The Integration of Form and Structure in The Work of Louis Kahn

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ABSTRACT

An important aspect of design, as a product of a cultural context, is the unity between form and structure in architecture. In modern architecture, since the Renaissance, the emphasis has been on stylistic expression, and consequently much consideration has been placed on formalistic and geometric elements of design, as for example, the tradition of Baroque and Neo-Calssical architecture.

Since the Industrial Revolution, and particularly with the increasing use of modern materials and structural systems (e.g. iron, steel. glass, reinforced concrete, high-rise and wide span structures) the expression of structure began to emerge as main stylistic criteria. But, this expression was not a balanced statement between form and structure but rather the emphasis was on tectonic. This is one of the major criticisms of Postmodern architects regarding modern architecture; that is, the reduction of architecture to mechanical and functionalist expression.

By contrast, the work of Louis Kahn is a very good example of both a more balanced and holistic approach toward an inclusive design, in which the integration of form and structure plays a major role. The aim of this thesis is to discuss and analyze the ideas and methods implicit to Louis Kahn's work; i.e. an understanding of this integration and how he applied this to his design. This is important because, today, much architectural work suffers from the unbalanced emphasis upon formalist or tectonic expressionism. Louis Kahn, and his successors are examples of how architecture, as a cultural as well as tectonic/functionalist form is result of designing with an understanding of the integration of form and structure, as an expression of a

particular cultural period. This thesis will conclude with examples and a discussion, of relevant architectural successors of Kahn and their expression of this integral approach to architectural design in contemporary architecture.

Key Words: Louis I. Kahn, Influences, Theory, Form, Structure.

ÖZ

Bir kültürel bağlamda bir ürünü olarak tasarımın önemli bir yönü, form ve mimari yapısı arasındaki birliktir. Modern mimaride, Rönesans'tan bu yana, vurgu ve üslup ifade edilmiş dolayısıyla çok dikkate örnek olarak, tasarım şekilci ve geometrik elemanları yerleştirildi, Barok ve Neo-Calssical mimari geleneği.

Modern malzemeler ve yapısal sistemlerin kullanımının artması Sanayi Devriminden beri ve özellikle (örneğin demir, çelik, cam, beton, yüksek katlı ve geniş açıklıklı structure pekiştirmek) yapısının ifadesi ana biçimsel ölçüt olarak ortaya çıkmaya başladı. Ama, bu ifade form ve yapı değil vurgu yapısalcı vardı arasında dengeli bir açıklama değildi. Bu modern mimarisi ile ilgili Post-modern mimarlar önemli eleştirilerden biridir; mekanik ve fucntionalist ifade mimarisinin azalma olduğunu söyledi.

Buna karşılık, Louis Kahn çalışmaları hangi biçim ve yapı entegrasyon önemli bir rol oynar kapsayıcı bir tasarım doğru hem de daha dengeli ve bütüncül bir yaklaşımla, çok iyi bir örnektir.Ve bu bütünleşme bir anlayış yani onun tasarımı bu uygulanan nasıl, bu tezin amacı tartışmak ve fikir ve yöntemler Louis Kahn'ın eserleri ile örtülü analiz etmektir. Bugün, çok mimari eser formalist veya structurlist ekspresyonizm üzerine dengesiz vurgu muzdarip, çünkü bu önemlidir. Louis Kahn ve halefleri örnekleridir nasıl mimari, kültürel bir yanı structuralis / functionalis form olarak belli bir kültürel dönemin bir ifadesi olarak, biçim ve yapı entegrasyon anlayışı ile tasarımı sonucu olarak. Bu tez örnekleri ve Kahn ilgili mimari halefleri ve çağdaş

mimarlık mimari tasarım için bu entegre yaklaşımın kendi ifadesi bir tartışma ile sona erecektir.

Anahtar Kelimeler: Louis I. Kahn, etkileri, Teori, Form, Yapı.

To My Wife

ACKNOWLEDGMENT

I would like to acknowledge the advice and guidance of Asst. Prof. Dr. Isaac Lerner. Without his invaluable guidance and supervision, this study would not have been successful.

I would like to thank my parents, especially my father who always encourages me to continue my education. This thesis is dedicated to them as small thank you.

