section</td><td></td></tr>
</table>

Table 3: A checklist table to be used for analyzing different case studies in terms of their space, form and structural characteristics: Source: author

Specifications of architectural project — Space

	Space																			
Architectural elements	Planning and geometry		Spatial relation				Circulation		Function							Space organization				
	Regular plans	Irregular plans	Space within a space	Interlocking spaces	Adjacent spaces	Spaces lines by a common space	Exterior circulation	Interior circulation	Libraries	Galleries	Auditorium	Exhibitions	Conferences	Youth activities	Others	Centralized organizations	Linear organizations	Radial organizations	Clustered organizations	Grid organizations
Case study																				

Specifications of architectural project — Form

	Form															
Architectural elements	Architectural defining elements		Formative elements					Form organization					Geometry and form			
	Horizontal elements	Vertical elements	Walls	Floors	Ceilings	Stairs	Apertures	Centralized organizations	Linear organizations	Radial organizations	Clustered organizations	Grid organizations	Regular forms	Irregular forms	Transformation Form	Free-Form
Case study																

Specifications of architectural project — Structure

	Structure									
Architectural elements	Formative structure of space									
	Post and Beams	Walls	Floors	Ceilings	Stairs	Trusses	Membrane structure	Dome	Shell	Pneumatic
Case study										

Chapter 4

ANALYSIS OF SELECTED CASE STUDIES OF CULTURAL CENTERS IN TERMS SPACE, FORM AND STRUCTURE

The role of interior space will be studied by various constructed buildings which will be analyzed. Studying this manner in constructed buildings will build reliable outcomes on the influence of the interior space. On the other hand, architecture and interior architecture are categorized buildings in various types and each type has different characteristics according to users' needs and requirements. After conducting a research, it was chosen to use cultural centers for two reasons: the design of cultural centers varies from one building to another according to the variety of functions and the culture of the city. Moreover, the lack of researches conducted on cultural centers and their design criteria.

This chapter will include various sections: background on the architectural project specifications of cultural centers, methods of analysis, and criteria for cases' selection, analytical descriptive of the selected cases, and finally, a conclusion summarizing the outcomes from the analysis.

4.1 Background on the architectural project specification of cultural centers

Cultural centers are related to both culture and future of the city. They contains cultural facilities which represent the culture and history of the city, also they show the development towards the future of that city (Wei & Guo, 2014). Cultural programs are considered as a creative development since everyone can participate (Koch, 1979). Building a new cultural center in an area; it will become the essence of the culture of that area. In result, it will affect the residents' cultural lives and create a social space (Mackeith, 2001). Cultural centers are one of the most important public buildings in a city. It enhances the residents' life and activities for the city. There are various influences of cultural centers on the city as followed: "Promoting the rapid development of regional economy", "To meet the diversified needs of the public", "To solve the problem of employment of city resident", and "To enhance the whole cultural image of the city" (Wei & Guo, 2014).

Spaces in cultural centers, according to Kahya, Salman, & Akin (2004) are various including "groups of spaces, namely, educational concerts, administrative rooms, social and recreational spaces and technical spaces". Usually spaces are arranged with one main function and the other functions as services. Mainly, all the functions are connected with corridors (Kahya et al., 2004). Interior functions are presented using public definitions to accommodate the idea of cultural centers. Functions are stronger and more reinforced when they composed together as a whole unit (Sumita, 2011). Cultural centers are usually containing three to four functions, but they can be more complex composition with six and more functions (Yang et al., 2017). Cultural

centers are include functions such as, libraries, galleries, museums, theatres, exhibitions, conferences, youth activities, etc. (Hung et al., 2013).

Cultural centers are designed with a specific theme. For instance, Shenzhen new cultural center are designed using the concept of “cultural forest” which organize functions closely like a tree (Nan, 1997). Another functional organization is by design strategies. For example, National cultural center in Germany by Zaha Hadid is free-form architecture designed with a flexible layout and present a new study of functional organization (Koopmans & Statham, 2003). Also, Functions can be organized by integrating two different layouts as in Tongan cultural center which create a unity between the cultural center, the surrounding pars, roads and landscape (Huang et al., 2009).

The arrangement of spaces can be in a single form and or various forms with connection which build a complex formation. In both cases they will have cultural value. The proportion of cultural centers is usually large (Hung et al., 2013). Han and Feng (1999) categorized the cultural centers into four modes depend on groups of functions. First mode is public display which represents art, culture and urban improvement through exhibition. The main features are museums, art galleries and exhibitions. If the main function is the exhibition hall and the secondary spaces such as, art, history, domestic culture, science and technology, etc. Second mode is performances; a building for performing art, music, facial expression and movie research. Third mode is both drama and cultural displays. The functions are comprehensive and more organized. Forth mode is mixed type. This type contains two or more cultural functions (Han & Feng, 1999).

4.2 Method for analysis the case studies

This chapter analyzes and documents various case studies of cultural centers during the 20th century onwards with the three aspects that discussed in the literature review: space (interior spaces), formal appearance and structure. Two tables will be used as analytic criteria that were developed throughout the literature review (table 2 & 3). Table 2 will display technical drawings and 3-dimensional views for each case. The discussion parts of the drawings are emphasized by highlighting them to study the different relations. Table 3 is a checklist with all the discussed aspects in the literature review; the checklist will distinguish the used character for space, form, and structure for each case in a simpler and summarized presentation. Each building will be discussed and analyzed according to these tables to understand its features and the relation between the different aspects of the interior architecture. Then, a comparison between all the buildings will be conducting to compare their elements using the checklist.

The cases are documented as followed: The building will start with a brief description of the building in terms of architect, location, area, year of construction, and the concept behind the design. Then analyze the building's characteristics within the two tables. First, the use of table 2 to present the technical drawings and views of the building within three categories: Space, formal appearance and formative structure of the building. Space will contain different sections including interior views, functions, floor plans and sections. Form will include the exterior views, 3-dimensional modeling and elevations. Finally, the structure will include the used structural systems and elements. Second, the use of the checklist (table 3) to assign the main characteristics of the building and which one is using. Then, analyzing the

plan and interior spaces of the cultural center and compare them with its formal appearance and structural systems (fig 74). After that, two descriptive discussions will implement: the relation of space to the formal appearance and the relation of space to the structural systems. The space-form relation will study whether the space characteristics are related to the final formation of the building. The space-structure relation will study whether the space characteristics and needs re related to the used structural system and elements. This procedure will be used to each case individually. Finally, the results of these relations for all the cases and their checklists will be compared and analyzed together to build an understanding of space-form and space-structure relations in cultural centers and their role in creating united and continuous designs; whether it's important to maintain these relations or not.

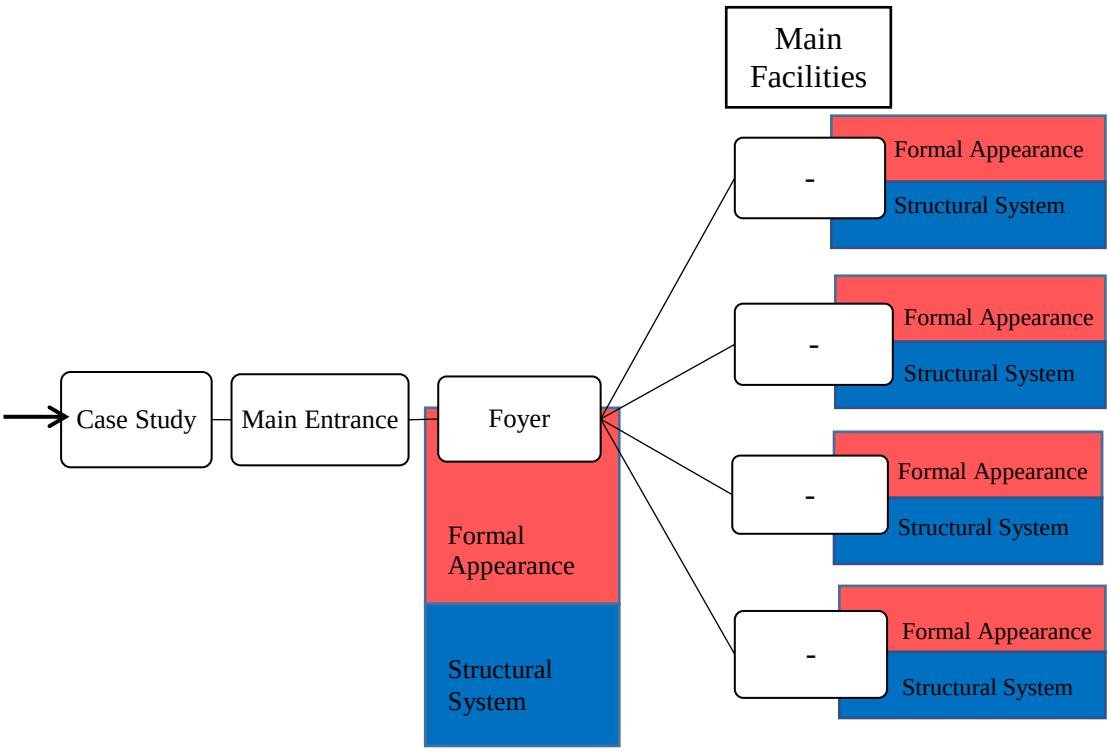


Figure 76: Method of analyzing the case studies (Source: Author)

4.3 Criteria for cases' selection

The investigation on the relation of space with form and structure is studied by analyzing cultural centers. The selection of cultural centers as case studies, as discussed before, was decided for the lack of research done on cultural centers and the importance of cultural centers in the cities with its large scale and various functions. The selection of buildings of cultural centers will be based on:

- International case studies: Buildings from various regions to expand the scope of the studied area.
- Known architects: It will be preferred to select buildings for internationally-known architects so the building analysis will be more reliable.
- Significant buildings: The cases will be selected regarding their importance in the urban fabric.
- Diversity of designs: Various case studies with different functions and appearances for the comparison.
- Diversity of year of construction: Various buildings in different decades in the twentieth century onwards.

4.4 Selected buildings

Table 4: List of the selected case studies of the analysis

Case study	Architect	Decade
House of Culture	Alvar Aalto	1950s
Wolfsburg Cultural Centre	Alvar Aalto	1960s
The Centre Pompidou	Renzo Piano & Richard Rogers	1970s
Tjibaou Cultural Centre	Renzo Piano	1990s
Lucerne Culture and Congress Centre	Jean Nouvel	1990s
Casa da Musica	OMA	2000s
Heydar Aliyev Center	Zaha hadid	2010s
Teopanzolco Cultural Center	Isaac Broid & PRODUCTORA	2010s
Bergama Cultural Center	EAA - Emre Arolat Architecture	2010s
l'Étoile, Scène de Mouvaux	Atelier d'architecture King Kong	2010s

4.4.1 Case 1: House of culture

Table 5: House of culture

(URL 27)

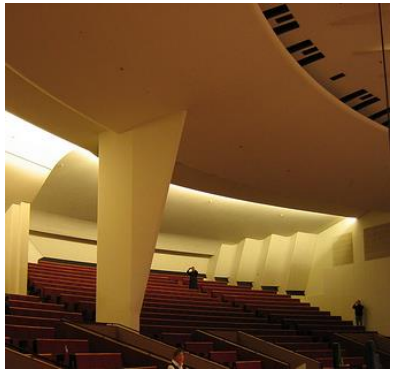
(URL29)

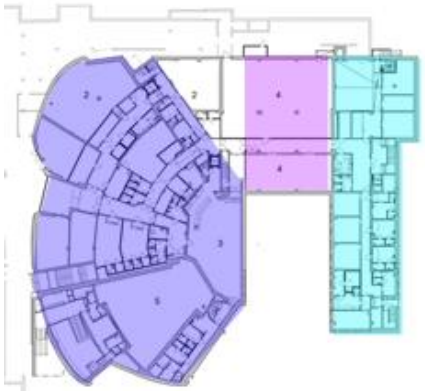
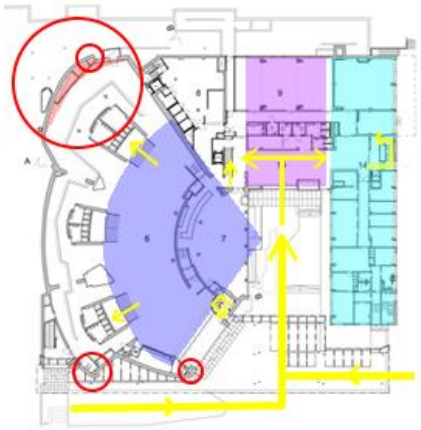
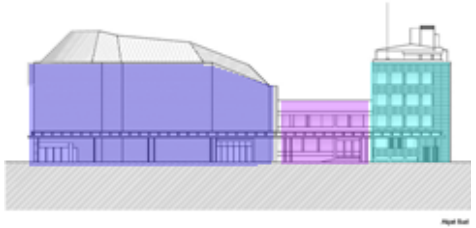
Location	Helsinki, Finland
Architect	Alvar Aalto
Year of construction	1955
Floor Area	-

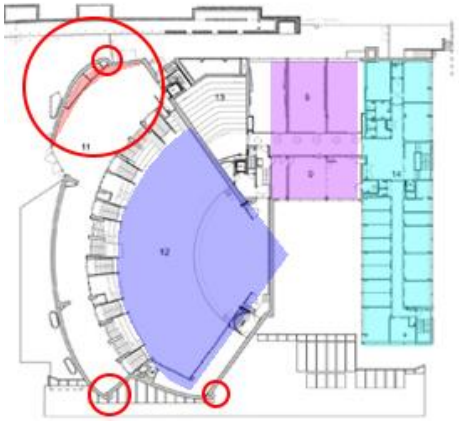
House of Culture (Kultuuritalo in Finnish) is a significant concert venue in Helsinki. The centre contains three parts: rectangular-shaped offices block, curved auditorium, and the part that connects them. The distribution of the three parts is according to the program of each part. The centre represents many political ideologies so the building needed to serve many facilities related to administrative and bureaucratic work and they are separated as an individual part. Also, it is designed for public use so there are many facilities for public events and they are in a separated part. And the entrance and the connection between both of them are a third part.

Table 6: Interior space, formal appearance and formative structure of the House of culture

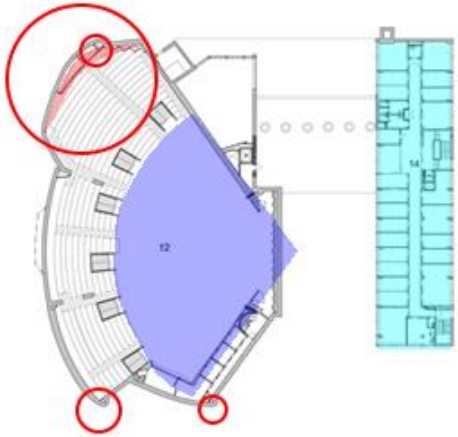
Interior space		Formal appearance		Formative Structure
Interior Views	 (URL27)   (URL29)	**3D-formation**	  	  (URL28)

	 (URL37)		 Exterior views (URL28)	 (URL30)
Functions	- Auditorium - Offices - Conference room - Restaurant - Library - Meeting room - Gymnasium			

Plans	Auditorioum Foyer Administrative Block Circulation and Entrances Discussed Elements  Basement Floor Plan  Ground Floor Plan	**Elevation**	 Fornt view (URL30)	



First Floor Plan



Second Floor Plan

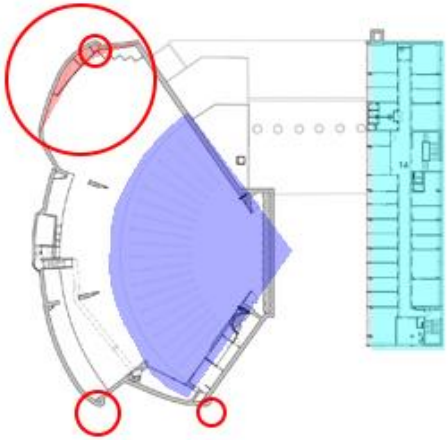
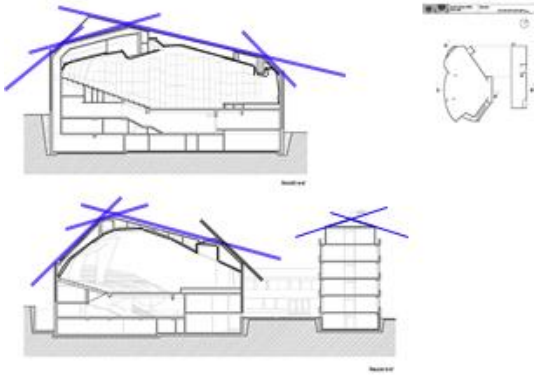
	 Third Floor Plan (URL30)			
Section	 Sections (URL30)			

Table 7: A checklist of the space, form and structural characteristics of the House of culture

Specifications of architectural project				
Architectural elements				**House of Culture**
Structure	Formative structure of space	Pneumatic		
		Shell		
		Dome		
		Membrane structure		
		Trusses		
		Stairs		
		Ceilings	✓	
		Floors	✓	
		Walls	✓	
		Post and Beams	✓	
Form	Geometry and form	Free-Form		
		Transformation Form		
		Irregular forms	✓	
		Regular forms	✓	
	Form organization	Grid organizations		
		Clustered organizations	✓	
		Radial organizations		
		Linear organizations		
		Centralized organizations		
	Formative elements	Apertures		
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
	Architectural defining elements	Vertical elements	✓	
		Horizontal elements	✓	
Space	Space organization	Grid organizations		
		Clustered organizations	✓	
		Radial organizations		
		Linear organizations		
		Centralized organizations		
	Function	Others	✓	
		Youth activities	✓	
		Conferences	✓	
		Exhibitions		
		Auditorium	✓	
		Galleries		
		Libraries	✓	
	Circulation	Interior circulation		
		Exterior circulation	✓	
	Spatial relation	Spaces lines by a common space	✓	
		Adjacent spaces		
		Interlocking spaces		
		Space within a space		
	Planning and geometry	Irregular plans	✓	
		Regular plans		

Space-form relation:

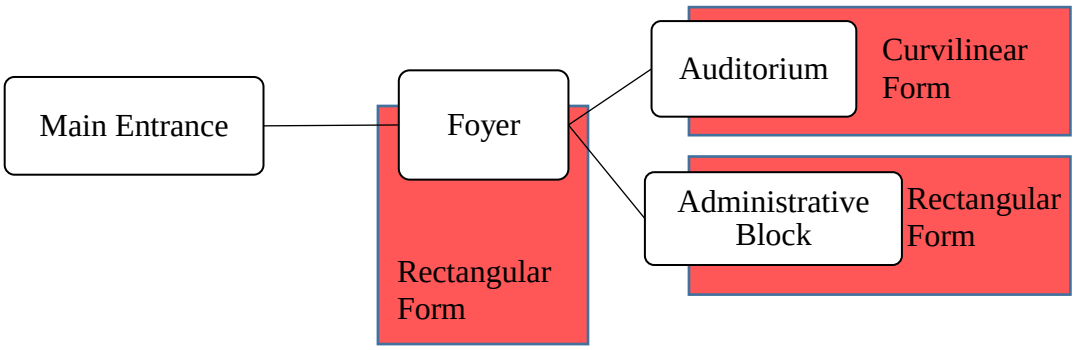


Figure 77: Space and form analysis of House of culture (Source: Author)

House of Culture contains three parts which they highlighted in the ground floor plan and the Front elevation: Foyer (in purple), auditorium (in dark blue), and administrative block (in light blue). The main part of the cultural center is the auditorium with 1500 seats. However, each part is indicated as a separate space which in regards separate forms. Also, the ground plan shows the horizontal and vertical circulation towards and within the building.

The planning and interior spaces of the center are emphasized as following (shown in the plans): The exterior circulation begins from the front façade leading to the main entrance of the center. The main entrance is defied by the auditorium and the offices and it leads to a foyer space that connects the two main facilities together by horizontal circulation. The foyer considers as a common space between the two main buildings and contains common facilities. The main two building are contains several floors that are connected with vertical circulation. The auditorium building is mainly consists the hall but it also have several other facilities which have been hidden in a basement floor. The other building consists of standard offices and conference rooms.

The definition of formal appearance: The auditorium and the administrative block are larger in forms than the foyer to define the main entrance. The foyer is designed as a separate part; it was designed with lower height and thinner spaces. Also, the formal appearance followed the square geometry of the plan and a visual connection between the two main buildings creating a cubic form as shown in the technical drawings and 3D views. The foyer space as a function aims to introduce the main facilities to the users and welcome them into the center. However, the welcoming space in the foyer is deficient in terms presenting the importance of these buildings; as it does not offer a strong character that introduce the two parts. Exterior form of the foyer part is also poorly reflecting the importance of the foyer as it's not distinguished from the other parts especially the administrative block.

The auditorium building is the main part of the center so it was distinguished from the other parts. The auditorium is mainly shaped as a sector of the circle but the curved line was shifted to maximize the space to the edges of the site as shown in the plans (dark blue). This causes to create several curved lines and angles. The auditorium has a large number of seats so the scale of the interior space is massive. Interior space has several types of solutions at horizontal and vertical space defining elements. The usage of base plane gave opportunity to create level differences to increase the number of the audience in the hall and their visual connection to performance area. On the other hand vertical overhead and vertical planes have contributed to spatial unity to define boundaries for the performance hall and additionally solved lighting and especially acoustic needs of the space. This led to form an irregular ceiling and to even this out the roof lining followed the direction of this irregularity to form the roof (sections). The surface of the interior space reflects

simplicity in design to prevent any distractions in the hall so the stage will be the focal point. However, the importance of the space is being reflected in the exterior appearance which shows a strong solid massive form with red brick texture representing the large scale of the interior space and captures the significance of the hall. On the other hand, the exterior form contains many curved and circular edges with no relation to the interior space (red circles in plans). Also, there is a space in the auditorium that shows the curved element (red colored in the plan, top left) as deformed from the circular curved with no relation or need to create that space.

The third part of the building, called the administrative block, contains mainly offices in the form of rectangular (light blue in the plans). The interior spaces have standard functions with rectangular layout and the exterior form followed a rectangular shape (compare plans and elevation). The exterior appearance of the administrative block is distinguished from the auditorium as less eye-catching design. At the same time, it reflects the spaces' functions of the office as repetitive rectangular spaces.