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INTRODUCTION

1.1 Aim of The Study

The thematic study of this thesis focuses mainly on the integration of form and structure in the architectural work of Louis Kahn which, in turn had a significant influence on Modern architecture; an influence that compares with that of Frank Lloyd Wright and Le Corbusier. An important aspect of Louis Kahn's architecture is the production of meaning and identity as realized through his attempt to integrate geometry, form and structure through design. This research therefore, necessarily involves the related discussion of both traditional and contemporary architecture and technology as vital precedents that facilitated his design.

Another aim of this study is to describe how certain architects influenced Kahn in terms of realizing the significant integration of form and structure. For instance, how Paul Cret, Le Corbusier, Frank Lloyd Wright, Ludwig Mies van der Rohe and Robert Venturi's design, ideas and structural expression influenced Kahn and, how Kahn in turn influenced contemporary architects such as Tadao Ando, Moshe Safdie, Mario Botta, Renzo Piano and Norman Foster.

Kahn agreed with Paul Cret, who strongly believed that the only suitable style of architectural design is Classicism. Cret, who was Kahn's most influential teacher during his student years thought that contemporary architecture could be more

meaningful by means of proper composition of elements for the specific circumstances, that is, a more contextually and socially responsive design rather than relating to an accepted style. “Cret’s cautious exploration of modern architecture came as no surprise”, as he stated in Philadelphia in 1923 that “Our architecture is modern and cannot be anything else”.

Vitruvius, a roman architect who was first to formulate, overall scope of architecture in the first century. He described architecture’s responsibilities “to provide utility (utilitas), durability (firmitas) and delight (venustas)” in the complete guide, titled "The Ten Books of Architecture" (Gast, 1998, p.185). Durability refers to how buildings stand up over time against natural forces. Utility focused on how the building can be more useful to the occupant in a way it serves its function. Delight refers to the aesthetics, or beauty of the buildings.

As a result, Kahn as a modern architect always struggled with the historical, cultural and the physical context as influences for his design. Although it has been variously interpreted over the centuries, these three aspects of architecture serve to describe the most important requirement of a building; i.e. how it remains standing and provides the viewer and user with an identifiable form as well as an understanding of technology of its time in the service of establishing a sense of place. These are similar qualities that we can find in Louis Kahn’s work.

With regard to a brief biography, Louis Isadore Kahn (1901-1974) was born on the 20th of February, 1901, on the Baltic island of Saaremaa in Estonia, to Leopold and Bertha Mendelson. The 14th-century Bishop’s Castle in his birthplace Kuresaare was the largest structure in the Saaremaa. The interior courtyard created a centralized

building organization which has massive stonewalls cut by small windows and pinnacled with crenellated fortification and an attached tower; while the whole building was surrounded by a pond. His father Leopold worked in the castle as a scribe for the residents, while Kahn's family lived in Saaremaa. Kahn was directly very impressed by this place as a child. Kahn returned to visit Saaremaa at the age of twenty-seven, and he visited the castle and its protected interior space, whereby "it is clear that Kahn's lifelong love of castles had its beginnings in his early experiences of this powerful structure" (McCarter, 2005, p.12).

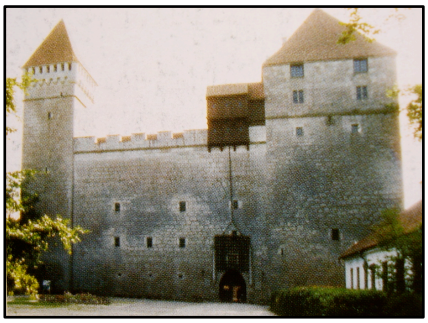


Figure 1.1: Bishop's Castle at Kuressaare on the island of Saaremaa, 14th century (McCarter, 2005, p.12)

In 1906 the family immigrated to the United States and settled in Philadelphia where they changed their last name to Kahn. Kahn lived his entire life in the city of Philadelphia, which had a great influence on Kahn's conception of the facilities and institutions of a city, and the way its architecture affects the lives of its citizens.

Although Kahn had talents, such as playing piano that resulted in a music scholarship; which he refused in order to focus more on the visual arts. This talent also provided him with a scholarship from the Pennsylvania Academy of Fine Arts. There was another opportunity for the young Kahn when he took a course in the

history of architecture in his senior year of high school. A course consisting of various assignments included such as drawing and lectures, taught by William F. Gray. Kahn clearly remembered all the slide-show lectures on "Gothic, Renaissance, Greek, Roman and Egyptian architecture" (McCarter, 2005, p.15) by Gray, because he said at end of his life, "I can still see those examples after so many years as the most resounding influence…of powerful commonality". Kahn was always struck by this fact, that architecture is not like other arts but rather it is experienced through inhabitation – architecture is "an art you can walk *around* and *be in*" (Louis Kahn, 1972, pp. 298-9). So Kahn became attached to architecture and refused the art scholarship to study architecture at University of Pennsylvania instead.

Tradition of building and making of places was much more important to Kahn who was less concerned with fashion than with traditional forms. For Kahn, what architecture meant was related to how a building is built and how spaces are ordered as this normally affects the inhabitant who experiences it; that is the meaning and identity of those buildings. What is important in the architecture of Louis Kahn is the production of meaning and identity as realized through his attempt to integrate geometry, form and structure in his design.

During the second half of the twentieth century, Louis Kahn's works had a dominant influence upon architecture. There have been relatively few critical studies of Kahn's work since Kahn's death, in 1974, and they indirectly inspired both the post-modernist and neo-rationalist critique of Modernism. His work also expanded modern architecture, with its emphasis on a visible style of construction for our time. It inspired contemporary architects who also apply a modern tectonic and material order. Some of these architects, who extend Kahn's insights, include Tadao Ando,

Moshe Safdie, Mario Botta, Renzo Piano, and Norman Foster. Although Kahn worked his entire life as a modern architect he admitted, at the end of his life, that his Beaux-Art University training under Paul Cret (Instructor of University of Pennsylvania) had a most important effect on his architectural design ability. For example, Kahn's late work share qualities found in his student projects.

Consequently, Louis Kahn had a significant influence on modern architecture but he was not as well known as Frank Lloyd Wright and Le Corbusier. As Kenneth Frampton claims "almost no one now turns to mention [His] name…..the subtlety, stoicism, and relevance of Kahn's poetic contribution" should serve as "a kind of sharp reminder of what we have lost" (Frampton, K, 1986, p.135). Also late architect James Stirling said to Robert McCarter (author) in 1990 that "It is appalling what students talk about in American architecture schools today- Derrida, indeed! Why doesn't anyone study Kahn?" (McCarter, 2005, p.7) and Vincent Scully, who had wrote a book about Kahn in 1962, stated that "No one can sum up Louis I. Kahn" (Scully, V, 1962, p.43). And also Moshe Safdie who is a Contemporary Architect stated in his Book "Moshe Safdie" in 2009 that "Kahn spoke of the qualities of calmness that breed contemplation, he was obsessed with the interdependence of communal work and individual work, with the balance between privacy and community." (Safdie, 2009, p.6).

1.2 Statement of The Problem

Today, we live in a very complex world where everything is rapidly transforming; new form and design in a new way (e.g. Deconstructive, Hi-tech and a pluralism of styles). We have seen very exaggerated designs from various architects that we couldn't imagine before due to new materials and information technology. We live in a world where anything is possible and expressed in a variety of styles. The problem

is if we continue to go further in this manner, we may end up with some kind of new free style; a pluralism that lacks architectural and cultural tradition or forms, that don't refer to history and social context.

Therefore, a study of an architect who had great influence on modern architecture, in that his inspiration for design comes from monumental buildings and history of architecture is relevant in this pluralist context. Although Kahn was a modern architect, he always struggled with the historical, cultural and the physical contents as they influenced his design.

1.3 Research Questions

The following questions are considered in this thesis:

1. How did Paul Cret inspire Louis Kahn?
2. How Frank Lloyd Wright, Le Corbusier and Mies van der Rohe influenced Kahn?
3. How Robert Venturi shaped Kahn's thinking and practice?
4. A comparison of Monumental and Modern buildings in terms of Kahn's ideas and philosophy of architecture?
5. What is meant by the Served & Servant spaces functions of an integration principle in Kahn's work; an integration of Function, Form, and Structure?
6. How Kahn inspired other younger architects such as Moshe Safdie, Mario Botta, Tadao Ando, Renzo Piano and Norman Foster?
7. All of the above questions are a means of understanding what is the fundamental relation between Form and Structure in Louis Kahn's work as a designer.