Space-structure relation:

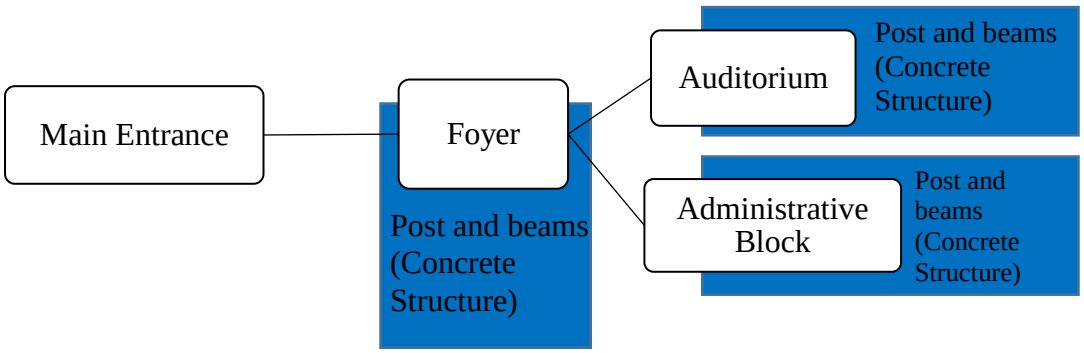


Figure 78: Space and structure analysis of House of culture (Source: Author)

The main facilities of the center are the foyer, auditorium and administrative block. For the building, a structural system must be applied to carry the loads and support the spatial and formal correction. The structure of the House of Culture is mainly with the use of loadbearing walls which is post and beams structural systems as shown in the formative structure (table 6). The main part of the center is the auditorium. The auditorium building is large in scale according to the scale of the interior space. So the used structural system is a concrete skeleton and v-columns as shown. The use of the concrete is strongly indicated from the interior views. However, for the exterior it was used red brick cladding to create a stronger appearance than the concrete and highly distinguished design as an important part. On the other hand, the use of column in the hall may cause physical and visual blocking for the audience. A column-free area can be more suitable for an auditorium which can maintain a free-visual space towards the stage. The concrete and post and beams system is used in the administrative block and the foyer. The exterior cladding of the administrative block is a copper material opposing the auditorium part to differentiate between them. Also, it preserves the repetitive in the spaces of the offices. The foyer follows the same structure and cladding system which diminish its own individual character which is not competitive with auditorium part and implying a minor focus on formal appearance.

4.4.2 Case 2: Wolfsburg cultural center

Table 8: Wolfsburg cultural center

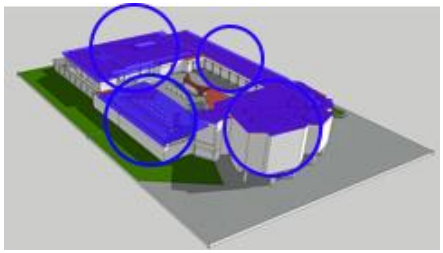
(URL 31)

(URL34)

Location	Wolfsburg, Germany
Architect	Alvar Aalto
Year of construction	1962
Floor Area	-

Wolfsburg Cultural center aims to provide a relief area from the industrial life for the citizens. The feature of the center is containing all cultural facilities in one building for the city including spaces for meetings and cultural activities. Also, it serves all the citizens of both genders and different ages. The building is divided into four parts: library, adult college, youth center, and business offices. Each part is designed in a separate group in the form of faculty around a central square. Alvar Aalto gave attention to both exterior features and interior design for the building.

Table 9: Interior space, formal appearance and formative structure of the Wolfsburg cultural center

Interior space		Formal appearance		Formative Structure
Interior Views	  	**3D-formation**	 3D Modeling (URL35)  	  (URL34)

(URL34)

(URL34)

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(URL33)</td>
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<td>- Offices
- Library
- Children’s library
- Auditorium
- Workshop
- Conference rooms
- Courtyard</td>
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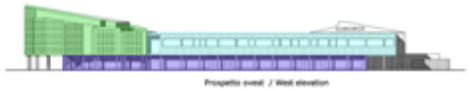
<tr>
<td>Plans</td>
<td> 
Top floor plan</td>
<td>Elevation</td>
<td>Foyer
Auditorium and adult center
Library and conference rooms
Youth center and children’s department
Business spaces
Club rooms
Workshops
  </td>
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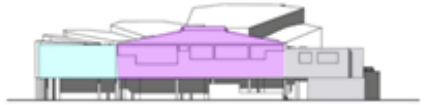
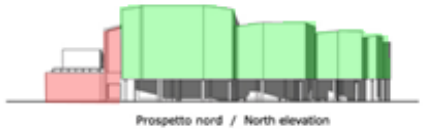
</table>

Foyer
Auditorium and adult center
Library and conference rooms
Youth center and children's department
Business spaces
Club rooms
Workshops
Circulation and entrances

Ground Floor plan

First Floor plan (URL31)





(URL32)

Section	 Sections (URL31)			

Table 10: A checklist of the space, form and structural characteristics of the Wolfsburg cultural center

Specifications of architectural project				
	Structure	Formative structure of space	Pneumatic	
			Shell	
			Dome	
			Membrane structure	
			Trusses	
			Stairs	
			Ceilings	
			Floors	
			Walls	
			Post and Beams	✓
	Form	Geometry and form	Free-Form	
			Transformation Form	
			Irregular forms	✓
			Regular forms	
		Form organization	Grid organizations	
			Clustered organizations	✓
			Radial organizations	
			Linear organizations	
			Centralized organizations	✓
		Formative elements	Apertures	✓
			Stairs	
			Ceilings	
			Floors	
			Walls	✓
		Architectural defining elements	Vertical elements	✓
			Horizontal elements	✓
	Space	Space organization	Grid organizations	
			Clustered organizations	✓
			Radial organizations	
			Linear organizations	
			Centralized organizations	✓
		Function	Others	✓
			Youth activities	✓
			Conferences	
			Exhibitions	
			Auditorium	✓
			Galleries	
			Libraries	✓
		Circulation	Interior circulation	✓
			Exterior circulation	✓
		Spatial relation	Spaces lines by a common space	
			Adjacent spaces	
			Interlocking spaces	✓
			Space within a space	
		Planning and geometry	Irregular plans	✓
			Regular plans	
	Architectural elements			**Wolfsburg Centre**

Space-form relation:

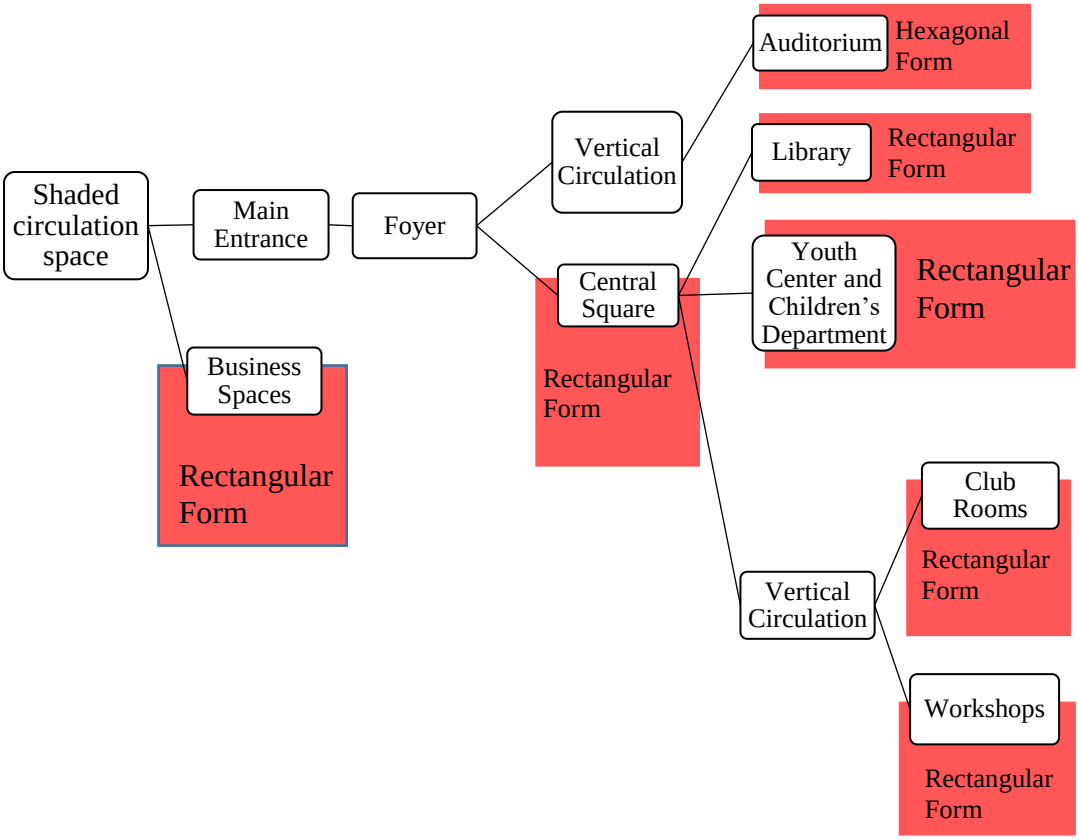


Figure 79: Space and form analysis of Wolfsburg cultural center (Source: Author)

Wolfsburg Cultural center contains various parts and each part has a separated volume design and they are distributed in ground and first floors. It contains auditorium and adult center, library, business spaces, youth center and children's department, workshops, and club rooms. The spaces are located and directed towards a central square space which connects all of them together except the business spaces which have only external entrances. Moreover, regarding the intensive facilities, the architect is using skylights beside the window openings for natural lightings.

The planning and interior spaces of the center are emphasized as following (shown in the plans): The different colors in the plans show the different parts and connections. The ground floor plan is being pushed back to create an exterior circulation to define the entrance to the building and the business spaces (in yellow). However, the main entrance is being defined by the massive and distinguished form of the auditorium and adult center (in green). The floor plans indicate the circulation of the different parts. The main entrance leads to the foyer which leads to either the auditorium and adult center or the central square. The central square leads towards the various functions in the ground and first floors. The two floors are following the same layout with separated space organizations.

The definition of formal appearance: The central space is defined in the ground floor as a central square space. The central space is defined with a depressed plane (section, blue frame) and the ceiling of this part is depressed comparing to other forms (3D modeling and sections) as if it gather all the spaces in this focal point. The depressed level of the space and form gave the sense of transition from one area to another (shown in volumetric articulation). Also, the space contains a central skylight with relatively large in size which differentiate it more as a central space.

The ground floor is mainly distinguished with the shaded space or the openings in the facade. The ground floor contains business spaces with an only entrance from the shaded space. It's the least obvious form but it distinguished with full glass regarding the functional purpose; business spaces require visual access with the exterior. The business spaces mainly for stores and they are not main functions in the cultural center so they are visually hidden beneath the cultural facilities. Also, the center

contains a youth and children department. This part is distributed in the ground and first floors with an entrance from the exterior and from the central square. The facilities are varies in scale and cause an irregularity in the plan but it merge with the other facilities. The department is mainly offices and not related with the public use so it located in the back of the building with less obvious formal appearance. However, is being distinguished as a whole block with different openings than the other parts. The window openings reflect the repetitive of the offices spaces of the department (grey in elevation). Then the library part and the conference rooms, it's a large and important space in the building with one floor height. The height and the scale of the space identify it as a separated large volume. The distinguish feature of this part is the one floor height with a relatively large scale according to the interior space and the plane elevation with no openings (red in elevation). The natural light is accessible though the skylights.

The first floor contains groups of spaces that defined in various visual forms and openings. The auditorium in the adult center has a functional relation with the form. The auditorium requires relativity a large space. It shaped as a hexagonal geometry according to the seat distribution towards the stage with maintaining straight lines. The other facilities are the lecture halls and they all arranged around a main space. The space shape of the lecture halls follows the same geometrical concept which gave this part a strong identifiable appearance. The auditorium is the larger form and while the lecture halls have the same shape, they are reducing in size until it reaches the other part of the building to create a continuous connection. The forms contain no openings to present a solid and strong appearance considering they direct towards the main entrance. However, the natural lights are accessible through skylights (green in

plan and elevation). The workshops are connected with the lecture hall. They are shaped with standard square geometry for an educational facility with linear repetitive. The form follows the same simplicity as a linear rectangular box. This part is defined with its linear strong form and with its equal size of the openings according to the equal interior spaces (light blue in plan and elevation). Another part of the building is the club rooms in the first floor with an access from the ground floor. The club rooms are arranged around central space as an individual part. The youth center and the club rooms are in the same height. But the roof of the club rooms is distinguished with its skylight causing a higher roof. The space organization around a central space shaped a geometrical square and the form follows the same geometry. The exterior is also differentiated by its openings that follow the interior spaces (purple in plan and elevation).

Space-structure relation:

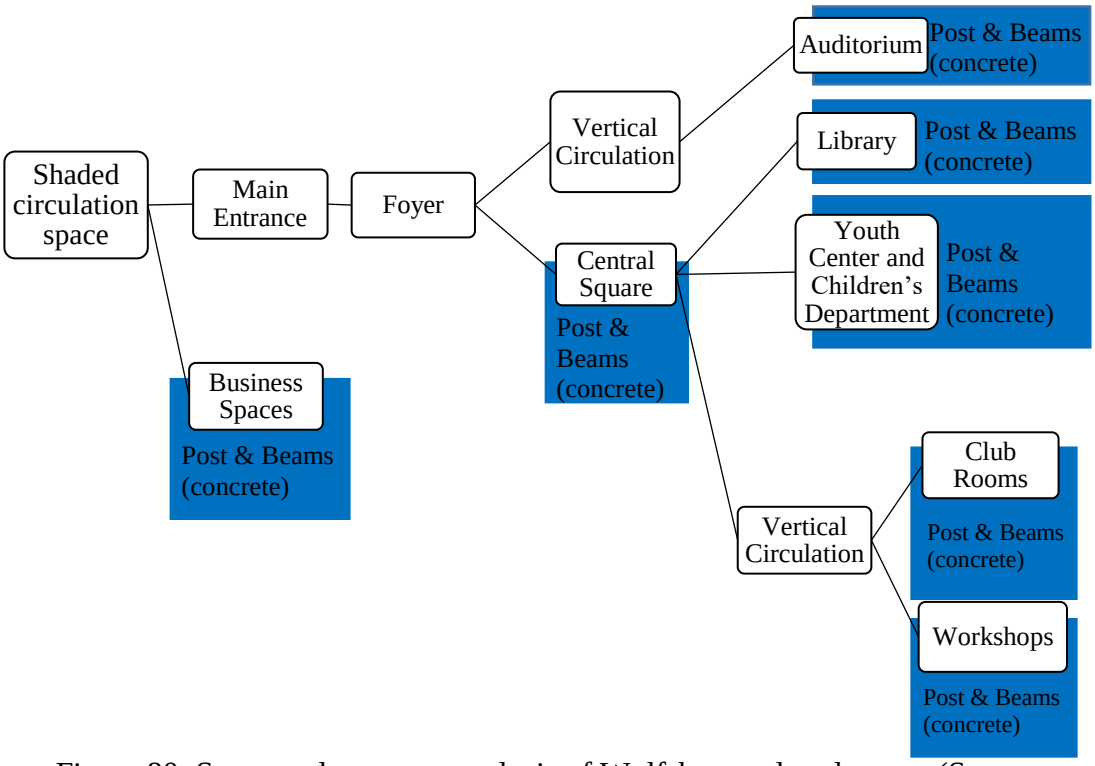


Figure 80: Space and structure analysis of Wolfsburg cultural center (Source: Author)

Wolfsburg Cultural center aims to provide a path that differentiates the various entrances. The path created by pushing the ground floor a step back. The upper floor became hanging so it has columns to support the building (structure section). In general, the all spaces in the center are not large and a P and beam system carried the loads. Also in the spaces with a larger area, columns are used in the interior spaces as needed. The center is constructed with a concrete skeleton with is distinguished in the interior and exterior of the building. However, the interior in the auditorium and lecture halls have wooden surfaces for acoustics reasons but the concrete is distinguished. Moreover, the exterior represents unity of the used material with various patterns for each part.

4.4.3 Case 3: The Centre Pompidou

Table 11: The Centre Pompidou

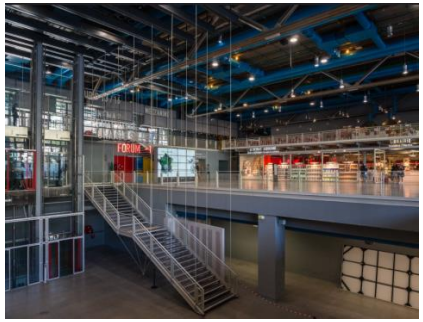
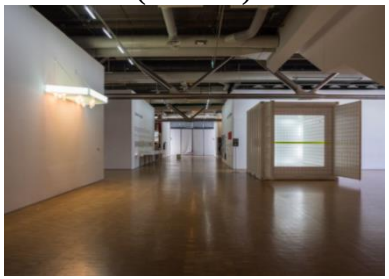
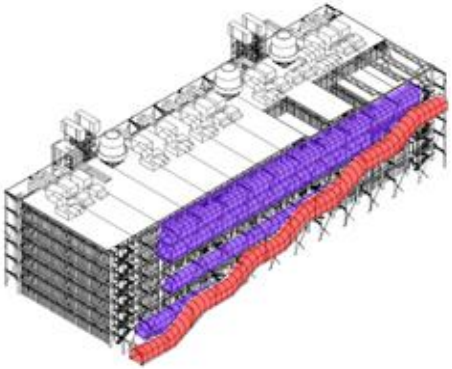
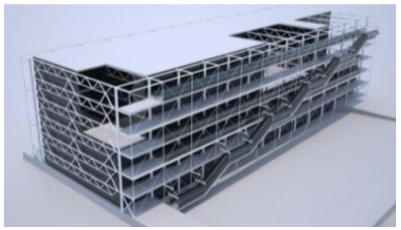

(URL 36)

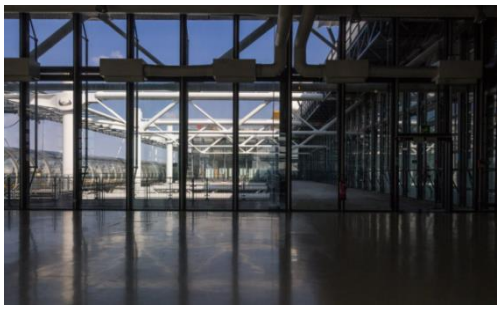
Location	France, Paris
Architect	Renzo Piano & Richard Rogers
Year of construction	1971 - 1977
Floor Area	103,305 m2

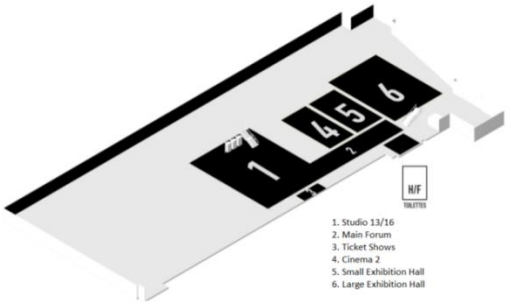
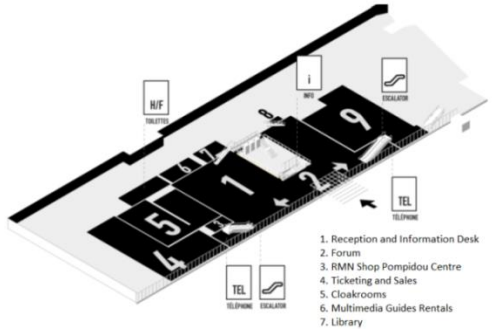
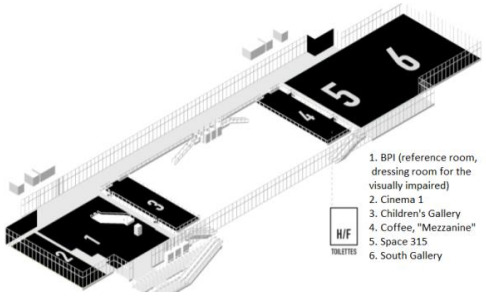
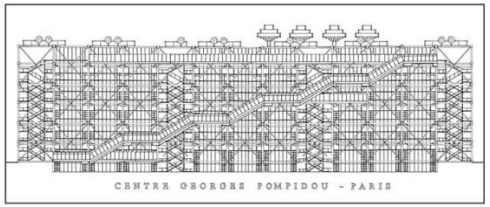
The Centre Pompidou considers a significant cultural landmark in Paris, France. George Pompidou, former president of France, wanted a new cultural center to

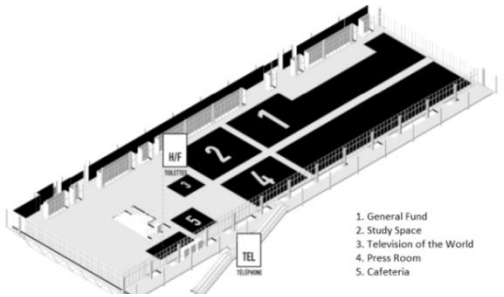
regenerate the lives in Beaubourg region and be an attraction point for the visitors and the city. Renzo Piano and Richard Rogers proposed this design in the competition. The concept of the building is to create a movement center and for the center to be structurally exposed. The Centre Pompidou contains the largest museum for modern art (Musée National d'Art Moderne), massive public library (Bibliothèque publique d'information), and music and acoustic research center (IRCAM).