1.4 Methodology

My methodology involves using case studies as a relevant reflection of Kahn's thought and methods. The case studies of Kahn's buildings, such as the Trenton

Bathhouse, the Richard Medical Research Building, the Philip Exeter Library and the Kimbell Art Museum, are based on an analysis of the relationship between form and structure. Further study will involve the analysis of Moshe Safdie, Mario Botta and Norman Foster's buildings in terms of forms and structure influenced by Kahn.

The research is structured to include both relevant historical and theoretical background constituting Louis Kahn's life story; e.g. how Louis Kahn started with Beaux-Art training until he become Modern architect. That is, during this period, there were great architects who had influenced Kahn, such as Paul Cret, Frank Lloyd Wright, Le Corbusier, Mies Van Der Rohe and Robert Venturi. In this regard there is philosophy which he developed overtime behind each of Kahn's buildings; ideas such as served & servant spaces and measurable & unmeasurable forms. These and other concepts will be part of the analysis of his case studies.

Kahn was very concerned with structure and the relationship between structure and form/function. For example, he always had discussions with Civil Engineers, such as August Komendant who was Kahn's Engineer for many years, who always was of great assistance towards originating a design (Komendant, 1975). This research will include how together they resolved structural form, as a complement of architectural form. The analysis of Kahn's late works, and also other architects who inspired by Kahn will be carried out in the chapters on case studies and in the conclusion. This study is limited with a special focus on Kahn late works, but is not limited geographically.

Therefore in order to perceive, how Louis Kahn integrated form and structure, the format of the case studies is, divided into five sections which include, (1) "servant

and served" spaces, (2) function and geometry, (3) form/structure and geometry, (4) structure and form, (5) details, and a summary for each case study. Servant and Service, because it is the most important idea that Kahn applied to his buildings, the notion of geometry and function shows how form follow function in Kahn's building, although he believed form shouldn't follow function in a utilitarian logical manner. Geometry and Form shows how Kahn used geometrical figures for his design and by dividing and scaling into smaller geometries, he derives a structural configuration. The idea of form and structure shows how he used structure, not only to carry the load but by designing structural elements, he gave identity to his building in the manner of ancient building. The study of detail provides more depth with regard to better understanding his building in terms of integration of form and structure.

Chapter2

PRIMARY ARCHITECTURAL INFLUENCES IN THE WORK OF LOUIS KAHN: FROM BEAUX-ARTS TO THE MODERN AND POSTMODERN PERIODS.

2.1. Beaux Arts; Paul Cret

The Beaux Arts style (1890-1920) derives its name from the L'Ecole Des Beaux-Arts in Paris, which among others served American architects who received their training, around the mid-19th century, such as H.H. Richardson, and Louis Sullivan. This style emphasized "the study of Greek and Roman structures, composition, and symmetry, and the creation of elaborate presentation drawings" (Black, 2007, p18). The Beaux Arts was an ideal style in America for expressing civic pride in a manner of the idealized origins and grandiose use of classical form; "Beaux-Arts design depended on the regular breaking and disguising of axes in order to reserve the freshness of their organizing effect" (Brownlee D, De Long D, 1991, p.21). "This style's expression mostly consists of grandiose compositions, exuberance of detail, and a variety of stone finishes" (Black, 2007, p18).

Paul Philippe Cret graduated from the L'Ecole, and later became an instructor at the University of Pennsylvania (1930 to 1937); this is the University where Kahn started his architectural studies in the autumn of 1920. The university was recognized as providing an outstanding architectural program in the U.S.A,

which was based, at the time, on the same method of teaching as Ecole des Beaus-Arts in Paris. The author, David Brownlee stated that “Cret thought that Modern democracy would consequently achieve its own architectural expression” (Brownlee D, De Long D, 1991, p.21). In terms of these ideas he sympathized with his contemporary, Louis Sullivan.