Table 12: Interior space, formal appearance and formative structure of The Centre Pompidou

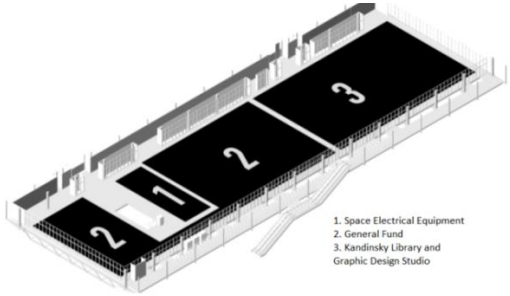
Interior space		Formal appearance		Formative Structure
Interior Views	  (URL36)  (URL37)	**3D-formation**	 Exterior view (URL41)  3D Modeling (URL42)	 (URL43)  Ventaltision components Stairs and elevator elements Vantilation Plumping and fire pipes Electrical elements Movement elements (srairs and elevator)

	 (URL38)			 (URL44)   (URL44)
Functions	- Exhibition halls - Cinemas - Shop center - Library - Music and acoustic research center - Bookstore - Galleries - Press and television room - Restaurants and cafes			

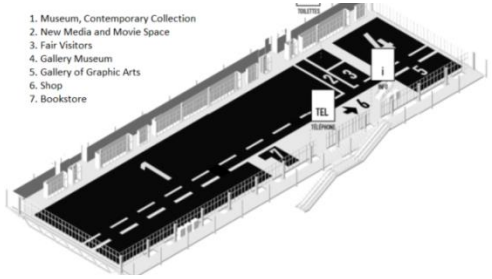
Plans	 Basement Plan  Ground Floor  First Plan	**Elevation**	 (URL46)	



Second Floor



Third Plan



Fourth Floor

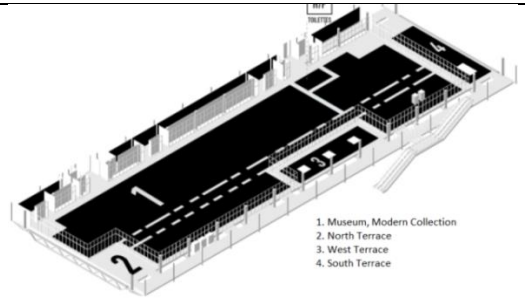
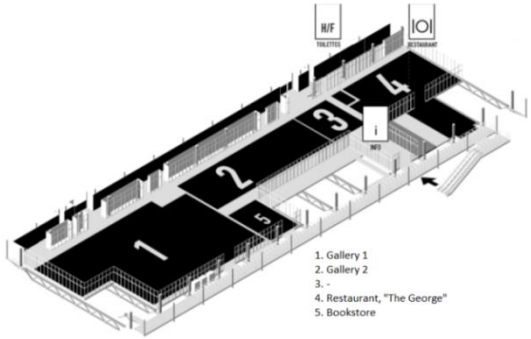
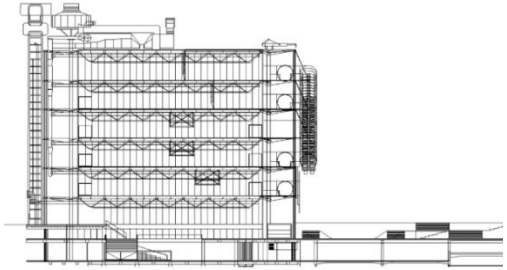
	 Fifth Plan  Sixth Plan (URL39)			
Section	 Section (URL40)			

Table 13: A checklist of the space, form and structural characteristics of the Centre Pompidou

Specifications of architectural project				
Architectural elements				**Centre Pompidou**
Structure	Formative structure of space	Pneumatic		
		Shell		
		Dome		
		Membrane structure		
		Trusses	✓	
		Stairs		
		Ceilings	✓	
		Floors	✓	
		Walls	✓	
		Post and Beams		
Form	Geometry and form	Free-Form		
		Transformation Form		
		Irregular forms		
		Regular forms	✓	
	Form organization	Grid organizations		
		Clustered organizations		
		Radial organizations		
		Linear organizations	✓	
		Centralized organizations		
	Formative elements	Apertures	✓	
		Stairs	✓	
		Ceilings	✓	
		Floors		
		Walls	✓	
	Architectural defining elements	Vertical elements	✓	
		Horizontal elements	✓	
Space	Space organization	Grid organizations		
		Clustered organizations		
		Radial organizations		
		Linear organizations	✓	
		Centralized organizations		
	Function	Others	✓	
		Youth activities	✓	
		Conferences		
		Exhibitions	✓	
		Auditorium		
		Galleries	✓	
		Libraries	✓	
	Circulation	Interior circulation	✓	
		Exterior circulation	✓	
	Spatial relation	Spaces lines by a common space	✓	
		Adjacent spaces	✓	
		Interlocking spaces		
		Space within a space		
	Planning and geometry	Irregular plans	✓	
		Regular plans		

Space-form relation:

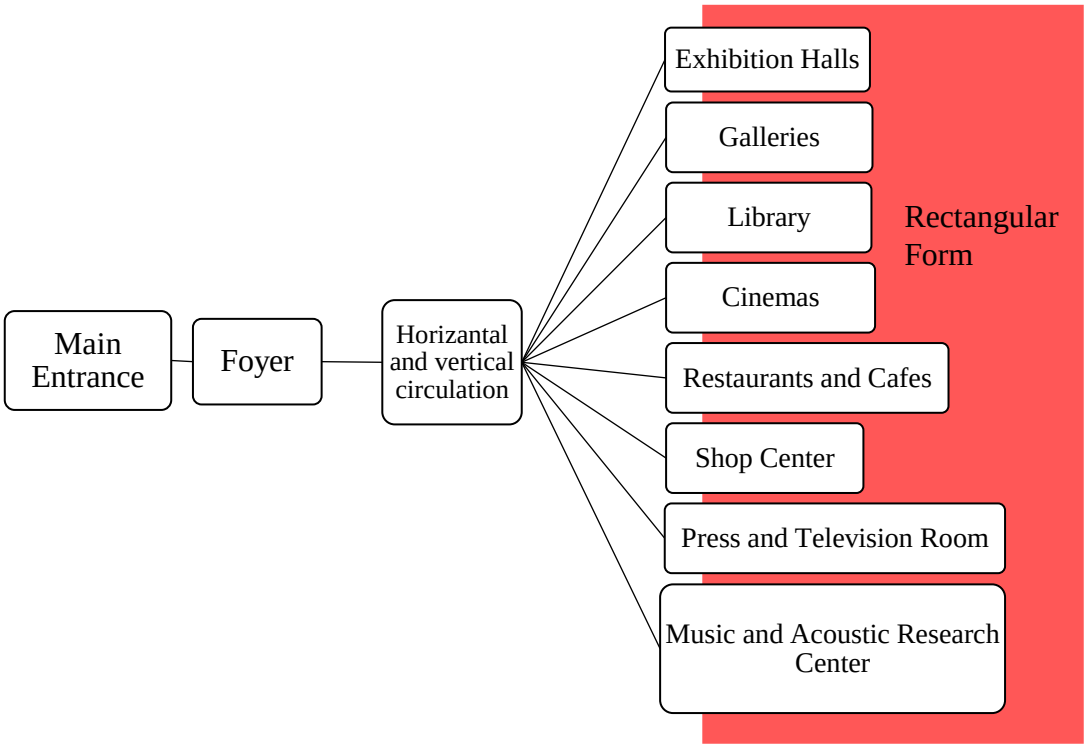


Figure 81: Space and form analysis of Centre Pompidou (Source: Author)

Centre Pompidou has an industrial unique appearance with an overall rectangular geometrical form. The building contains various internationally significant facilities including exhibition halls, library, music and acoustic research center, and galleries. And it contains other facilities such as cinemas, shop center, press and television room, and restaurants and cafes.

The planning and interior spaces of the center are emphasized as following (shown in the plans): The Centre Pompidou maintains a simple floors layout. The main entrance is identified in the middle of building which leads to the foyer. The foyer is a double height area to provide visual access and introduce the building. The

wide space of the foyer creates a strong distinguished area that directs the visitors towards the facilities. The floors are connected with vertical circulation elements that are visually recognized. Moreover, the horizontal circulation is identified with the wide interior spaces and linear corridor.

The definition of formal appearance: The main entrance of the Centre Pompidou and the lobby are a double height space which creates a good transition between exterior and interior. The lobby provided a wide visual space to navigate through the building. The sense of the cuboid formative is recognized from the interior perspective especially with the used of wide space. The layout of each space for the various functions is in a rectangular shape and the best competition between them is to follow the same shape. With the plans and the general concept of the center, there is no specific space for most of the functions, rather it's a wide space with varies options that can modified according to the various events.

The different technical and structural elements of the building are identified with various colors which they are merging with the formal appearance of the center and the interior spaces. The movement and circulation element through the building, stairs and elevators, are identified by red color; the red color connects all the floors and interior space.. The center aimed for the spaces to be flexible and easily rearranged so the building services include corridors, stairs, structural membrane etc. are located on its exterior without the change of its geometrical aspects (red and blue in the 3d modeling). With the corridors and stairs position on the exterior it provided the formal appearance a functional dimension. The vertical and horizontal circulation of the building became part of the formal appearance which connected the interior

with the exterior environment. The building surface material is glass to create transparency with the exterior and separate the interior spaces from the exterior environmental conditions. The formal appearance of the building is a cuboid geometry with a rectangular elevation which reflects the concept of wide and free spaces; rectangular-shaped space can be contains any desired space arrangement to host events, exhibitions, etc.

Space-structure relation:

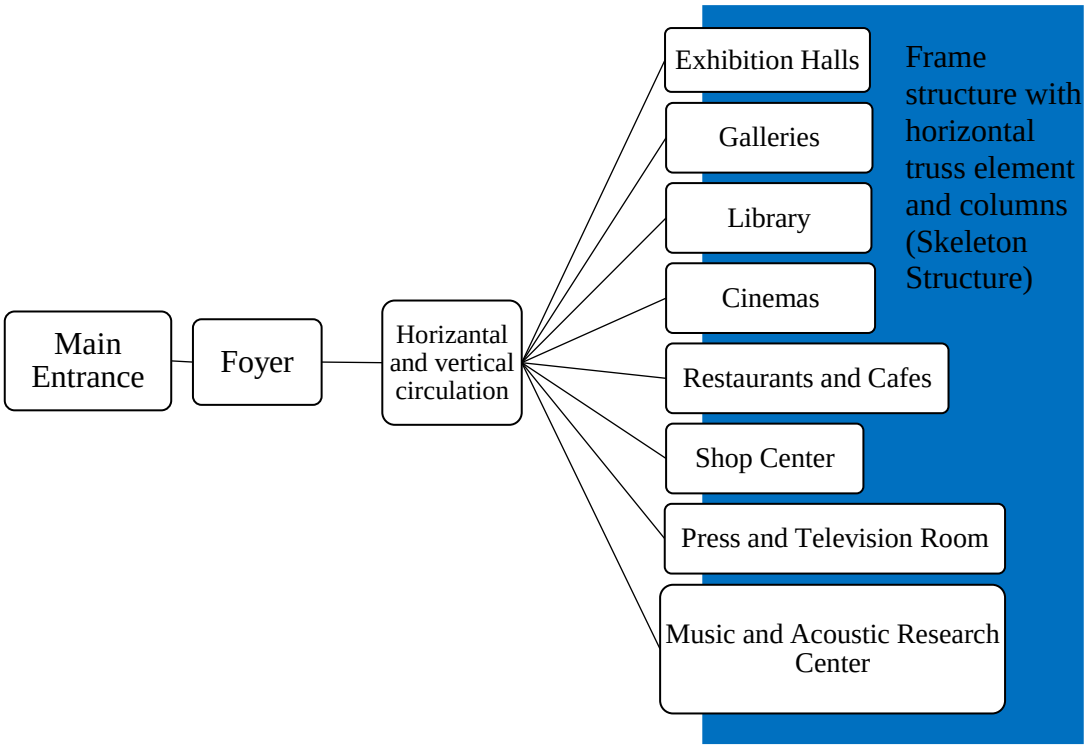


Figure 82: Space and structure analysis of Centre Pompidou (Source: Author)

Exterior appearance of the Centre Pompidou is a celebration of its structural elements. It gave the building an individual character. Structural elements are differentiated with the use of different colors to support the building and reflect aesthetic of the structure (formative structural section). The structural elements: the largest ventilation components are white, smaller ventilation is blue, stairs and

elevators structures are gray, electrical elements are yellow and orange, etc. The structure of the building is clearly shown in the exterior appearance and through the interior spaces. Moreover, the need for wide spaces and the ability to rearrange the spaces, led to the use of frame from horizontal steel trusses in which they can be used for long spans without the need of interior supported-columns. In result, it created clear and wide spaces that the users will be easily recognized. Also, the interior spaces will have flexibility with the space distribution as needed without any fixed divided elements. The center offers transparency throughout the different layers of the building which strongly emphasized the space with the all the used structural elements. Moreover, it emphasized the different parts clearly which offer strong statement for the different part of the building.

4.4.4 Case 4: Tjibaou cultural centre

Table 14: Tjibaou cultural centre

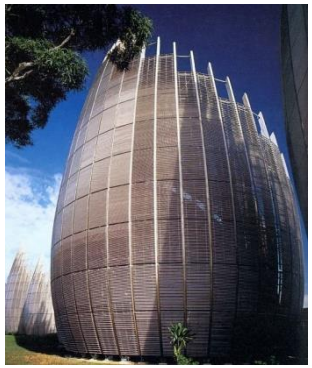
(URL46)

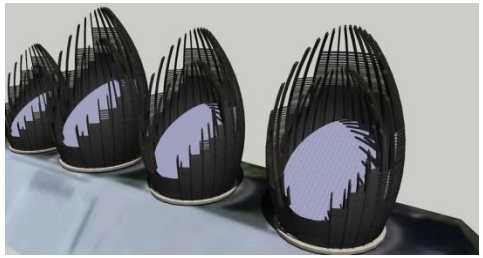
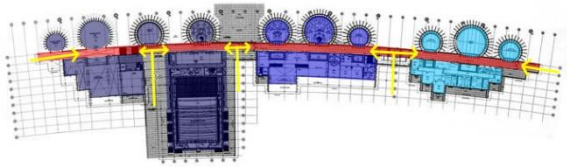
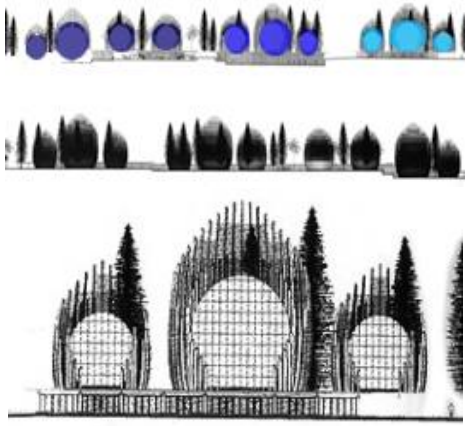
(URL47)

Location	Nouméa, New Caledonia
Architect	Renzo Piano
Year of construction	1991 - 1998
Floor Area	8550 m^2

Renzo Piano meant to create a cultural center that represents the Kanak native culture in New Caledonia, which aimed to unit both Kanak people and the other island's inhabitants. Tjibaou Cultural Centre became an international recognition. The center is inspired from the traditional Kanak houses with many modifications to create a rounded shape and shells. The center is divided into ten objects along the hills with different heights between 20 to 28 meters which serves the main activities of the villages of New Caledonia. On the other hand, In between these objects there are museum spaces that provide connections to the various enclosed spaces. The concept of Renzo Piano is to show ability to influence the site into the design.

Table 15: Interior space, formal appearance and formative structure of Tjibaou cultural center

Interior space		Formal appearance		Formative Structure
Interior Views	   (URL47)	**3D-formation**	 (URL45)  Exterior view (URL46)  Main Unit form(URL49)	 (URL51)  (URL52)

<table>
<tr>
<td>Functions</td>
<td>
- Exhibitions
- Conference room
- Library
- Media library
- Studios (music, arts, dance, painting, etc.)
- Café
- Auditorium
- Open-air theater
- Administrative offices
</td>
<td></td>
<td> 
3D Modeling (URL50)</td>
<td> 
(URL53)</td>
</tr>
<tr>
<td>Plans</td>
<td>Studios of music, Dance, Painting and Sculpture
Llibrary, Conference and Research area
Exhibitions
Circulation and entrances
Corridor
 
Floor Plan (URL48)</td>
<td>ELevation</td>
<td>Studios of music, Dance, Painting and Sculpture
Llibrary, Conference and Research area
Exhibitions
  </td>
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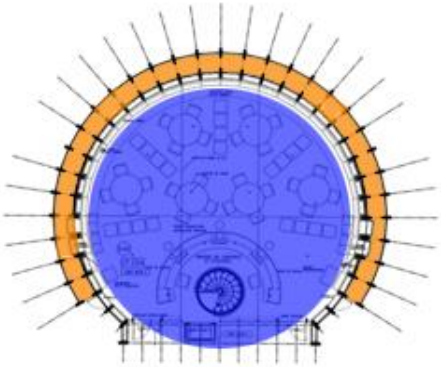
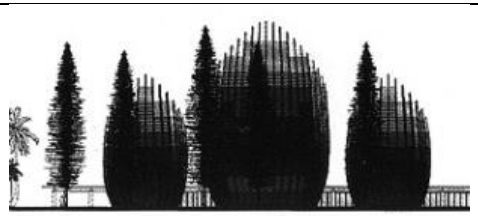
	 Plan for one unit (URL49)		 (URL49)	
Section	 (URL48)			

Table 16: A checklist of the space, form and structural characteristics of the Tjibaou cultural centre

Specifications of architectural project				
Architectural elements				**Tjibaou Centre**
Structure	Formative structure of space	Pneumatic		
		Shell		
		Dome		
		Membrane structure		
		Trusses		
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
		Post and Beams	✓	
Form	Geometry and form	Free-Form		
		Transformation Form		
		Irregular forms	✓	
		Regular forms	✓	
	Form organization	Grid organizations		
		Clustered organizations		
		Radial organizations		
		Linear organizations	✓	
		Centralized organizations		
	Formative elements	Apertures	✓	
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
	Architectural defining elements	Vertical elements	✓	
		Horizontal elements		
Space	Space organization	Grid organizations		
		Clustered organizations	✓	
		Radial organizations		
		Linear organizations	✓	
		Centralized organizations		
	Function	Others	✓	
		Youth activities	✓	
		Conferences		
		Exhibitions	✓	
		Auditorium	✓	
		Galleries		
		Libraries	✓	
	Circulation	Interior circulation	✓	
		Exterior circulation	✓	
	Spatial relation	Spaces lines by a common space		
		Adjacent spaces		
		Interlocking spaces		
		Space within a space	✓	
	Planning and geometry	Irregular plans		
		Regular plans	✓	

Space-form relation:

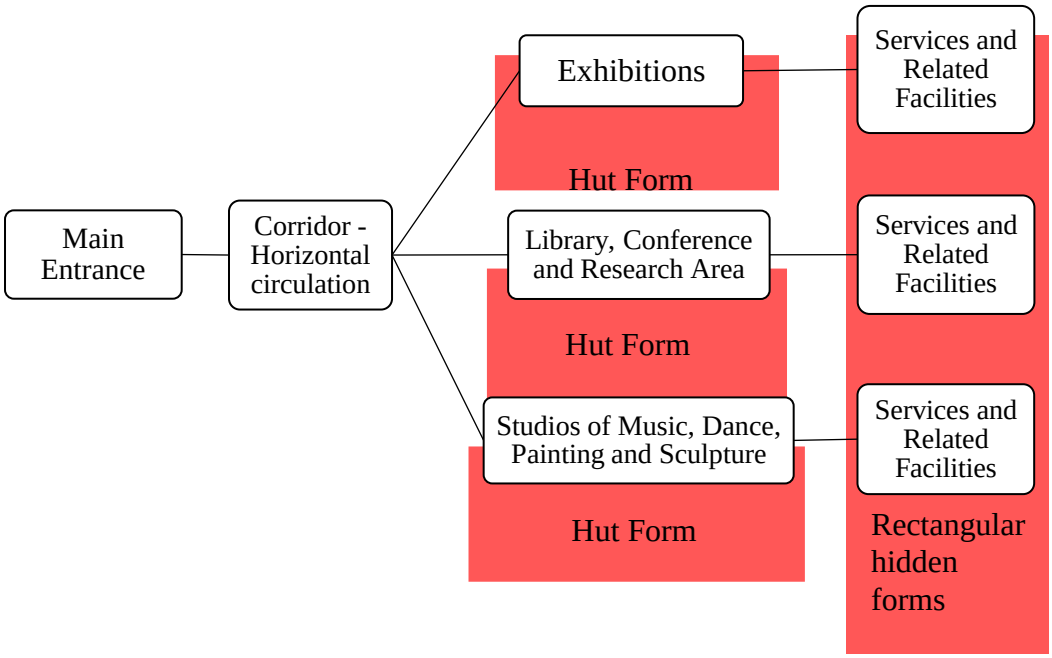


Figure 83: Space and form analysis of Tjibaou cultural center (Source: Author)

The Tjibaou Cultural Centre is an international recognition building. The center is designed on the conceptual idea to interact with the local resident. The building consists of various functions including exhibitions, conference room, library, media library, studios (music, arts, dance, painting, etc.), café, auditorium open-air theater, and administrative offices. The main facilities are organized in huts forms and other facilities are located in hidden spaces with the use of the underground.

The planning and interior spaces of the center are emphasized as following (shown in the plans): The space distribution of the center is linear organization with shared corridor to connect them (red color in the plan). The center is divided mainly into two parts along the corridor (ground plan). The first part is 10 similar forms with various sizes in the shape of huts. The 10 spaces are divided into three groups: 4 spaces for exhibitions, 3 spaces for library, conference and research area, and 3

spaces for studios of music, dance, painting and sculpture (each group in different color in the plan). The spaces in the same group are defined by distance; in the same group are relatively closer and the distance between the groups are larger. Also they are separated with doors to identify the zones. The spaces in the other side of the corridor are related facilities with the groups of huts (same color of the huts). They contain an auditorium, open air theater, workshops, administrative offices, shops and utilities.

The definition of formal appearance: The center constructed with tapered profile which blends with the surrounding trees. The huts are representing the traditional houses in Kanak. But instead of using a traditional fiber material, the center uses modern materials of wooden ribs and slats. The huts parts are similar in form and construction by varying in size. The size of each hut is determined by the function's requirement of the space and the circulation needs through the space. The walls of the hut are constructed using a wooden shell to integrate with the Kanak environment. The architect built a sustainable design for the huts; he used double layers in the walls to create a ventilation system without using an air condition. Also the common corridor is defined with the ceiling with no walls to provide circular ventilation. As shown in the plan of one unit and in the section, the plan is a curved circular shape and the exterior layer is a curved surface. However, the interior space is facing the interior layer as a straight vertical surface which caused to loss the curved sense that the building is reflecting from the exterior. On the other hand, it maintains the used material and appearance of the exterior which units the two layers with both the interior space and exterior form.