Although Cret strongly believed that the only suitable style for architectural design is Classicism, he also thought that contemporary architecture could become more relevant by using a proper rational composition of elements for the specific circumstances, rather than with an accepted style. “ This problem-solving approach accepted the idea that new functions and new contexts would lead to new modes of formal expression”, and it had a primary and lifelong influence on Kahn (McCarter, 2005, p18). That is, “Dynamic balance rather than symmetry was evidently Kahn’s objective, although it was imperfectly attained. This experience with non-axial planning provided the foundation on which he would build his experiments with modernist composition in the thirties and forties, while the concern for planning in general would persist throughout this career”. (Brownlee D, De Long D, 1991,P.21)

Cret introduced the opposing theories in architecture, which were published by the “French Rationalist Ecole des Beaux-Art” in the 19th century and he had introduced these ideas to his students. As Kenneth Frampton has stated, Cret engaged his students “in debating the opposition that existed between, on the one hand, Structural Rationalism of Viollet-Le-Duc and De Baudot, with their strong affinity for Gothic, and on other hand the Classicism of Durand’s permutative system (Fig 2.21), with its rather arbitrary method for combining facades with the modular fabric of the building itself” (Frampton K. 1980 p.26).

Cret had attempted to accept features from both theories and using Durand's idea, regarding material systems, in his individual design development whereby, he claimed that the "architect cannot allow himself to forget… that the spirit of a steel form is not the spirit of stone" (Cret p. 1927 p.26). This had a great influence on Kahn, who tried to use both concepts in his work and with outstanding success, by combining two systems of thought (i.e. Tectonic Rationalist and Classicist Functionalism) as apparent opposing points of view. As Paul Cret's Hartford County Building (Fig 2.1) influenced Kahn for his later design such as Trenton Jewish Community Center (Fig 2.2) and Family Planning Center (Fig 2.4).

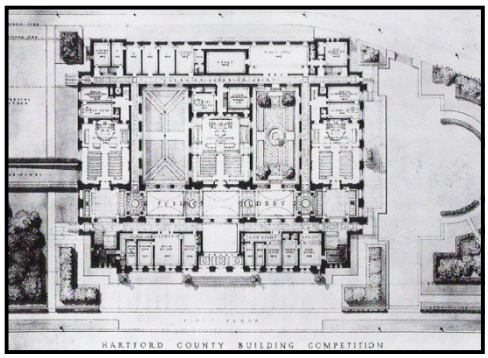


Figure 2.1: Paul Cret Hartford County Building Hartford, Connecticut 1926

(Goldhagen S W, 2001, p.130)

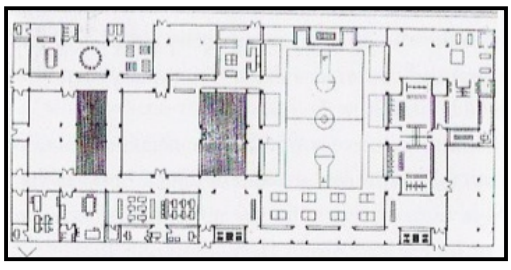


Figure 2.2: Louis Kahn Plan of the third scheme for the unbuilt Jewish community Center, 1957 (Goldhagen S W, 2001, p.129)

The economic use of materials and the equilibrium of structure became largely important principles of Modernism, which was something that Frank Lloyd Wright and Le Corbusier were also aware of at the time. Also, there are more subtle structural and construction lessons that can be found in the Medieval Cathedral that were very important for Modernism. “Firstly, the perception of buildings as composed of a framed or skeleton and skin and secondly the idea that, despite the interdependence of parts, the function of each should be clearly expressed” (Ford. 1996. p.3).

Figure 2.3: Paul Cret Hartford County Building Hartford, Connecticut 1926

(Goldhagen S W, 2001, p.130)

Figure 2.4: Louis Kahn Exterior view of partially realized Family Planning Center, Nepal, 1970 (McCarter, 2005, p.385)

While Kahn was student of Cret, during his senior year (1920-1924), he won a national award for design at the University of Pennsylvania. He would later refer to his section drawings, which were derived from axial floor plans and that were symmetrical, as inspired from the Parthenon and asymmetrical as derived from the Erechtheum and the Athenian Acropolis; these types of examples are atypical part of the Beaux-Arts training that Kahn had received. In Kahn's student projects we can also see a dynamic balance and limited symmetries (Fig 2.8) as was encouraged at the University of Pennsylvania; that is, a "relaxed axial planning compared with the multiple symmetrical crossed axes typical of the Ecole", which is not something developed in early modern architecture (Fig 2.21) (Brownlee and De Long.1991, p.21).