The interior spaces divers in size and scale, for instance, the auditorium have 400 seats so the general form will be relatively large. But the huts are the main concept of the center and for the aim to maintain visibility to only these forms, the base horizontal plane of the site is depressed to contain the secondary facilities; by leaving only one floor above the surface for the accessibility and any larger scale is beneath the surface. In this way the huts are the main visual form of the building containing the main facilities and the other spaces are hidden. The center's geometry follows the space dimensions and needs. The formal appearances of the secondary spaces are hidden mostly beneath the ground. However, the spaces are identified by connecting all the spaces under the same roof using the same wood material. The roof is defining a circulation path towards the different facilities and the huts by forming an overhead plane (ground floor in yellow). Also the corridor is a main circulation path for the huts.

Space-structure relation:

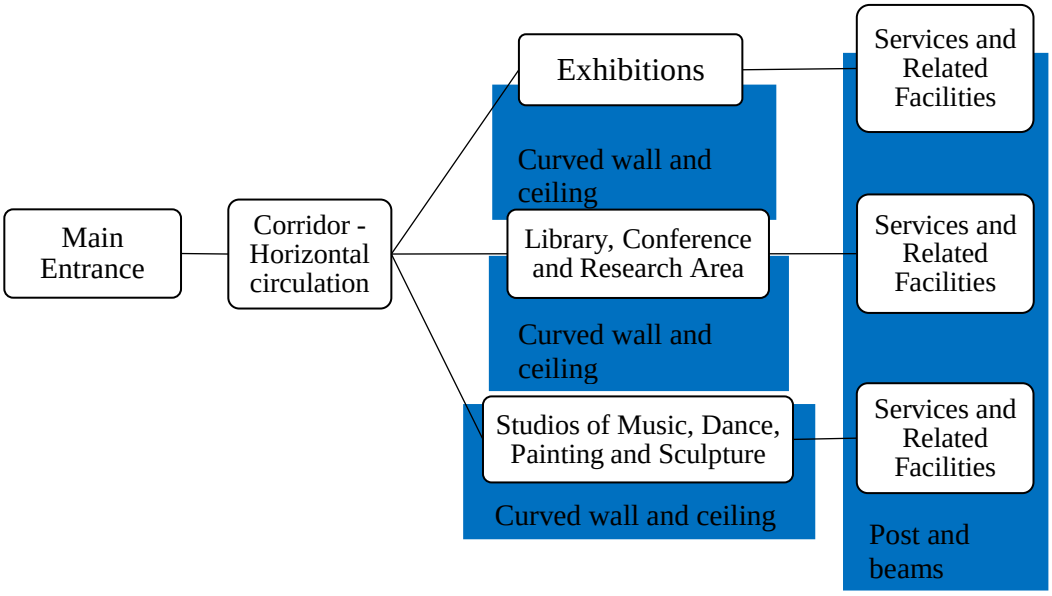


Figure 84: Space and structure analysis of Tjibaou cultural center (Source: Author)

The formation of the building (the shells) is constructed with traditional methods and traditional regional material of the Kanak architecture. The structure of the huts is the double layer facade that forms the walls. The use of double layered façade is for ventilation natural air between the layers and it depends on the flow rate. So the huts towards the see are designed to bear the storms but the huts on the other side have a lighter structure and more transparency in the façade. The structural material is the African wooden because it a durable and low maintenance material. The interior spaces are strongly related with the structural material as it's visually recognized from the interior. This created a continuous design from the environments towards the exterior and interior of the center. Moreover, the structures of the secondary parts are also using the same material with a post and beam structural system. Moreover, in the different part of the building, the wooden material is emphasized through the different layers of the design.

4.4.5 Case 5: Lucerne Culture and Congress Centre, KKL Luzern

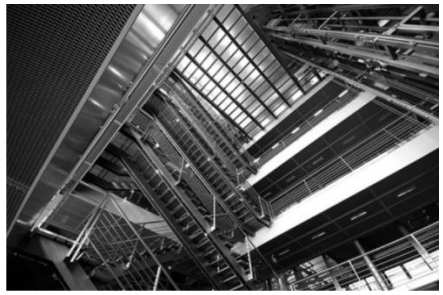
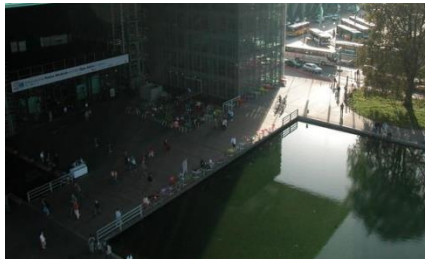
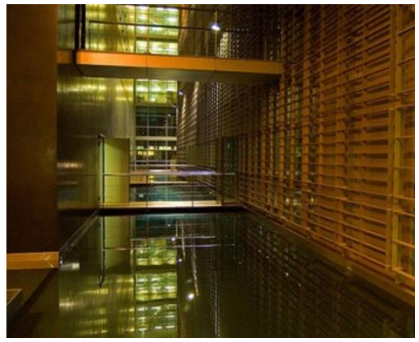
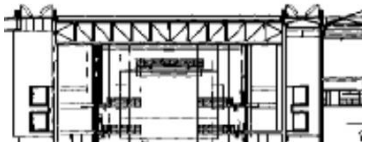
Table 17: Lucerne Culture and Congress Centre


(URL55)

Location	Lucerne, Switzerland
Architect	Jean Nouvel
Year of construction	1995-1998
Floor Area	12,000 m^2

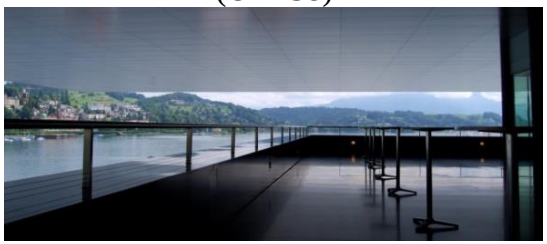
Lucerne Culture and Congress Centre or known in its German name as KKL. The Lucerne city is a traditional city that did not introduced any new architectural building. The cultural city considers an innovative building in this urban fabric. The cultural center serves the local and international populations; it built as an orientation for cultural life in the city and to host events and performances from all over the world. The building is a new landmark for the city and the concert hall is one of the most important halls in the in the world. One of the main concepts of the architect is to not disturb the lake next to the location. The location connects between the past and the future; is between the city from the seventeenth century and the Lake Lucerne and near a train station which designed by Santiago Calatrava.

Table 18: Interior space, formal appearance and formative structure of Lucerne Culture and Congress Centre

Interior space		Formal appearance		Formative Structure
Interior Views	  (URL55)  (URL56)	**3D-formation**	  Water element and bridges (URL55)  	 Staris as structure (URL55)  Roof constructoin (URL60)   Structural elements (URL55)

(URL57)

(URL58)

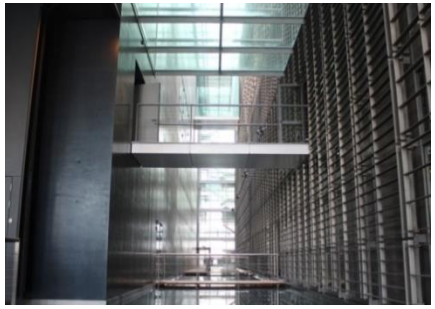


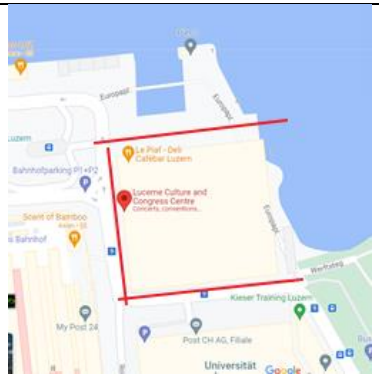
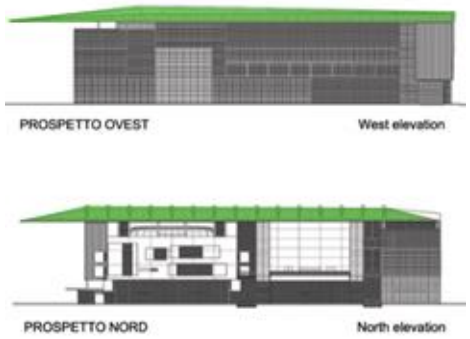
(URL55)

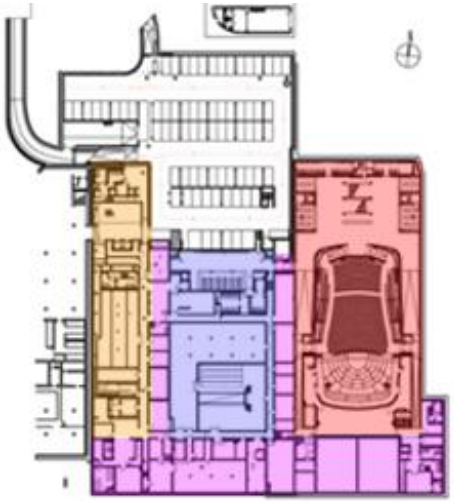
Overhead plane

Entrance and main staris

Exterior views (URL55)

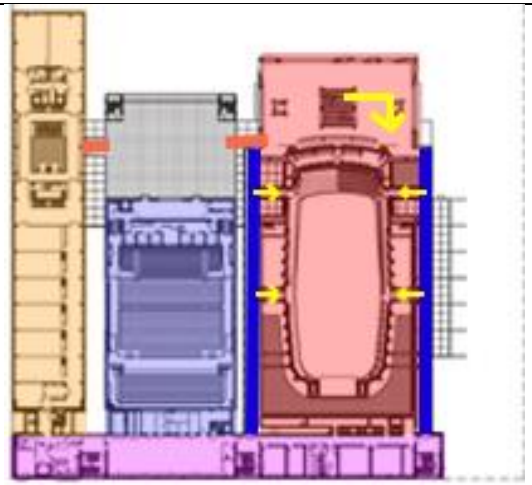
			 Corridors of the Auditorium	
Functions	- Auditorium - Lucerne hall (Multi-purpose hall) - Concert hall - Conference rooms - Offices - Restaurants and cafes - Services		 Entrance area  Connected bridges (URL56)	

Plans	 Site plan Concert hall Lucerne hall Auditorium hall Water element Common space Ciculation and Main entrance  Conceptual plan	**Elevation**	 Elevations (URL59)	

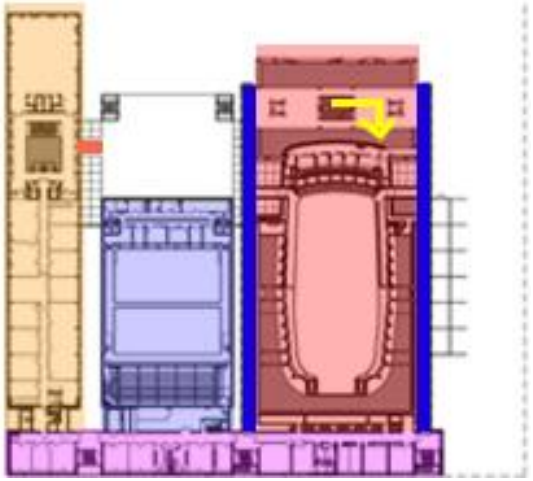


Basement floor

Ground floor



First floor



Second floor

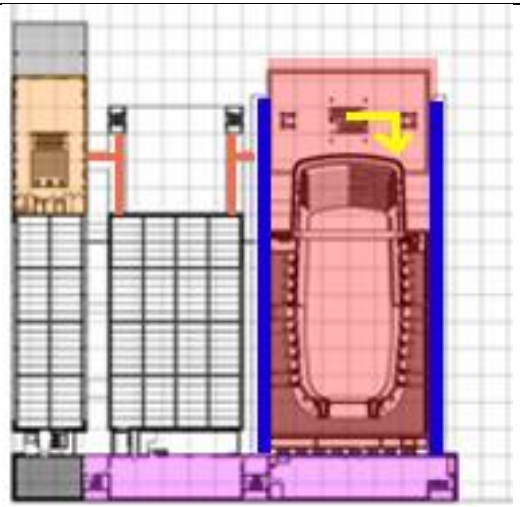
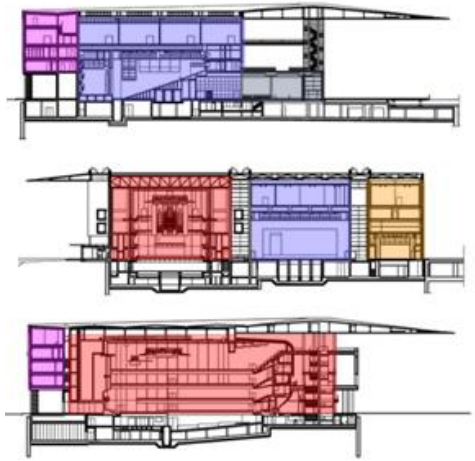
	 Third floor (URL59)			
Section	 Sections (URL59)			

Table 19: A checklist of the space, form and structural characteristics of the Lucerne Culture and Congress Centre

Specifications of architectural project				
Structure	Formative structure of space	Pneumatic		
		Shell		
		Dome		
		Membrane structure		
		Trusses	✓	
		Stairs	✓	
		Ceilings	✓	
		Floors		
		Walls	✓	
		Post and Beams	✓	
Form	Geometry and form	Free-Form		
		Transformation Form		
		Irregular forms	✓	
		Regular forms		
	Form organization	Grid organizations	✓	
		Clustered organizations		
		Radial organizations		
		Linear organizations		
		Centralized organizations		
	Formative elements	Apertures		
		Stairs	✓	
		Ceilings	✓	
		Floors		
		Walls	✓	
	Architectural defining elements	Vertical elements	✓	
		Horizontal elements	✓	
Space	Space organization	Grid organizations	✓	
		Clustered organizations		
		Radial organizations		
		Linear organizations		
		Centralized organizations		
	Function	Others	✓	
		Youth activities		
		Conferences	✓	
		Exhibitions		
		Auditorium	✓	
		Galleries		
		Libraries		
	Circulation	Interior circulation	✓	
		Exterior circulation	✓	
	Spatial relation	Spaces lines by a common space	✓	
		Adjacent spaces		
		Interlocking spaces		
		Space within a space		
	Planning and geometry	Irregular plans	✓	
		Regular plans		
Architectural elements			**KKL**	

Space-form relation:

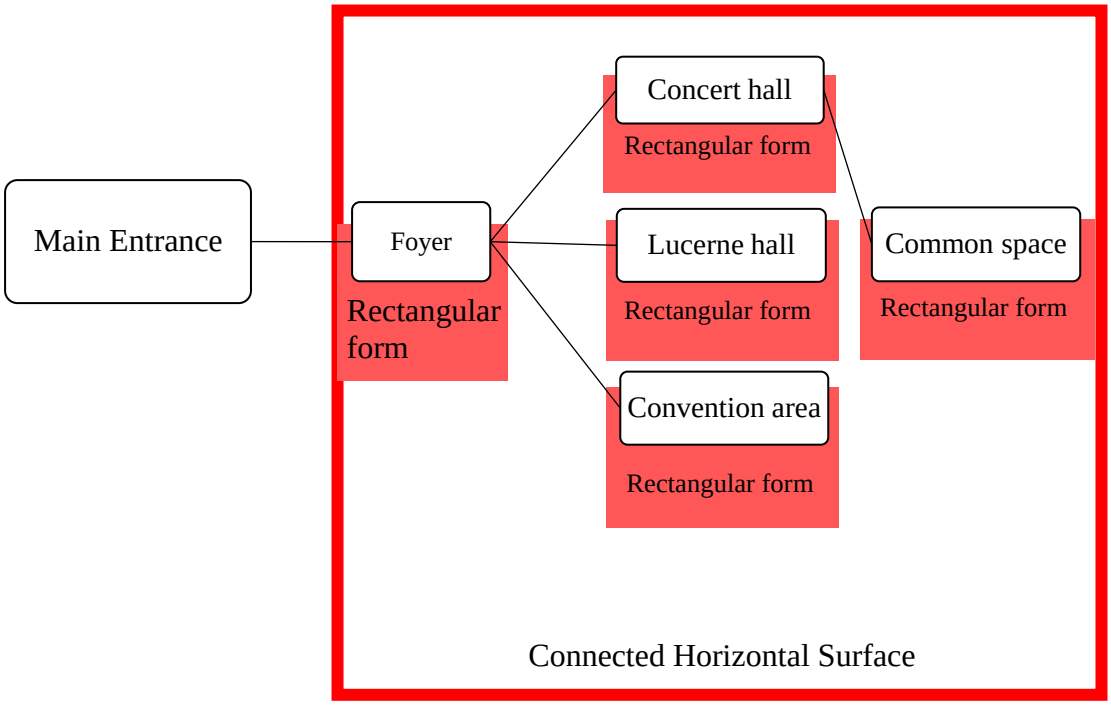


Figure 85: Space and form analysis of Lucerne Culture and Congress Centre (Source: Author)

Lucerne Culture and Congress Centre or KKL Luzern is consists of three main parts (overall plan): Concert hall area, Lucerne hall area and Convention area. To differentiate between the three parts (functions), the center was divided into three buildings according to the main functions. The Lucerna hall which is a multi-purpose hall is located in the middle and the other two parts are located on the sides. However, these parts belong to the same building so the architect created an overhead horizontal surface that connects all the parts together visually (elevations in green and exterior views).

The planning and interior spaces of the center are emphasized as following (shown in the plans): The three parts of the building are accessible from a foyer

space which is located in the front façade, in the middle of the building, with visual and physical differentiation. The foyer creates a welcoming space and leads to the three parts through horizontal circulation. Also, the functions are accessible to each other in each floor by a common space which defined as a whole block that connects the three parts (plans in purple) but the ground floor was removed for the purpose to provide a circulation space for the vehicles. Moreover, the parts are connected with many bridges in between (plans in brown). On the other hand, the vertical circulation of the building is strongly identified in the front façade in which the stairs are visually recognized with solid vertical elements (exterior views). The stairs are connected to the different parts with visual bridges.

The definition of formal appearance: The creation of the building begun from the geometrical shape of the site; the space on the site is almost a square shape (site plan) and it's easy to recognize that the building geometrical form followed that shape. Evidently the form starts with a cube then divided it into three parts according to the different functions. Moreover, the architect concept to bring the lake into the building and the water element follows the space organization reflecting the buildings as ships; the water element distributed in front of the building and between the three parts (light blue in conceptual plan). The circulation towards the main entrance is defined with accessible paths. Also, the main entrance is identified by the two stairs in the main entrance and they extend above the entrance to all the floors as shown in the exterior views. Despite the far distance, they connected through bridges. The stairs are creating an interesting visual appearance of the vertical circulation and as flags recognizing the gathering space.

The main entrance is located in the middle with the Lucerna area. The main entrance leads to a foyer space (ground floor in grey) which leads to the three parts. To differentiate the foyer space from the three parts and especially the Lucerna hall, the Lucerna hall was pushed behind the foyer and it defined as a separate form with divided surface. The foyer is only one floor high while the other parts are higher as shown in the plans and 3D-views. Also, the foyer is defined with transparent surfaces (curtain walls) which reflect the functional values of the space as welcome and gathering space as well as it's a transition area to the main facilities so it kept connected with the exterior environment.

The scale of each part is being defined regarding the certain hall of each part. Each hall had a specific capacity which determined the width of the space. Moreover, as shown in the conceptual plan, each form followed exactly that width and the other functions in each area distributed in a way that it will maintain that size. All the parts reflect a rectangular form of the rectangular plans. For the concert hall, it was noticed that the horizontal corridor was placed outside of the main form (blue stripes in the sides) of the concert so it kept the actual size of the concert area. This created an interested blocks on the façade. The corridor blocks reflect the massive number that this building can hold and differentiated from the other part. On the other hand, the exterior appearances of the three forms are various according to the function. The convention part, the design part kept visible to maintain a connection between the museum and the city to preserve its cultural value and it apparent from the interior space. But the Concert hall is designed with stronger solid form to accommodate international events. And the Lucerne hall is also designed as a solid form to accommodate different events local and international with less eye-catching

appearance than the Concert hall for its significance and larger scale. On the other hand, the solid form of the Lucerne hall distinguish it from the foyer space.

The three parts are connected to each other by two main elements: The roof plane and common space. This created a compact connection between the parts. The large roof surface unified the building as one whole form visually and presents the parts as one center which is will-recognized in the views. On the other hand, the different parts are accessible to each other through a common space that designed as a whole rectangular block. But it is located in the back of the building as a hidden element and less important feature to maintain the separation.

Space-structure relation:

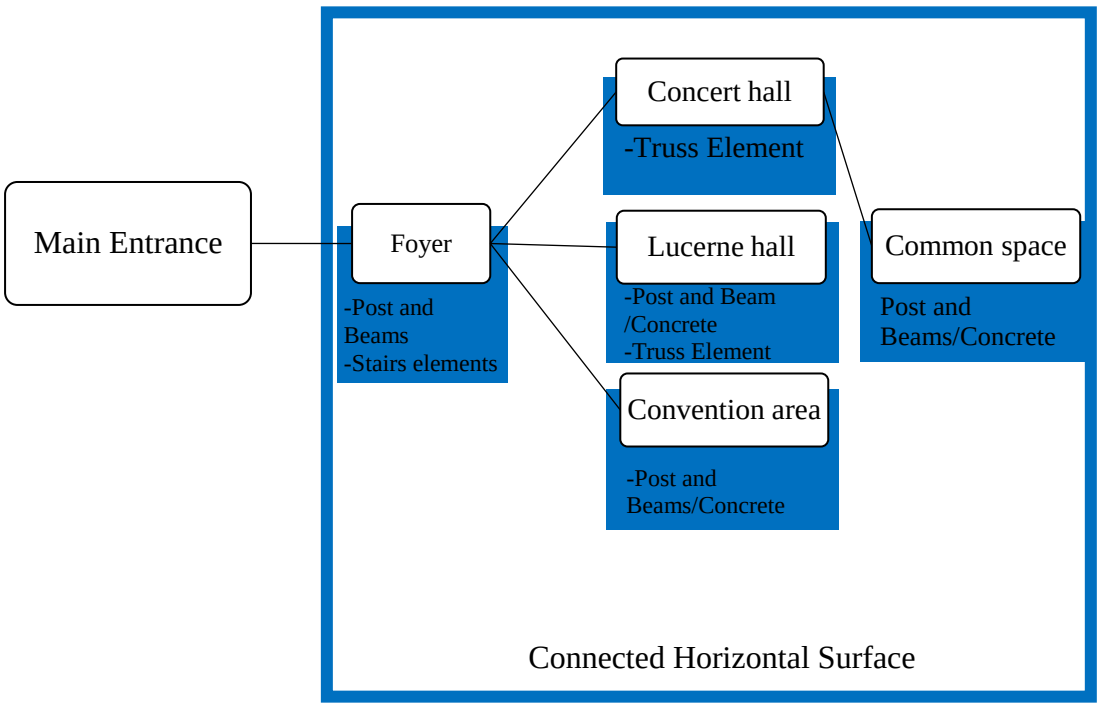


Figure 86: Space and structure analysis of Lucerne Culture and Congress Centre (Source: Author)

Lucerne Culture and Congress Centre or KKL Luzern has a various structural systems according to the space requirements as shown in the formative structure part. The most challenging part of the building was the horizontal plane above the building with a cantilever of 45 meters. It was created using steel beams with the help of engineers. However, the plane is created to identify the various spaces together. The stairs, vertical circulation, were used as a supportive element for the plane. The various parts have long space regarding to the functions and capacity. To bear the loads and avoid any abstraction in the space, it was used the trusses. For the rest of the building and other less important facilities, it was used the post and beam structural system. Also, the bridges span was small so it designed with simple post and beam system. The concert hall is designed with two different appearances. The ground floor is defined with transparence surfaces which connect the building with the exterior environment. The transparency element is supported with columns. The other floors are a solid plane surfaces (concrete) that reflects a strong appearance for the used function. The concrete material is well-recognized from the interior spaces as the exterior. On the other hand, the convention area which includes convention center and museum of art of Lucerne city was aimed to preserve visual connection with the city so the space was not fully isolated and it created with transparence surfaces by the support of steel frames. Then, the Lucerna hall is designed with solid plane surface opposing the foyer area which creates a differentiation between the two functions. The solid plane surfaces (concrete) are as the concert hall reflecting a functional aspect which is a generally auditorium or theater. In regards, the center is built with two main materials: the steel and concrete according to the functional aspect of each space and the desire of visibility.

4.4.6 Case 6: Casa da Musica

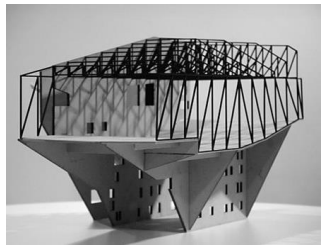
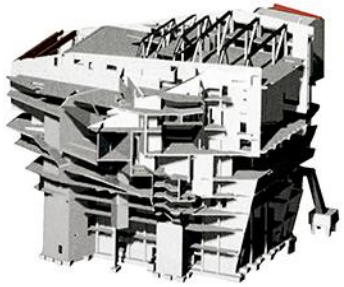
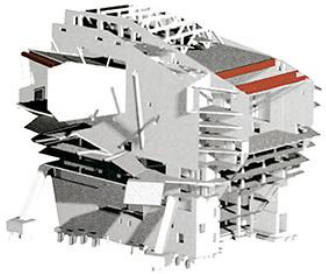
Table 20: Casa da Musica

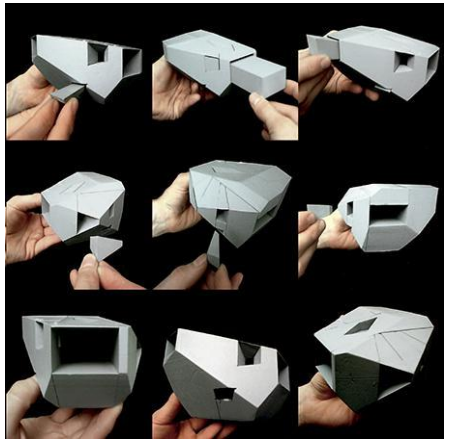

(URL62)

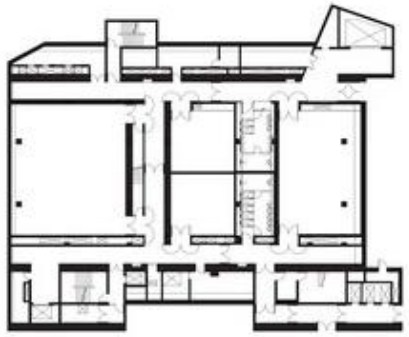
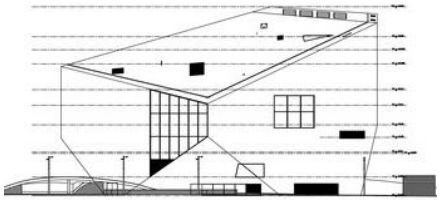
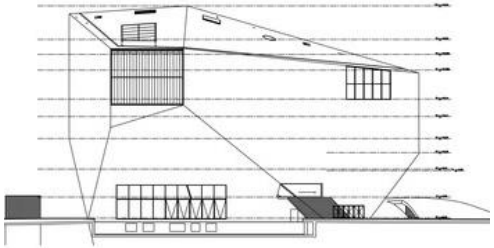
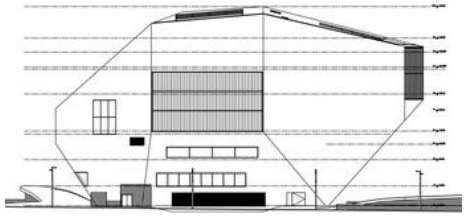
Location	Porto, Portugal
Architect	OMA
Year of construction	2005
Floor Area	22,000 m^2

Porto city in 2001 was considered as a cultural capital in Europe so the Minister of Cultural founded to for a new cultural hall. The Minister invited five architectural organizations to a competition for choosing a cultural hall. So the design of OMA was chosen. Casa da Musica is designed to change the previous domination of the "shoe box" design for concert halls and to solve the acoustic problem that comes with this traditional concept. Casa da Musica is a concert house and cultural center which consider a new destination for Orchestra in Porto located in the historic area called Rotunda da Boavista. The building has a unique form which believed to be an icon for the city, it became an architectural adventure. The OMA solved the issue of symbolism, visibility and accessibility by selecting a proper site above travertine pavement. The building shows an impressive use of materials and curtain walls in the auditorium.

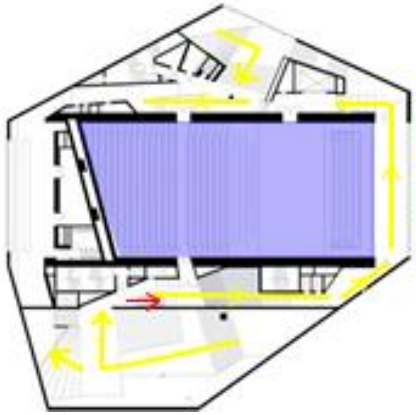
Table 21: Interior space, formal appearance and formative structure of the Casa da Musica

Interior space		Formal appearance		Formative Structure
Interior Views	 (URL62)  	**3D-formation**	  Exterior views (URL63)  3D Modeling (URL62)	 Structural model (URL64)   Interior 3D-structurs

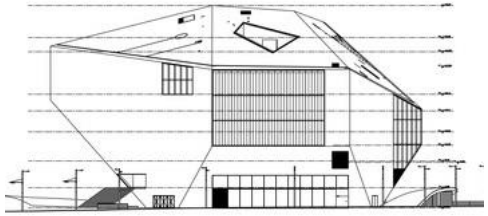
	  (URL63)		 3D concept (URL62)	(URL62)
Functions	- Auditorium - Performance space - Rehearsal rooms - Studios - Educational area - Restaurant - Administrative area			

Plans	Auditorium hall Performance space Ciculation and Main entrance  Ground floor plan  First floor plan	**Elevation**	  	

Second floor plan (Entrance)

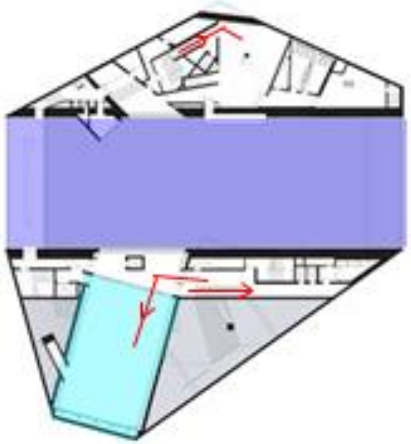


Third floor plan

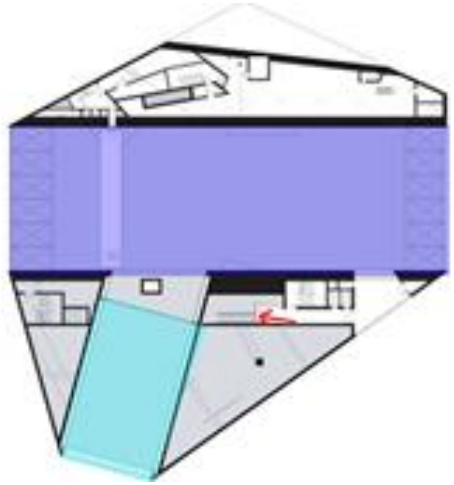
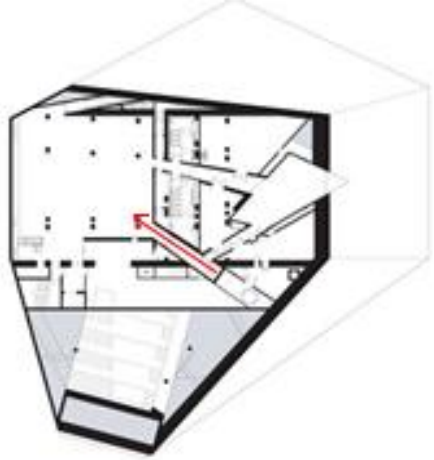


(URL63)

Fourth floor plan



Fifth floor plan

	 Sixth floor plan  Seventh floor plan (URL63)			

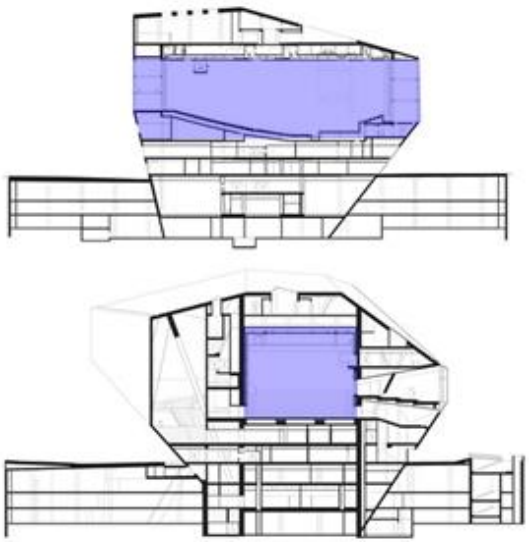
Section	 (URL63)			

Table 22: A checklist of the space, form and structural characteristics of the Casa da Musica

Specifications of architectural project				
Structure	Formative structure of space	Pneumatic		
		Shell		
		Dome		
		Membrane structure		
		Trusses	✓	
		Stairs		
		Ceilings	✓	
		Floors	✓	
		Walls	✓	
		Post and Beams		
Form	Geometry and form	Free-Form		
		Transformation Form	✓	
		Irregular forms	✓	
		Regular forms		
	Form organization	Grid organizations		
		Clustered organizations		
		Radial organizations		
		Linear organizations		
		Centralized organizations	✓	
	Formative elements	Apertures		
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
	Architectural defining elements	Vertical elements	✓	
		Horizontal elements	✓	
Space	Space organization	Grid organizations		
		Clustered organizations		
		Radial organizations		
		Linear organizations		
		Centralized organizations	✓	
	Function	Others	✓	
		Youth activities		
		Conferences		
		Exhibitions		
		Auditorium	✓	
		Galleries		
		Libraries		
	Circulation	Interior circulation	✓	
		Exterior circulation	✓	
	Spatial relation	Spaces lines by a common space		
		Adjacent spaces		
		Interlocking spaces	✓	
		Space within a space		
	Planning and geometry	Irregular plans	✓	
		Regular plans		
Architectural elements				**Casa da Musica**

Space-form relation:

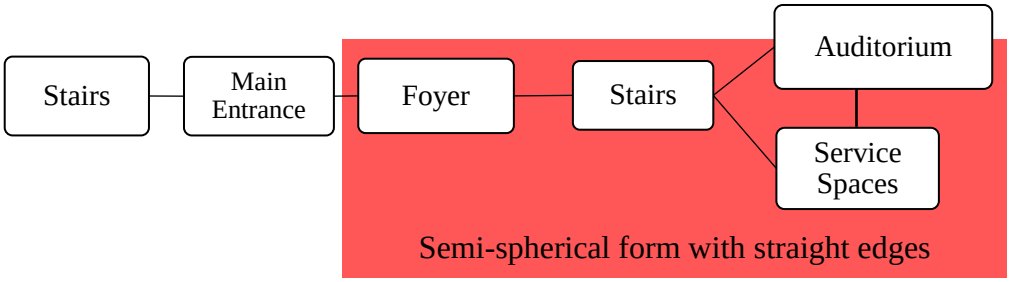


Figure 87: Space and form analysis of Casa da Musica (Source: Author)

Casa da Musica is a cultural center contains an auditorium as the main facility. Also the building contains various secondary facilities such as performance space, rehearsal rooms, studios, educational area, restaurant, and administrative area. The building and the secondary spaces are emphasized around the main space (auditorium).

The planning and interior spaces of the center are emphasized as following (shown in the plans): The building's form created as a solid mass and avoided the shoe-box concept. OMA considered the relation between the cultural building with the interior and exterior of the building. The building exposes its contents to the city without instructions and the city is connected with the interior with a unique experience. The main function of the building is the auditorium located in the middle of the building and surrounded with secondary functions including restaurant, services rooms, etc. As shown in comparing the plans and the sections, the auditorium in the central space which present a central organization in a vertical and horizontal dimensions. The center contain another significant spaces but with less obvious presentation. The floors are connected with path throughout the building; the circulation is designed around the main auditorium and through the floors (yellow in

plans represent the main circulation and red for the other services). It's noticeable the wide stairs towards the auditorium and for the services are thin stairs.

The definition of formal appearance: The center's form was determined according the concept of opposing the shoe-box idea. So the building begun with the most important function, the auditorium, and locate the other spaces around it. The huge scale of the auditorium determined the scale of the formation. The secondary functions are all surrounding the auditorium as services which reflected in the form as if the whole building maintained in one volume. However, the space distribution and size of interior spaces created the exterior lining of the exterior form which is clearly reflected on the exterior. The auditorium is distinguished by using the glass façade (curtain wall) which differentiate this part from the rest of the volume which is strongly distinguished in the formal appearance. The transparency created a strong definition on the location of the auditorium in the whole building and it creates a connection between the interior and exterior. It also reflects the spaces distribution around the auditorium and emphasizes it as the main space.

Space-structure relation:

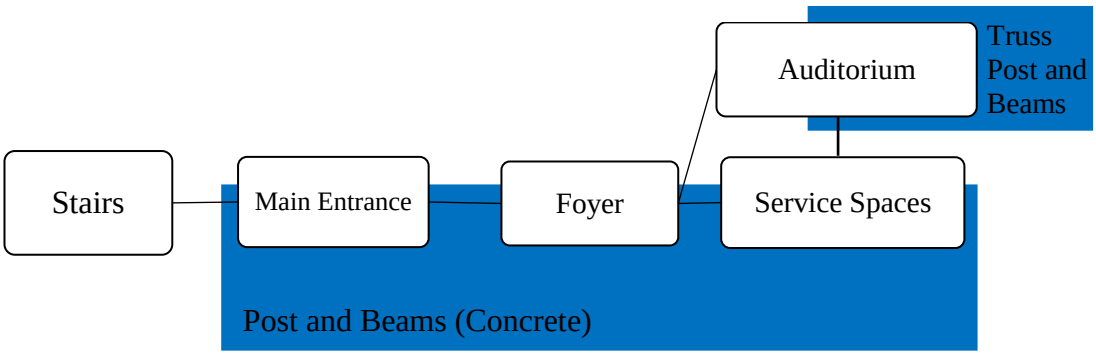


Figure 88: Space and structure analysis of Casa da Musica (Source: Author)

Casa da Musica has a unique and individual exterior formation. The building contains a 0.4 meter thick shell for the exterior and the auditorium walls are 1 meter thick which they designed to maintain stability and carry the loads. The auditorium walls are the main loadbearing walls (post and beams system) that attaching the shell in a longitude direction. The concrete of the building was studied to contain the loads. The structure system in this building is determined with both the interior spaces and formal concept of the building; for the building to carry the load of such unique design and to preserve the large scale space of the auditorium without any abstraction. Moreover, the slope of the roofs and walls required sloped columns for the load to transfer in the right direction.

The continuous using of the concrete is well-recognized through the interior spaces and the exterior which unified the building's design. Moreover, the use of the concrete with the same pattern in the whole construction unites the building as one volume. However, for the aim to distinguish the auditorium space, the front and back surface of the space were not emphasized with structural material. Also, other spaces were designed to not have an exterior structural wall to emphasize them as solid and open spaces.

4.4.7 Case 7: Heydar Aliyev center

Table 23: Heydar Aliyev center

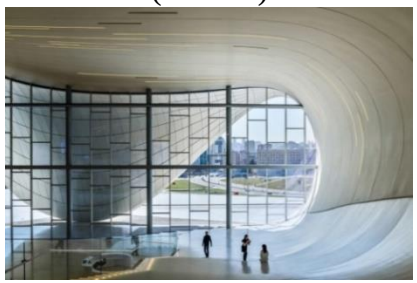
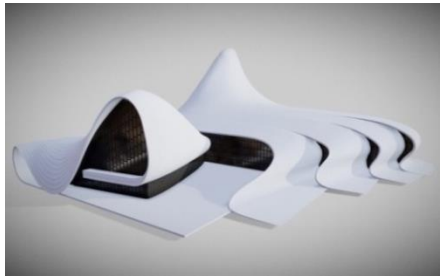
(URL71)

(URL65)

Location	Baku, Azerbaijan
Architect	Zaha Hadid Architects
Year of construction	2013
Floor Area	101801 m²

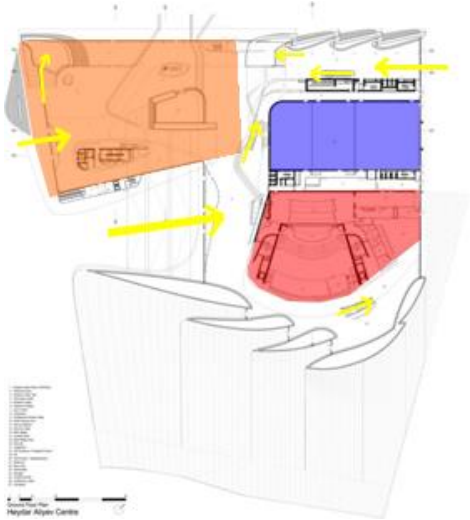
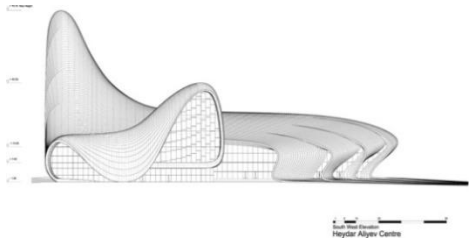
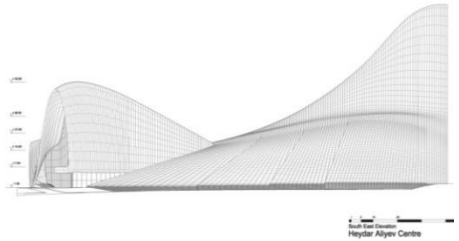
Heydar Aliyev Center is an important cultural center in Baku; it consider as a symbol of Azerbaijan development and modernization. The culture promotes Azerbaijan's history and culture and hosts various cultural events. Heydar Aliyev Center is a fluid continuous design between the surrounding plaza and the interior of the building. The design of the center hides the differentiations and integrates between the architectural characteristics, landscape, building formation, urban plaza and the interior and exterior of the building. Fluidity in this design and mostly in general meant to create a flow between walls and ceilings; blurring the boundaries between the architectural elements and the ground. The architect intended to use the fluidity from historical architecture and develop it into a contemporary architecture. On the other hand, the fluidity design allows the building to adjust with the topography.

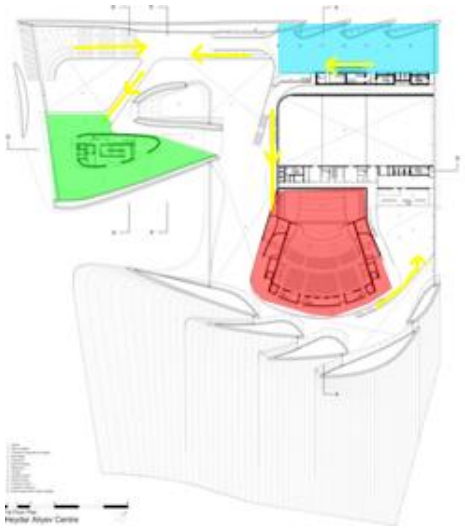
Table 24: Interior space, formal appearance and formative structure of the Heydar Aliyev center

Interior space		Formal appearance		Formative Structure
Interior Views	 (URL65)  (URL66) 	**3D-formation**	 (URL71)  3D Modeling (URL72) 	 (URL74)  (URL75)

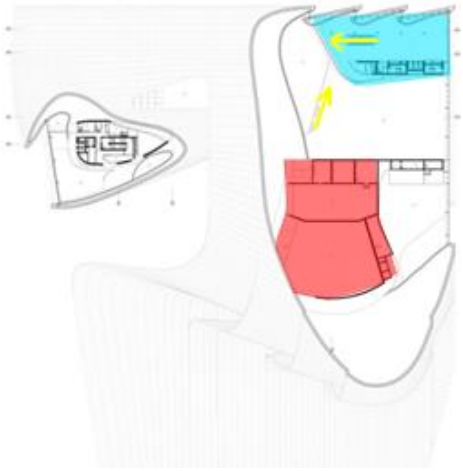
(URL67)

Exterior views (URL73)

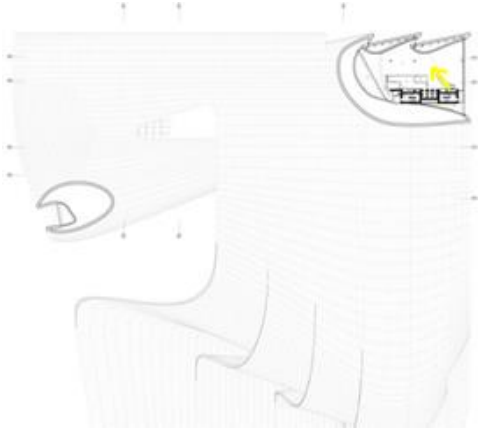
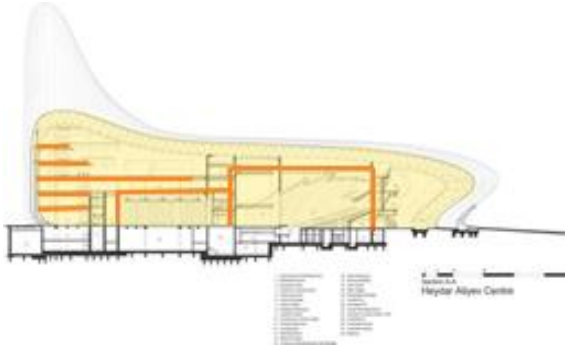
Functions	- Auditorium - Multipurpose hall - Library - Conference center - Galleries - Museum - Cafes, restaurants and gift shop - Offices - Meeting room			
Plans	Museum Multipurpose hall Auditorium hall Art gallery Library Circulation and Main entrance  Ground Floor plan	**ELevation**	 (URL69)  (URL70)	



First Floor plan



Fourth Floor Plan

	 Seventh Floor plan (URL68)			
Section	 Section 1			

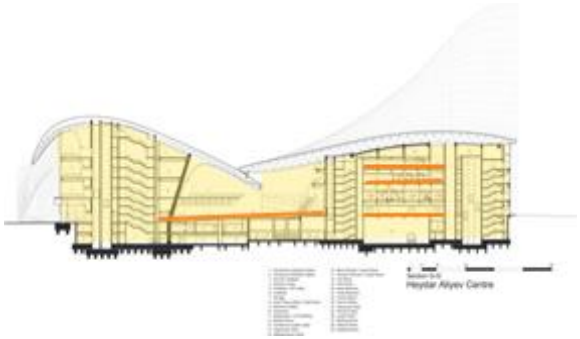
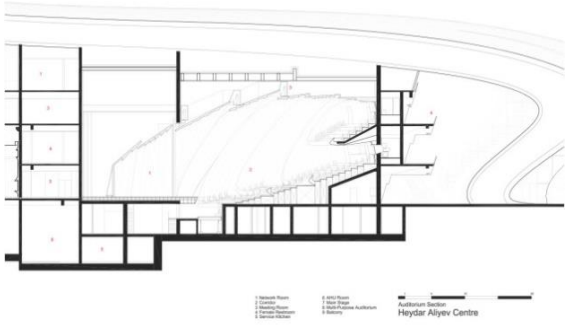
	 Section 2  Auditorium Section (URL68)			

Table 25: A checklist of the space, form and structural characteristics of the Heydar Aliyev center

Specifications of architectural project				
	Structure	Formative structure of space	Pneumatic	
			Shell	
			Dome	
			Membrane structure	
			Trusses	✓
			Stairs	
			Ceilings	✓
			Floors	
			Walls	✓
			Post and Beams	
	Form	Geometry and form	Free-Form	✓
			Transformation Form	
			Irregular forms	
			Regular forms	
		Form organization	Grid organizations	
			Clustered organizations	✓
			Radial organizations	
			Linear organizations	
			Centralized organizations	
		Formative elements	Apertures	✓
			Stairs	
			Ceilings	✓
			Floors	
			Walls	✓
		Architectural defining elements	Vertical elements	
			Horizontal elements	✓
	Space	Space organization	Grid organizations	
			Clustered organizations	✓
			Radial organizations	
			Linear organizations	
			Centralized organizations	
		Function	Others	✓
			Youth activities	
			Conferences	✓
			Exhibitions	✓
			Auditorium	✓
			Galleries	✓
			Libraries	✓
		Circulation	Interior circulation	✓
			Exterior circulation	✓
		Spatial relation	Spaces lines by a common space	
			Adjacent spaces	✓
			Interlocking spaces	
			Space within a space	
		Planning and geometry	Irregular plans	✓
			Regular plans	
		Architectural elements		**Heydar Center**

Space-form relation:

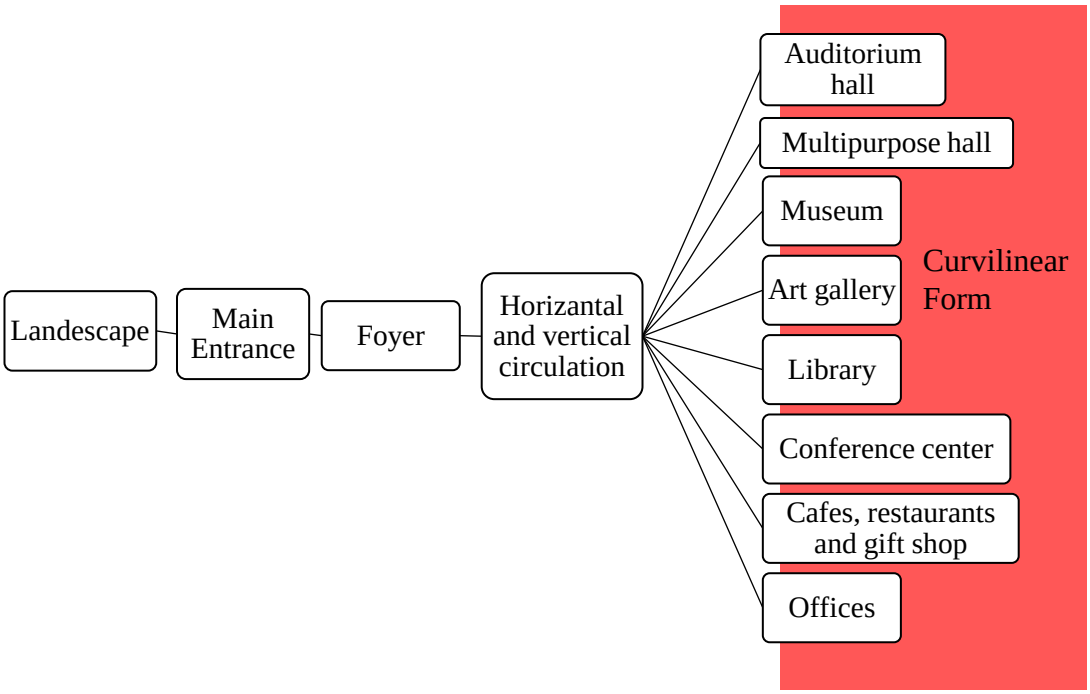


Figure 89: Space and form analysis of Heydar Aliyev center (Source: Author)

Heydar Aliyev Center is an extraordinary designing building presenting the futuristic of architecture. The center is large in scale and it offers several significant functions for the city including auditorium hall, multipurpose hall, library, conference center, galleries, museum, cafes, restaurants, gift shop, offices, and meeting room. The facilities are distributed in seven floors under a curvilinear surface.

The planning and interior spaces of the center are emphasized as following (shown in the plans): Heydar Aliyev Center begins from the urban plaza of the building in which the center's design intended to integrate the ground with building design; the plaza is part of the fabric of the building. The plaza integration with the building creates an exterior path and movement towards the building and it's connected with the interior spaces and defines cultural event spaces. Moreover, the plaza formed to be an architectural landscape that provides various features such as,

welcoming, sense of direction, and embracing visitors through the interior spaces. The entrance leads to foyer space that leads to the different main facilities to the identified stairs towards to the upper floor to the other facilities. The facilities are mainly large in scale for hosting large number of visitors and significant events.

The definition of formal appearance: The architect's ambition was to create a continuous surface which reflects harmonious; the design contains various functions, constructions logics and technical systems under the designs' envelop. The main and secondary interior spaces where consider to blend with the fluidity of the whole space and avoid rigidity.

The building's form is a very unique and creative design with curved surfaces and large spans. Despite of that, the interior spaces and their functions and characteristics does not seemed to have a related relationship with the form of the building except the large scale of the spaces; the large scale of the building indicate to the importance of the functions and their large in scale. However, the various spaces or areas are not indicated from the exterior form. The space towards the building is well-emphasized by the formal appearance but the interior spaces were enveloped by the exterior skin.

The aim of the project is to create a creative and innovative building. Studying the plans shows well-distributed spaces starting form welcoming spaces towards the main functions and many well-defined vertical circulation elements through the floors. However, comparing the functions and interior space characteristics with the fluidity of the formal appearance gave a sense that the building was more about the form in which it will contain these functions; the spaces are located and following

the curvilinear form. One connection that can be considered is the relative large scale of the functions such as the auditorium or the museum. But yet it does not describe the use of such form in terms of interior space characterizes. On the other hand, the architect considered the importance of connecting the interior space with the formal appearance to create continuity in design as shown in the interior space of the auditorium and the other spaces.

Space-structure relation:

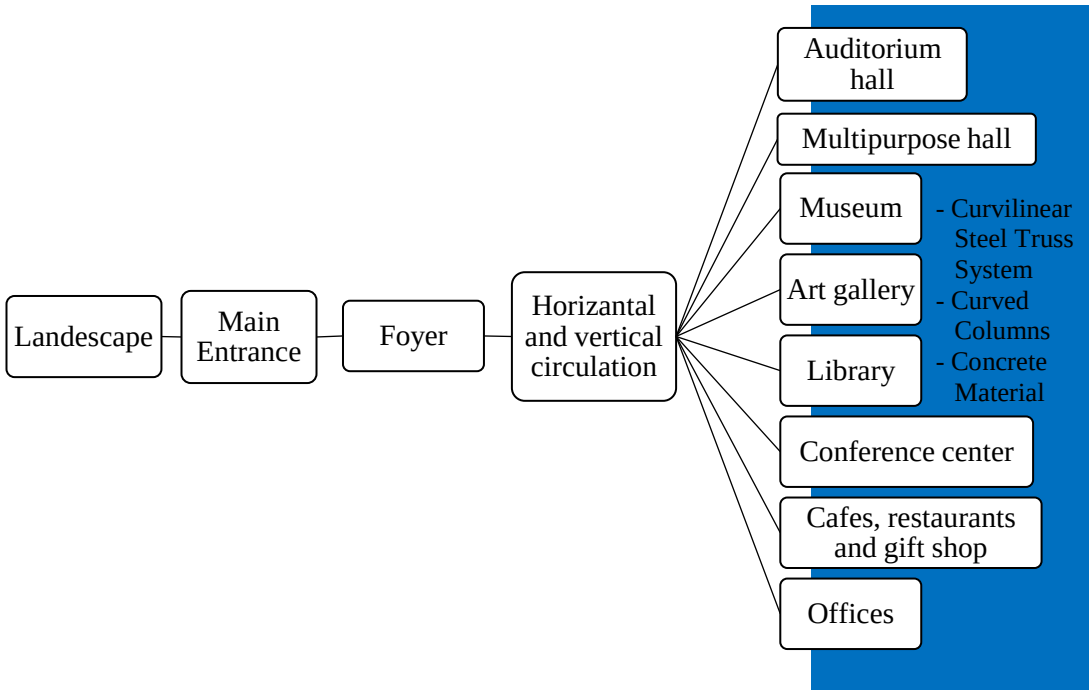


Figure 90: Space and structure analysis of Heydar Aliyev center (Source: Author)

The Heydar Aliyev Center have two constructed systems: concrete structure collaborated with steel frame system (formative structure). The construction of the building was a challenging part is the development of the exterior skin. The center has large spans that were able to maintain by the use of column-free systems. The interior spaces needed to be column-free in order to create open spaces without any blocking elements for the visitors to be able to experience the fluidity of interior

space. Vertical elements represent the walls which they are the envelope skin and curtain walls; they are merged with the ceilings in a curved smooth surface. The building introduces curved columns, boot columns, to achieve the curved surfaces through the building. On the other hand, a structural system to support the cantilever of the building by using steel beams called dovetail. The spaces distribution and the use of cantilever in one side determined the need for dovetail beams. However, these structural descriptive are mainly following the desire of creating a certain formal concept; it does not have a direct relation with the space. The structural elements are cladded with concrete material to create smooth continuous curves that unite the interior with the exterior of the building.

4.4.8 Case 8: Bergama cultural center

Table 26: Bergama cultural center

(URL77)

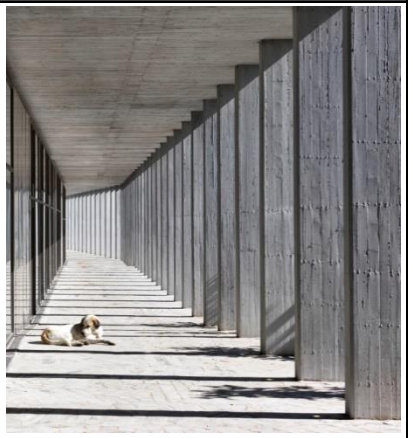
(URL78)

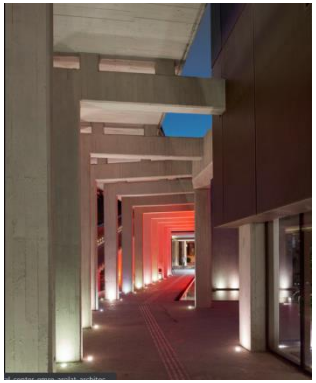
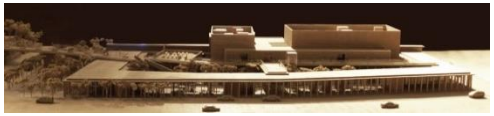
Location	Izmir, Turkey
Architect	EAA - Emre Arolat Architecture
Year of construction	2016
Floor Area	5000 m^2

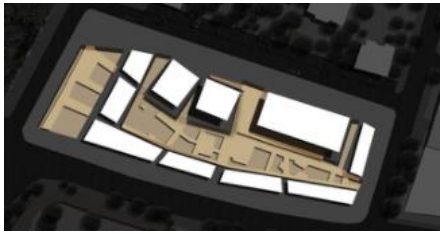
Bergama city reflects a rural city texture. The urban texture of such small city is mainly apartments. Bergama Cultural Center is created to host the cultural life of

Bergama with maintaining the memory of the city. The city had the idea of distributing stores along the walkways for the purpose of maintain commercial life of the city. So the design is inspired from this idea; the building is designed with commercial blocks that pushed back to create a shaded arcade and sidewalk. The blocks are stores located in three sides of the building which creates a courtyard in the middle. The cultural center is connected with the park on the other side with a bridge.

Table 27: Interior space, formal appearance and formative structure of the Bergama cultural center

Interior space		Formal appearance		Formative Structure
Interior Views	  	**3D-formation**	 (URL79)  Courtyard 	  (URL80)

	  (URL78)		 3D-Modeling (URL80)	
Functions	- Stores - Library - Cinemas - Theater - Cafes - Courtyard			

Plans	 Spaces Arrangement Theater Library Cinema Stores Circulation and entrance  Ground floor plan	**Elevation**	 F`ront view (URL79)	

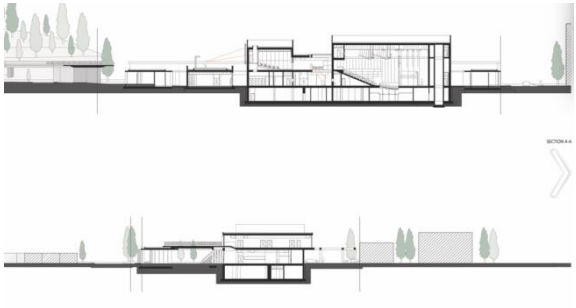
	 First floor plan (URL79)			
Section	 Sections (URL79)			

Table 28: A checklist of the space, form and structural characteristics of the Bergama cultural center

Specifications of architectural project				
Architectural elements				**Bergama Center**
Structure	Formative structure of space	Pneumatic		
		Shell		
		Dome		
		Membrane structure		
		Trusses		
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
		Post and Beams	✓	
Form	Geometry and form	Free-Form		
		Transformation Form		
		Irregular forms		
		Regular forms	✓	
	Form organization	Grid organizations		
		Clustered organizations		
		Radial organizations		
		Linear organizations	✓	
		Centralized organizations		
	Formative elements	Apertures	✓	
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
	Architectural defining elements	Vertical elements	✓	
		Horizontal elements	✓	
Space	Space organization	Grid organizations		
		Clustered organizations		
		Radial organizations		
		Linear organizations	✓	
		Centralized organizations		
	Function	Others	✓	
		Youth activities		
		Conferences		
		Exhibitions		
		Auditorium	✓	
		Galleries		
		Libraries	✓	
	Circulation	Interior circulation	✓	
		Exterior circulation	✓	
	Spatial relation	Spaces lines by a common space		
		Adjacent spaces	✓	
		Interlocking spaces		
		Space within a space		
	Planning and geometry	Irregular plans	✓	
		Regular plans		

Space-form relation:

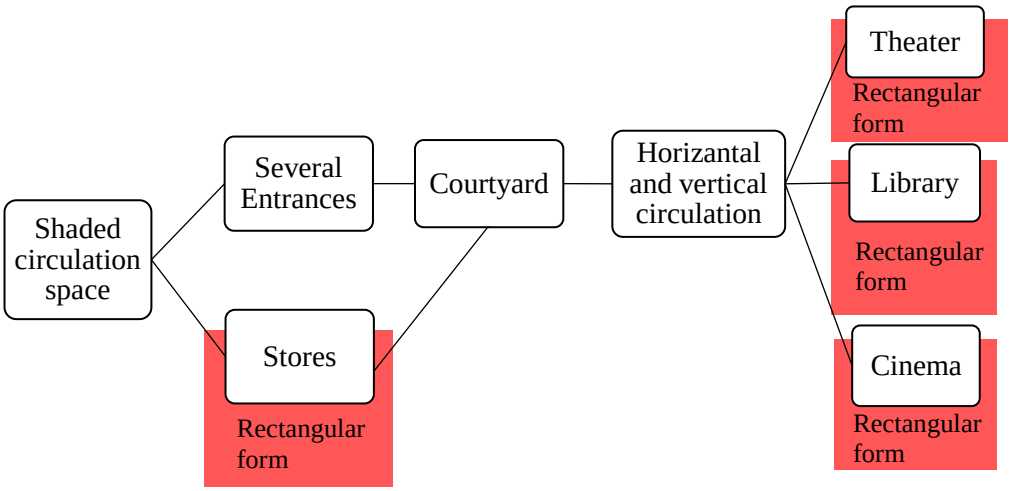


Figure 91: Space and form analysis of Bergama cultural center (Source: Author)

Bergama Cultural Center has a space arrangement and shapes that generally related to city's image. The center consists of a theater, library, cinema and stores. The spaces are distributed in the site as separated blocks. The stores are arranged in all sides of the building with a central courtyard. And the theater, library and cinema are located in the courtyard. The stores have direct entrances from the exterior and the entrance to the courtyard is in between the stores.

The planning and interior spaces of the center are emphasized as following (shown in the plans): Bergama Cultural Center consists of various blocks distributed along the sides of the building with a courtyard (spaces arrangement plan). The distribution of the stores creates a courtyard. The main functions are located in the courtyard. For the aim to create the same concept of the city's stores which is having a sidewalk in front of the stores; the stores were pushed back to create a shaded space used as sidewalks. The stores have access from the shaded space and from the courtyard. Moreover, the access to the courtyard towards the

main facilities is in between the stores (ground plan in yellow). The courtyard offers a circulation towards the main facilities. On the other hand, the courtyards contain a vertical circulation element (stairs) that is connected with overhead bridge. The bridge is connected with the upper floor of the main facilities and it extended to the park in the other side of the building which creates a direct access to the main facilities and the courtyard.

The definition of formal appearance: Bergama Cultural Center consists of various stores distributed along the sides of the building with a courtyard. The stores are following the same concept of the city's stores so they mainly rectangular shaped plan. The aim for creating a sidewalk in front of the stores leads to pushing the stores a step back. The stores were pushed but the vertical overhead element maintained its position to create a defined shaded space. However, the distribution of the stores and the relatively large scale of the site lead to create a wide defined courtyard. And to provide an access to the courtyard, the stores were organized as groups with a recognized space in between to provide entrances.

The spaces between the stores create a circulation path towards the cultural facilities. The stores are connected with continues roof but the cultural masses are defined as separated larger blocks located in the courtyard. The cultural functions are the theater, library and cinemas. Regarding the importance of these functions in the cultural center and their need for larger scale space, they were constructed in obvious and larger masses. The scale of the blocks indicates them as the main cultural centers' facilities and creates a strong statement as they are the focal parts of the center. Also, they are located in the same area and following the same formal

appearance to build a stronger indication as they are the main facilities and connected to each other. On the other hand, the park next to the center is connected with the center through a bridge. The bridge is integrated with the building; creates a circulation between the park and the various cultural facilities and to the courtyard. This bridge creates a strong visual connection between the center and the exterior environment.

Space-structure relation:

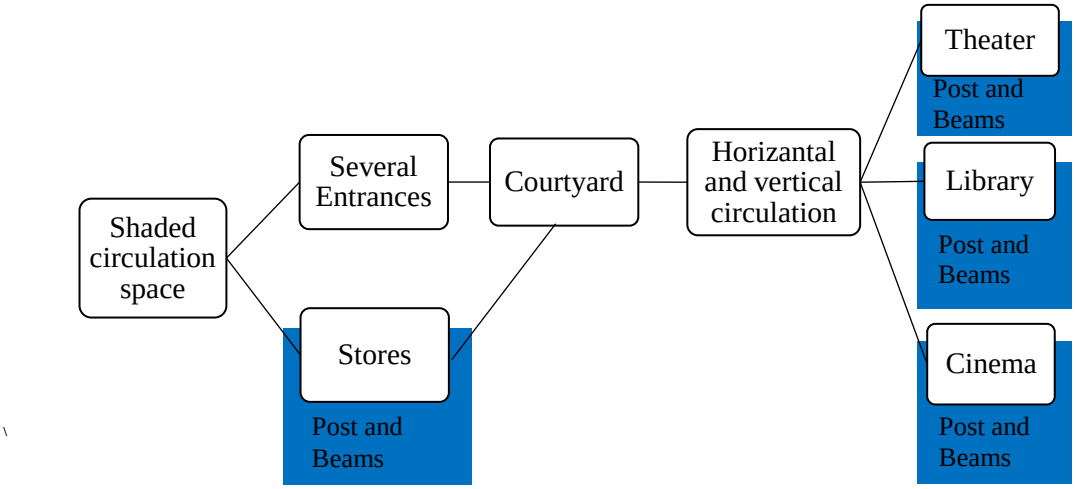


Figure 92: Space and structure analysis of Bergama cultural center (Source: Author)

The cultural center is meant to follow the principle of the small city so the center's main structural systems are the use of post-beam system (Formative structure). The simplicity of the building design and spaces required a simple structural system. The roof of the created sidewalk is supported with visual columns. The columns create a well-defined space for the sidewalk space and entrances. Also, they unite the whole part of the stores as one continuous building. The used structural material is concrete and it's recognized through the building, interior and exterior. Also for adding aesthetic aspects to the concrete to the space, the architect kept the concrete austerity.

On the other hand, the connected roof of the stores and entrances is built as green roof which give the sense as if the roof is been pulling out of the ground which creates a unique relation with the original space of the site. Also, it emphasizes the cultural facilities more strongly (Formal apperence).

4.4.9 Case 9: Teopanzolco cultural center

Table 29: Teopanzolco Cultural Center

(URL81)

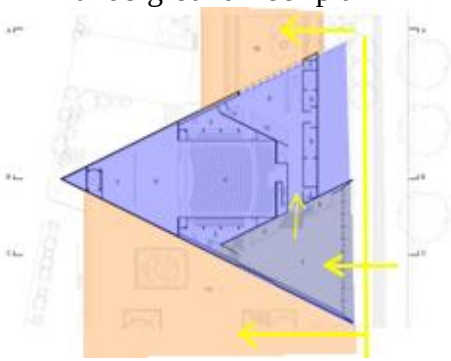
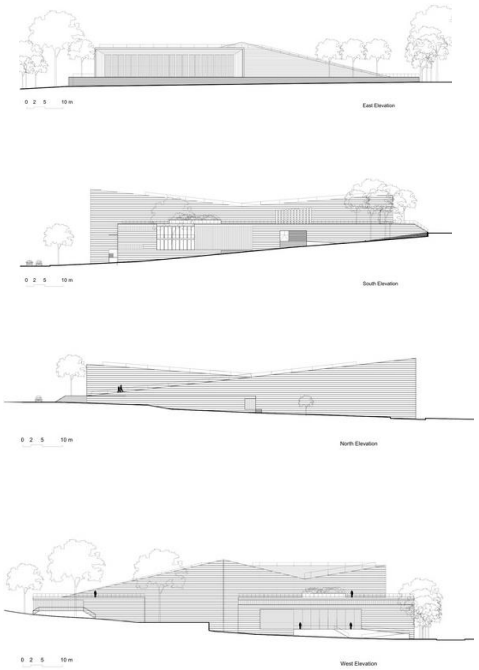
Location	Cuernavaca, Mexico
Architect	Isaac Broid & PRODUCTORA
Year of construction	2017
Floor Area	7000 m^2

Teopanzolco Cultural Center is a new cultural center located in near archeological area of Teopanzolco with the aim of maintains the relation of archeological area with the people and to build an attracted public space. The archeological area is the ruins of Teopanzolco, remains of the Aztec temples from 15th century in Mexico. The remains originally were basalt pyramids and the new cultural center is located near the remains using the pyramid concept. The building is divided into two parts: the first part is the main triangular-shaped form with the main facilities and the second part is an attached platform contains operation zones.

Table 30; Interior space, formal appearance and formative structure of the Teopanzolco cultural center

Interior space		Formal appearance		Formative Structure
Interior Views	 	**3D-formation**	 3D Modeling (URL83) 	   (URL84)

	 (URL81)		 (URL82)	
Functions	- Auditorium - Box office - Cloakroom - Services, dressing and storage rooms - Workshops			

Plans	Services Auditorium Main hall/Foyer Circulation and Entrance Services Roof  underground floor plan  Ground floor plan (URL82)	**Elevation**	 Elevations (URL82)	

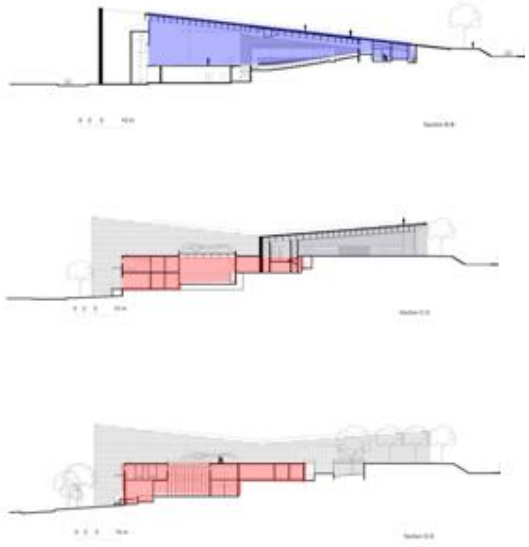
Sections	 Sections (URL82)			

Table 31: A checklist of the space, form and structural characteristics of the Teopanzolco cultural center

Specifications of architectural project				
Architectural elements				**Teopanzolco Center**
Structure	Formative structure of space	Pneumatic		
		Shell		
		Dome		
		Membrane structure		
		Trusses	✓	
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
		Post and Beams	✓	
Form	Geometry and form	Free-Form		
		Transformation Form		
		Irregular forms	✓	
		Regular forms		
	Form organization	Grid organizations		
		Clustered organizations	✓	
		Radial organizations		
		Linear organizations		
		Centralized organizations		
	Formative elements	Apertures	✓	
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
	Architectural defining elements	Vertical elements		
		Horizontal elements	✓	
Space	Space organization	Grid organizations		
		Clustered organizations	✓	
		Radial organizations		
		Linear organizations		
		Centralized organizations		
	Function	Others	✓	
		Youth activities		
		Conferences		
		Exhibitions		
		Auditorium	✓	
		Galleries		
		Libraries		
	Circulation	Interior circulation	✓	
		Exterior circulation	✓	
	Spatial relation	Spaces lines by a common space		
		Adjacent spaces		
		Interlocking spaces	✓	
		Space within a space		
	Planning and geometry	Irregular plans	✓	
		Regular plans		

Space-form relation:

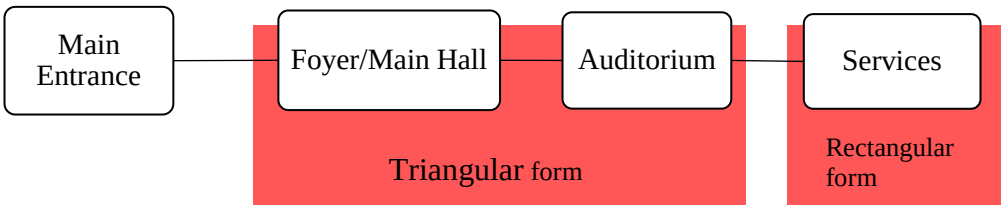


Figure 93: Space and form analysis of Teopanzolco Cultural Center (Source: Author)

Teopanzolco Cultural Center is consists of triangular form, the main part of the building and has a pyramid appearance, interlocking with horizontal triangular platform (3D Modeling). The main function of the center is the auditorium and it's located in the triangular space. The center is contain a defined foyer area and attached service spaces that located in the triangular platform.

The planning and interior spaces of the center are emphasized as following (shown in the plans): The main triangular shape consists of two triangular spaces; a bigger triangular contains a smaller triangular. The main entrance of the building is from the smaller triangular which consists of movable walls that welcome the visitors in a wide area (ground plan in grey). The position of entrance is settled to face the archeological area to connect the visitors with the culture and history of the city. The surrounded platform is a horizontal surface that provides viewing areas of the city and the archeological area (ground plan in orange). The main entrance leads to the foyer space which is a wide space that consider as gathering and welcoming space. The foyer leads to the auditorium with vertical circulation element. On the other hand, the services area has a separate entrance from outside for the workers and it connected to the auditorium (plans in yellow).

The parts of the building have a defined formal appearance: The horizontal platform does not have significant facilities for the public, only services areas, so it designed in a less obvious formation and it is sunk under the ground surface of the archeological area which reduces its physical presence as shown in the sections (in red). However, the roof serves as a walking area to view the city and exterior activities (Exterior views).

The circulation towards the main entrance is defined using stairs which they leads to the foyer area. The stairs in the center serves as well-defined elements for the different spaces. The main function of this cultural center is the auditorium which located in the triangular-shaped space and accessible through the foyer. The foyer is in a triangular-shaped space and the formal appearance strongly indicates that shape. The use of the same shape as the auditorium introduces an image of the space of the main function for the visitors. Also, the formal appearance of the foyer is indicated with different height than the auditorium which defines it as an individual form.

The main triangular-shaped space is defined with triangular-shaped form in the shape of pyramid representing the historical area. The slope of the pyramid is determined by the purpose of the ability to walk above. Moreover, the scale of the pyramid form followed the scale of auditorium space. The character of the space is defining the formal appearance of the center as it's being reflecting outside and it can be indicated in both interior and exterior of the building.

Space-structure relation:

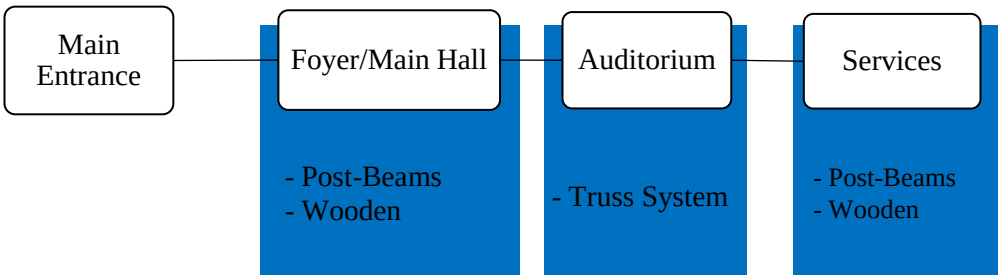


Figure 94: Space and structure analysis of Teopanzolco cultural center (Source: Author)

Teopanzolco Cultural Center is mostly a standard structural system (Formative structure). In which the center is designed with flat surfaces and regular shapes. The platform part of the building contains small spaces so it needed a post-beam structure. The walls of the center are mainly loadbearing walls which is post-beams systems with the use of wooden material. However, the important part is the auditorium. The auditorium is relatively a large scale with the need of wide-free space so it was constructed with truss-frame system. The system also was designed to carry the load of the visitors that will walk above the roof. On the other perspective, the building is using wooden structural elements to present the culture of the city and blend with the environment. The wooden material is also reflected in the interior spaces even it cover the truss system in the auditorium to maintain the same impression of the structural material which strongly define the used material.

4.4.10 Case 10: l'Étoile, Scène de Mouvaux

Table 32: l'Étoile, Scène de Mouvaux

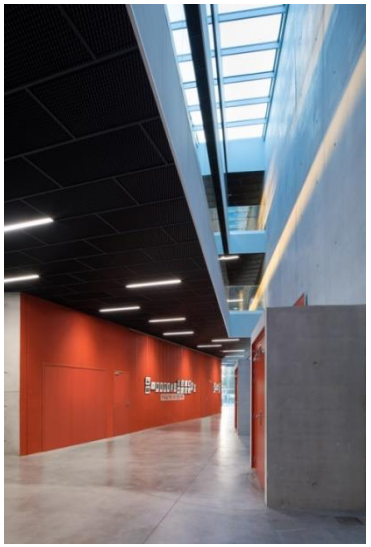
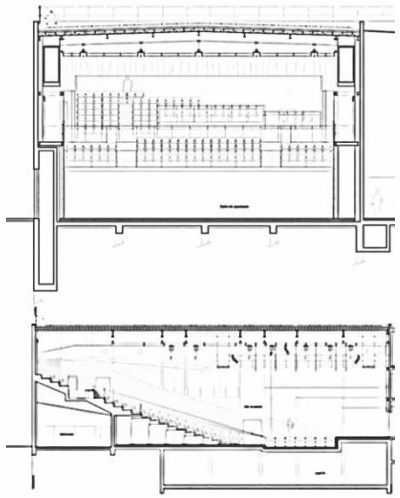
(URL85)

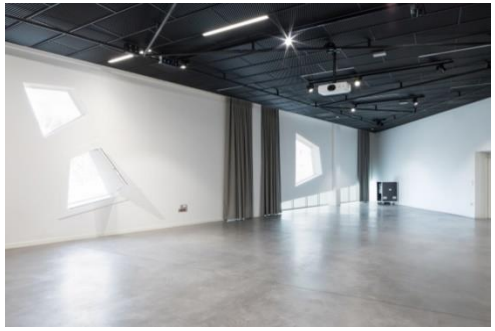
(URL86)

Location	Mouvaux, Hauts-de-France, France
Architect	Atelier d'architecture King Kong
Year of construction	2017
Floor Area	3295 m^2

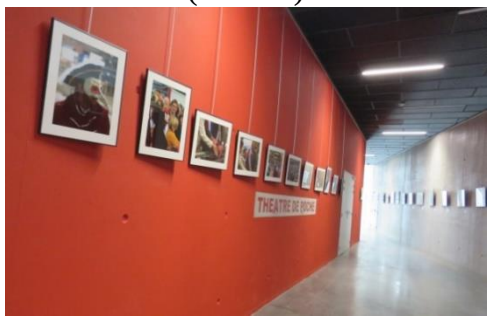
Mouvaux is a commune in the Hauts-de-France region with a 14,000 population. The history of Mouvaux extends from the 12th century but the wars demolished the town and it was restored in 1945. The Mouvaux town developed an urban hub that contains houses, sports buildings and a school. For the purpose to hold this area together, it was proposed to create a cultural center for the community. l'Étoile, Scène de Mouvaux is the cultural centre for the Mouvaux city. The location of the center is visually accessible through the town to blend with the whole urban fabric. The main aim of the cultural center is to provide one space with various facilities such as performance halls, venues for events and seminars, conference area and workshops for different activities.

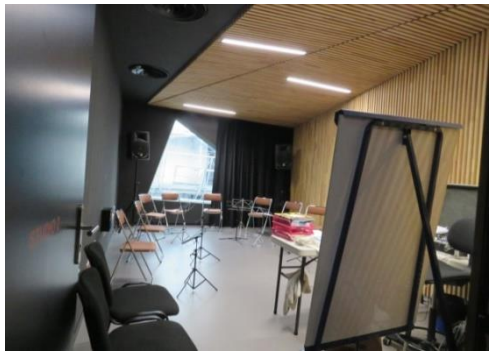
Table 33: Interior space, formal appearance and formative structure of l'Étoile, Scène de Mouvaux

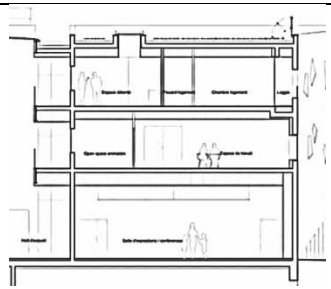
Interior space		Formal appearance		Formative Structure
Interior Views	 	**3D-formation**	   Exterior view (URL86)	  Structural sections of the performance hall (URL89)



(URL86)

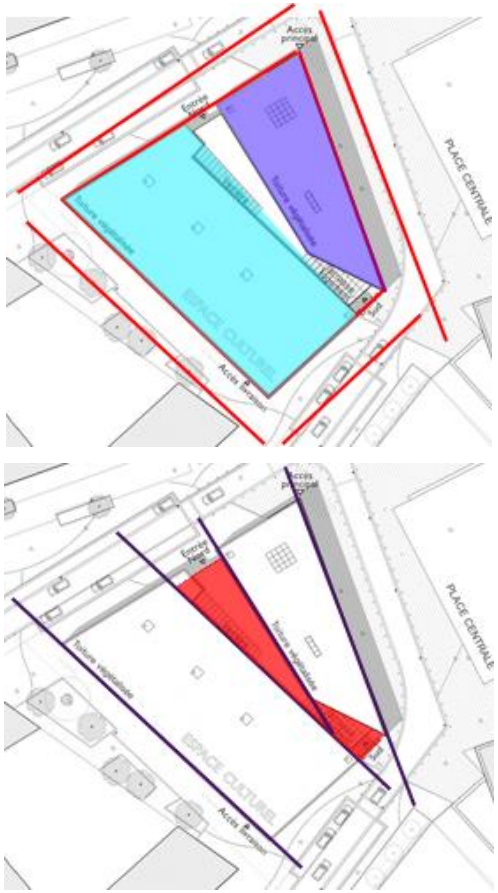
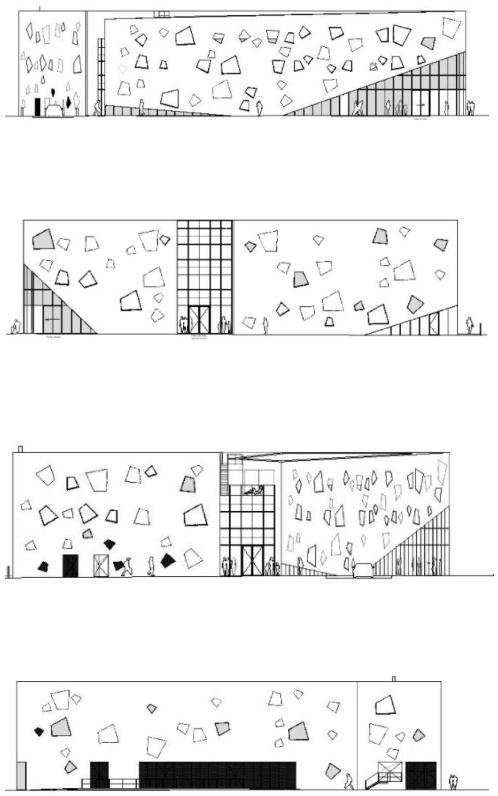






Structural section of standard spaces (URL86)

	 (URL87)			
Functions	- Performance hall - Venues for seminars - Conferences - Workshops (theater, music and visual arts)			

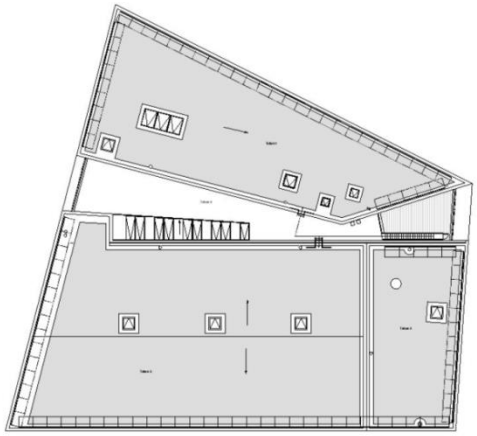
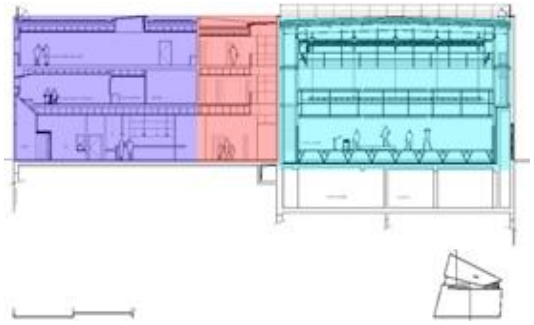
Plans	Workshops and Venues Performance Hall Foyer Circulation and Entrace  Layout planning	**Elevation**	 Elevations (URL88)	

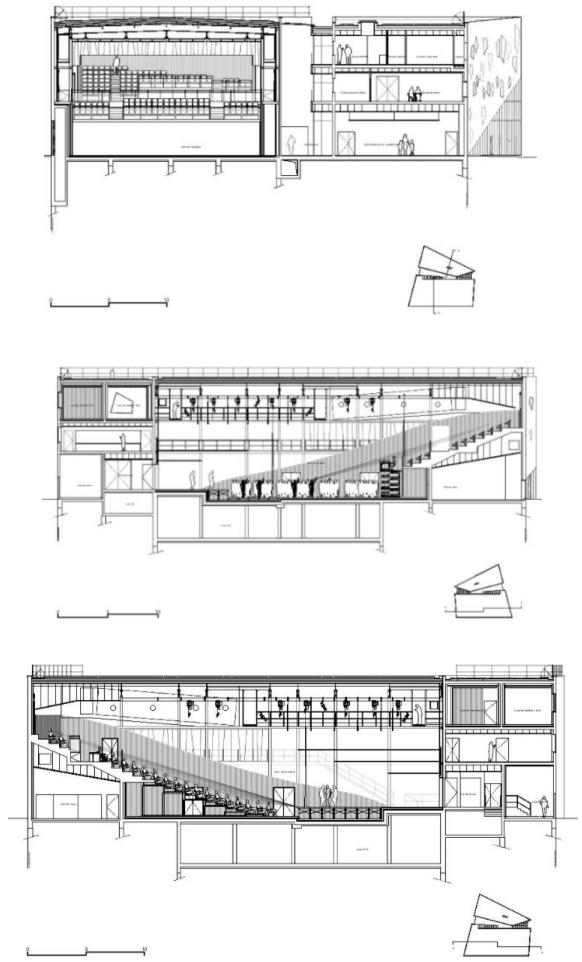
Basment floor plan

Ground floor plan

First floor plan

Second floor plan

	 Roof floor (URL88)			
Section				



Sections (URL88)

Table 34: A checklist of the space, form and structural characteristics of the l'Étoile, Scène de Mouvaux

Specifications of architectural project				
Architectural elements				**Scène de Mouvaux**
Structure	Formative structure of space	Pneumatic		
		Shell		
		Dome		
		Membrane structure		
		Trusses		
		Stairs		
		Ceilings	✓	
		Floors		
		Walls	✓	
		Post and Beams	✓	
Form	Geometry and form	Free-Form		
		Transformation Form	✓	
		Irregular forms	✓	
		Regular forms		
	Form organization	Grid organizations		
		Clustered organizations	✓	
		Radial organizations		
		Linear organizations		
		Centralized organizations		
	Formative elements	Apertures	✓	
		Stairs		
		Ceilings		
		Floors		
		Walls	✓	
	Architectural defining elements	Vertical elements		
		Horizontal elements	✓	
Space	Space organization	Grid organizations		
		Clustered organizations	✓	
		Radial organizations		
		Linear organizations		
		Centralized organizations		
	Function	Others	✓	
		Youth activities		
		Conferences	✓	
		Exhibitions		
		Auditorium	✓	
		Galleries		
		Libraries		
	Circulation	Interior circulation	✓	
		Exterior circulation	✓	
	Spatial relation	Spaces lines by a common space	✓	
		Adjacent spaces		
		Interlocking spaces		
		Space within a space		
	Planning and geometry	Irregular plans	✓	
		Regular plans		

Space-form relation:

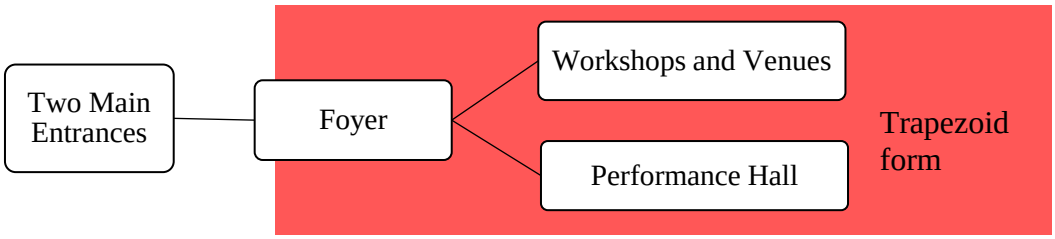


Figure 95: Space and form analysis of l'Étoile, Scène de Mouvaux (Source: Author)

l'Étoile, Scène de Mouvaux is a simple trapezoid-shaped building following the shape of the site. However, it was divided into two parts to emphasize the different functions. The main functions are: performance hall and workshops and venues. Also, there is a foyer space connecting them together.

The planning and interior spaces of the center are emphasized as following (shown in the plans): The facilities of the center were categorized into two parts (layout and plans): the performance hall, the most important space in the center, and the other facilities. The two parts are divided into two forms with common space (foyer). The foyer space provides entrances from two sides to the two parts of the building which offer a gather space for the visitors and orient them towards the facilities (ground floor in yellow). Each part contains several interior spaces that are connected with vertical circulation elements. Also, the upper floors of the two parts are connected with corridor in each level.

The definition of formal appearance: l'Étoile, Scène de Mouvaux give a sense of simplicity in this urban fabric which harmonize with such small town. The creation of the centre begun from determining the shape of the space of the site (detailed in the layout planning); the site is a trapezoid shape and the layout is following the

same shape with a step back from the site boundaries to emphasize an exterior circulation space and maximize the interior space. This idea determined the size of the whole form.

The layout of the two parts follows the main layout; the parallel lines in the main layout were copied and shifted inside which determined the two parts and the common space as shown in the layout planning with dark lines. The foyer space provides entrances to the building. However, to maintain unity in the building, the foyer space was defined by using vertical-formative elements which maintain the two parts as one strongly defined unit. A glass material was used to define the foyer space and preserve visual connection as it's a continuation of the exterior space towards the various facilities. Also, the visibility of the curtain walls indicates the entrances toward the building. The curtain walls preserve the space as a gathering and welcoming area. On the other hand, the solid appearance of the main two parts of the center indicates to the served functional spaces.

The two parts of the building stands as two huge forms and the bigger one refers to the most important function (performance whole). The form of the two parts is created with straight vertical surfaces to preserve the overall layout of the building. This maintains a strong defined and readable form for the public. The layout of the building is also maintained in the openings. The architect did not settle for standard lines but they inspired from the same shape of the main space (in the layout and exterior views). In result, each part of the building is related to the other in a certain aspect which creates a strong connection between the different aspects of space and form in the center.

Space-structure relation:

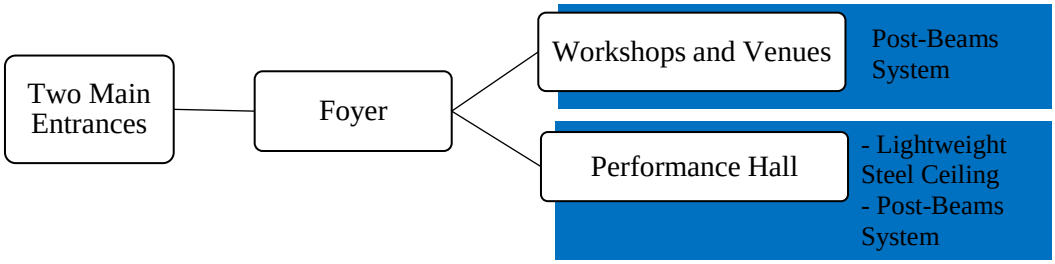


Figure 96: Space and structure analysis of l'Étoile, Scène de Mouvaux (Source: Author)

The most challenging part of the l'Étoile, Scène de Mouvaux is the performance hall regarding its large scale. The aim was to provide a large space to contain large number of audience without any physical blocking element to maintain visual connection to the stage. So the roof of this area was created with light weight steel material to cover the large span. The services of the performance hall and the other part of the building are constructed with post and beams system. However, the used material for the walls and floors is the concrete. Which is well-defend on the exterior. The interior spaces are presenting various using of materials according to the functional characteristics but it maintains the appearance of used concrete which create a connection between the structural elements and the interior spaces (interior views). The concrete material of the building reflects a strong and defined structure for the main spaces of the center.

4.5 Result of analysis the selected cases

The aim of this thesis is to investigate the generator role of the interior space in relation to formal appearance and formative structure of an architectural project. So a literature survey was conducted to create the frame of the discussion and the analysis. First, a research on the fundamental development of architectural project during the twentieth century onwards that introduced by different influential

architects. The architects developed various architectural ideas from the beginning of the twentieth century which they created a new understating of the design project. The research indicates that each architect studied different aspects of the architectural projects regarding the space, form and structure. However, each architect had a different perspective towards the relation between the space, form and structure. Their thoughts presented a frame and understanding on the development of the different design elements. Second, a literature survey was conducting to expand the research on the design elements that the architects developed: space, form and structure. This part presents a descriptive discussion on the different characteristics of the space form and structure. Also, to define the integration elements that combine space with form and space with structure for the aim to study specifically the relation of space with form and structure.

The literature survey presented an understanding on the role of space, form and structure to define an architectural project. However, for the aim to indicate the generator role of space to create the formal appearance and formative structure, an analytical study was conducted in the case of cultural centers. The cultural centers were selected according to their various facilities, the variety of design concepts, and the lack of researches done on this typological building. The method of the analysis is using the literature survey in which it created an analytical frame for the analysis. The analyzed architects and the architectural project elements study created a various tables to be used for well-emphasizing the case studies. The case studies were analyzed with the use of table that presents the different views and technical drawings of the project. Also, another table that presents the various aspects from the literature survey to identify which aspect the case study is maintaining. Both offer a

comparison element between the different part of the case and more defined criteria to compare the cases together (table35).

The analysis was conducted on 10 different case studies of cultural centers. The selected cases are varies in terms of selecting international centers and well-known architects. Each case reflects a different design than the other which creates a stronger statement for discussing the role of space in creating that design. The different elements of the space, form and structure of the case were emphasized with the use of 3D-views and technical drawing. Also, they analyzed by the use of the checklist as summarizing the importance elements. Regarding, the case is studied in two relations: space-form relation and space-structure relation. So following are the understanding outcomes of the cases studies.

The case studies were emphasized according to the use of table 2 & 3 for defining the different characteristics and elements of the cultural centers. Accordingly, table 35 is a checklist that summarizing the characteristics of all the cases in terms of space, form and structure for comparison. The table shows the variety of the features of cultural centers regarding flexibility in planning and geometry, different spatial relations between spaces, the importance of exterior and interior circulations to emphasize the space, variation in space and form organization, variation in the main architectural defining elements, variation in formative elements of the space, variation in geometrical form, and different formative structural elements that define the space. As a result of the analysis, it represents the significant of cultural center as a type of building; cultural center is a unique designing building for its variation in

the characteristics of space, form and structure which supports using it as selected typological building for the analysis.

The cultural centers maintain different main characteristics of interior space. The planning, spatial relations and space organization are various in all the cases. The cases represent these characteristics that were mentioned in the literature review and the table 35 which reflect varieties in space's features. Also, they show the wide designs of cultural center to expand the analysis for studying the relation for different collaborations.

The cases represent the significant on defining the exterior circulation towards the building; cultural centers serve all the resident of the city as it serves different cultural activist and events so the buildings need to emphasize the path towards the main entrance and the gathering space. They show the importance of leading the massive number of visitors towards the building and being visibly recognized. On the other hand, many cases show the significant of defining the interior circulation from the foyer as a welcoming and gather space towards the interior facilities. Also, the well-defined foyer space leads to defining the path towards the main facilities. However, there is a case that represents lacking in defining a foyer space which is House of Culture. The exterior space towards the main entrance is well-defined by the two main parts of the building. However, the interior space from the entrance is poorly defined which considers an important space for introducing the building to the visitors and serves as gathering space. In the absence of this feature in the House of Culture causes undefined interior circulation towards the main functions of the center.

Table 36 and the different case studies present the different functions that contained in cultural centers. Such as, auditorium, theater, exhibition, galleries, stores, libraries, offices, conference rooms and youth activities. However, the most common function between the cases is the auditorium. The auditorium as an individual function required standard characteristics including the stage, massive number of seating to contain large number of the public residents, and acoustic control elements. So the auditorium is standard in designing any building. However, the attitude of manifesting the auditorium is different from one case to another according to the conceptual design of the cultural center. On the other hand, most cases of the selected cultural centers with the auditorium as the main function reflect the same idea of defining and forming the auditorium with the formal appearance. For instance, the KKL Luzern is well-defining the auditorium as a separate volume but still maintaining connection with the whole building. The KKL Luzern also have smaller theaters is an important functions in the building which they were all well-defined as separated volumes with distinguished appearances and they were also well-defined as a whole building with the use of foyer space and connections elements. However, the Center Pompidou does not have an auditorium as the main function but it also well-defined center with its flexible space to accommodate different facilities and events which shows through the interior and exterior appearance of the center. On the other hand, the Heydar Aliyev Center is a unique-designed building with curvilinear form which reflects the future of architecture. But in terms of space is the generator of formal appearance, the Heydar Aliyev Center is opposing this idea. The concept of the building is to create a unique form that orients the city towards the future so the defined element of the center is the formal appearance and as discussed the interior space are located within the form. The

center maintains various important functions including the auditorium and exhibition area but they are not reflected on the exterior. The exterior curvilinear form introduces the visitors the interior experience with the use of curvilinear surfaces. The curvilinear surfaces in the exterior and interior shows the significant in preserve a connection between them however it hides the variation of the facilities and not defining them under the same surface. The visitors will be introduced to the formal appearance through the exterior and interior with no regards to the interior space characteristics.

The cultural centers were designed to serve the resident and connect a certain urban fabric. Which by comparing all the case studies, they show the architects of cultural centers were considering defining and reflecting the interior characteristics to the formal appearance to introduce the center to the public. So they maintained a connection between the center and the residents through the space by orient them starting from the exterior form; the exterior form in which it emphasizes the interior spaces' characteristics. However, in the case of Heydar Aliyev Center, the center losses the direct connection between the interior space and the urban fabric; in this case the formal appearance causes separation between the interior spaces and the urban fabric.

The less important functions in the cultural centres such as the stores, serves or offices are in the most cases are hidden with minimal eye-catching forms. However, these spaces are well-defined according to their importance level in the building. The design of these spaces is different than the main facilities in the centre with the use of simpler design or hidden-accessible forms. For instance, the House of Culture have

the offices in a separated well-defined building but it less eye-catching than the form of the main function. The main function, the auditorium, is defined as a stronger and massive block with the use of strong material as the red bricks to distinguish it as the most important part of the building. But, the offices are well-defined and reflected the idea of maintaining less important functions with relation to offices design. Also, in the Tjibaou Cultural Centre, the important parts of the building are defined by the use of hut shape reflecting the Kanak culture of the region. For distinguish the huts, the services and the followed functions of the huts were hidden under the ground but defining them by leaving one floor high above the ground. So they will not disturb the concept of the center but the spaces are defined and accessible. On the other hand, the Heydar Aliyev Center is locating all the spaces beneath the same surface. The variation between the main functions and the services is maintained by the space distribution under the surface and the curvilinear surfaces orient towards the main functions. Since the interior spaces are not reflected and defined by the exterior, the curvilinear surface of the exterior form has the role to distinguish between the spaces. But, as shown in the other cases, the spaces have the ability to be defined in terms of their significant role of the building. This also reflects the role of the form to follow the space and create variations in distinguished level of the spaces.

On another matter, the relation between the space and the used structure as shown in table 35 is differently emphasized in the different cases. In many cases, the auditorium is well-reflected on the formal appearance with the use of truss element of the structural system to create large spans and avoid any structural element in the space to maintain visual access through the space and to the stage. This procedure was lacking in the House of Culture for the use of V columns in the auditorium

which may cause blocking the visual access or distractions for the audience; marinating the auditorium space is one large space create a stronger statement and definition for the space. Moreover, the structure was used for bearing the loads and to define spaces. For instance, in the Bergama Cultural Center, the concrete columns are well-recognized through the building and they are used as a structure element for supporting the loads of the building and as defined element to emphasize the sidewalk area for the stores and the entrance towards the courtyard. In another case, Tjibaou Cultural Centre is using the wood material for constructing the huts and it well-recognized from the interior spaces which creates a direct relation between space and structure. Also, in the case of Heydar Aliyev Center the building is also using materials that create large spans but the used system is mainly designed to achieve the desired curvilinear form. The center has different facilities that required large free-spaces with no use of vertical elements to avoid physical and visual blocking of the space such as the galleries, exhibition and auditorium. But, the used structure was designed to follow the exterior form and not the interior spaces characteristics. The structure of the building is poorly connected with the interior space in this case. Maintaining direct connection between the interior spaces and the used structure for this space to form and bear loads create a stronger statement for the building and more unity in design the whole project.

According the above discussion, the analysis presented the different possibilities in design. It reflected the importance of the cultural centers with the variation of the contained facilities and the variation to deal with them. Generally, most of the cases studies present a connection between the different stages of designing an architectural project. Moreover, the interior space characteristics including

organization, circulation and functions were consider through the whole design process to reflect them in the formal appearances and the chosen structural elements to formative the space. The sense of the connection between the different layers of the centers, architectural project, unit the whole building together and offer a stronger statement for the aim of the building. This idea is opposing the formative architects in which they mainly consider the most important part of the building is the formal appearance. This idea managed to create new forms and free-forms but it reduces the significant of the interior space in which the interior space is the most important part of the building for the people to use and interact. As shown in the cases and the tables, the characteristics of the space have the ability to define the characteristics of form and structure. Which in result created a unite design though out the centers. While having the form as defining layer, it create a connection with one layer and reduced in the other; a strong relation with the used structure to maintain that form but it reduces the connection with the characteristics of the spaces and function. The form is being brought to the interior to unit them but it's not related with the specific features of the space.

Finally, according to the study and the discussion, the more unified design of architectural project is the projects that maintain the space as the generator element to define formal appearance and formative structure which created to continuous design through the project and more united building. This idea also creates a strong connection between the different layers of the architectural project and the urban fabric in which the public will recognize and understand the reason behind the different parts of the project including space, form and structure.

Table 35: A checklist of the space, form and structural characteristics for all the case studies for comparison

Specifications of architectural project — Space

Architectural elements	Planning and Geometry		Spatial Relation				Circulation		Function							Space Organization				
	Regular plans	Irregular plans	Space within a space	Interlocking spaces	Adjacent spaces	Spaces lines by a common space	Exterior circulation	Interior circulation	Libraries	Galleries	Auditorium	Exhibitions	Conferences	Youth activities	Others	Centralized organizations	Linear organizations	Radial organizations	Clustered organizations	Grid organizations
1	✓	✓				✓	✓		✓		✓		✓	✓	✓				✓	
2		✓		✓			✓	✓	✓		✓			✓	✓	✓			✓	
3	✓				✓	✓	✓	✓	✓	✓		✓		✓	✓		✓			
4	✓		✓				✓	✓	✓		✓	✓		✓	✓		✓		✓	
5		✓				✓	✓	✓			✓		✓		✓					✓
6		✓		✓			✓	✓			✓				✓			✓		
7		✓			✓		✓	✓	✓	✓	✓	✓	✓		✓				✓	
8		✓			✓		✓	✓	✓		✓				✓		✓			
9		✓		✓			✓	✓			✓				✓				✓	
10		✓				✓	✓	✓			✓		✓		✓				✓	

Specifications of architectural project — Form

Architectural elements	Architectural Defining Elements		Formative Elements					Form Organization					Geometry and Form			
	Horizontal elements	Vertical elements	Walls	Floors	Ceilings	Stairs	Apertures	Centralized organizations	Linear organizations	Radial organizations	Clustered organizations	Grid organizations	Regular forms	Irregular forms	Transformation Form	Free-Form
1	✓	✓	✓		✓				✓				✓			
2	✓	✓	✓					✓			✓			✓		
3	✓	✓	✓		✓	✓	✓		✓				✓			
4		✓	✓		✓		✓		✓				✓	✓		
5	✓	✓	✓		✓	✓						✓		✓		
6	✓	✓	✓		✓					✓				✓	✓	
7	✓		✓		✓		✓				✓					✓
8	✓	✓	✓		✓		✓		✓				✓			
9	✓		✓		✓		✓				✓			✓		
10	✓		✓				✓				✓			✓	✓	

Specifications of architectural project — Structure

Architectural elements	Formative Structure of Space									
	Columns and Beams	Walls	Floors	Ceilings	Stairs	Trusses	Membrane structure	Dome	Shell	Pneumatic
1		✓	✓	✓						
2	✓									
3		✓	✓	✓		✓				
4	✓	✓		✓						
5	✓	✓		✓	✓	✓				
6		✓	✓	✓		✓				
7		✓		✓		✓				
8	✓	✓		✓						
9	✓	✓		✓						
10	✓	✓		✓						

Chapter 5

CONCLUSION

The architectural project had developed with the begun of the twentieth century by various architects such as; Frank Lloyd Wright, Walter Gropius, Le Corbusier, Buckminster Fuller, Louis Kahn, and Robert Venturi who influenced the architecture of twentieth century onwards. The architects studied and developed the main elements of creating an architectural project which they are the interior space, formal appearance and formative structure. Also, they presented various relations between each other from different perspectives. So this thesis aims to investigate the relation between space with form and structure in an architectural project regarding the development aspects of the twentieth century onwards.

The concepts of interior space, formal appearance and formative structure were used in this thesis to create a further study regarding their characteristics and defining elements. In result, an analytical criterion was created regarding the investigation on the generator role of space in defining the formal appearance and formative structure. The study was implemented in 10 case studies of selected cultural center to analyze their space characteristics and distribution within the building. Then, compare the interior spaces with the formal appearance and formative structure of the center which create an understanding of the defining elements and concepts of space that formalized the center if available. So the outcomes of this analysis summarized as following:

The study shows the importance and the effect of preserving the interior space features as a generator of the form and structure in creating continues design and a unified building. The cultural centers strongly presented this idea because of its various functions and mostly they are being designed with more than one form which shows its direct relation with functional role of the interior space. The defining characterizes of the interior space can be the functions, circulation, scale, etc. and for the most cases they are being used to define the formal appearance and formative structure. However, the formal appearance and formative structure also defined by other factor such as following a certain concept or the urban fabric. This leads to create varieties in designs to deal with the interior spaces. However, the significant and the role of space to define the form and structure are still strongly maintained. But in few cases, the exterior form is neglecting the interior spaces and they are not being reflected outside rather than bring the exterior form into the interior.

The analysis shows the "space-form relation": Interior space with relation to formal appearance, according to the case studies, is maintaining a strong definition in the most cases. Interior space characteristics and functions can be major defining aspects for creating the formal appearance. For instance, the scale of the interior space is defining the scale of the formal appearance. The contained function or functions have the role to create different parts and organizations which reflected on the form of the center. The importance of the interior spaces is reflected on the exterior form by their differentiated appearances and the ability to visualize them; the most significant space or group of spaces is being more emphasized the others. For instance, one of the significant spaces in the interior space is the foyer, in which the cultural centers are usually contain various functions so the foyer gather the visitors and orient them

through the building. On the other hand, analyzing the other case studies with recognizing a direct relation of the interior spaces with the al appearance reflects a stronger statement for the center as a unified and continuous design. It offers a more comprehend design for analytical studies and regarding the public use in which the building introduces its interior characteristics through the formal appearance.

The analysis shows the “space-structure relation”: Interior space with relation to formative structure, according to the case studies, is offers a direct relation for most of the cases. The structural system is used mainly to bear the loads directed to buildings. The structure is formative element that defines an interior space. According to the analysis, the features of the interior spaces determined the used system and elements to occupy the space. For instance, the large scale spaces with the need to provide a wide column-free space especially for an auditorium or theater, the used structural system is steel trusses for its long spans.

According to the previous discussion and analysis, the interior space is a defined element of formal appearance and formative structure. Most of the cases indicate a strong relation with the interior space characteristics such as circulation, scale, and function. However, as discussed the formal appearance and formative structure can be determined by other factors beside the interior space which was also discussed by the mentioned architects in the literature survey. The feature in this case is that it may give the ability to be more creative in design but it reduces the connection between the different layers of the project. On the other hand, the analysis presents a strong and unified design that created with considering the interior space as generator of the cultural center. As the cultural center has a varieties of functions and features,

it create a stronger statement for the center to define the spaces through the form and structure. It creates an architectural project with well-defining each part of the project starting from the interior space towards form and structure without neglecting any layer. This idea is opposing the formative architects but this study support the role of space in offering a stronger statement and definition of the architectural project for create defined designs and for the visitors to sense the space within the form and structure.

Recommendation and further studies: A Further studies can be begun on this discussion to investigate the generator role of space in formal appearance and formative structure in different types of buildings. Also, the study can be extended by the use of observation method to create a more constructive study. Moreover, the analysis shows the ability of the formal appearance to generate the interior space so this relation can be discussed further to compare it with the idea of this thesis. One other words, the other relations between space, form and structure can be studied and another researches on comparison between the different relations and which one creates a stronger statements in creating architectural projects.

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