Kahn looked back to eighteenth-century sources, which inspired this shared vision of architecture, and was similar to what Cret applied to design (Whiffen M & Koeper F, 1984). As McCarter stated in his book "*Louis I. Kahn*" in 2005, that "it is important to remember that, this tradition of plan-making, drawn directly from the monuments of antiquity, also underlay the work of modern architects such as Frank Lloyd Wright and Le Corbusier, who could not help but acknowledge the dominance of the Beaux-Arts system of education in their published attacks upon it". The plan had a principled meaning to Wright as he argued, "axes and symmetry belonged to no architectural style, but were a fundamental part of human nature" (McCarter, 2005, p.23). Also, as Le Corbusier declared in his 1923 in his book *Towards a New Architecture* "the plan is the generator" which "Architecture is based on axes" where neither the plan nor the Axis was restricted to the rigid formalized methods of the Ecole des Beaux-Arts (Le Corbusier, 1927, p.45).

This combined style Structural Rationalism and Classical Functionalism was a new approach to architecture, in the manner that it was the key to architectural character derived from the nature of materials. Therefore, each material has its own form-identity, and a structural equilibrium dramatically affected the structural form so that buildings which consist of different materials express different forms, i.e. at the time structural expression become an emergent characteristic of Modernism (Ford, 1996, P.5).

Viollet-Le-Duc had dedicated the second volume of his "Entretiers" to construction, almost fifty years before Kahn started his studies in architecture (1920). He not only reviewed current practice but proposed an hybrid structure of steel and masonry that was tectonically logical, as for example the, "Market hall with room above, interior of large hall and iron and masonry-vaulting of the large space" which had a great influence upon Kahn (Fig 2.5) (McCarter R, 2005, p.19).

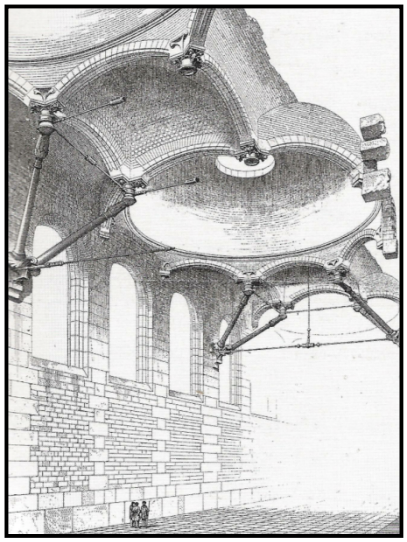


Figure 2.5: Eugene-Emmanuel Viollet-Le-Duc, "Perspective view of interior of large hall", 1872. This drawing illustrates Viollet-Le-Duc's proposed integration of heavy masonry and lightweight iron. (Ford, 1996, p.4)

2.1.1 Kahn and Monumentality

How could modern architecture achieve monumentality? It is what Kahn tried to achieve in his work. Kahn's work contrasted with what he had learned since working for Cret. Kahn's "monumentality in architecture may be defined as a quality, a spiritual quality inherent in a structure which conveys the feeling of its eternity, that it cannot be added to or changed." (Brownlee & De Long, 1991, p.44).

Kahn accepted the usefulness of history, that is, as he wrote the " Monumental structures of the past, have the common characteristics of greatness upon which the building of our future must, in one sense or another, rely" (Kahn, 1944, p.578). Kahn's conception regarding the combination of structure and history refers to the principle that was taught at the University of Pennsylvania under Paul Cret, who strongly believed that modern architecture could be made without rejecting the past.

What Kahn tried to propose was that the beginning of monumental architecture could be discovered in history as transferred to the Modern by new technologies. In particular, he believed that the "spiritual quality" required by monumental buildings which appeared first in the "structural skeleton" of the Gothic Architecture as well as in the Roman dome, vault, and arch-forms were influences that had "etched itself in deep furrows across the page of architectural history" (Kahn, 1944, p.578). In this context he always spoke of Roman architecture as a living, contemporary tradition.

As Kahn had learned this elemental tectonic lesson from history he therefore criticizes contemporary construction practices as emphasizing possibilities of the structure. Kahn tried to modernize the Gothic and Rome tectonic form by applying new modern materials and, as he said " Beauvais Cathedral needs the steel we have",

and he carries on to describe; the construction of Cathedral in terms of our contemporary materials and technology.

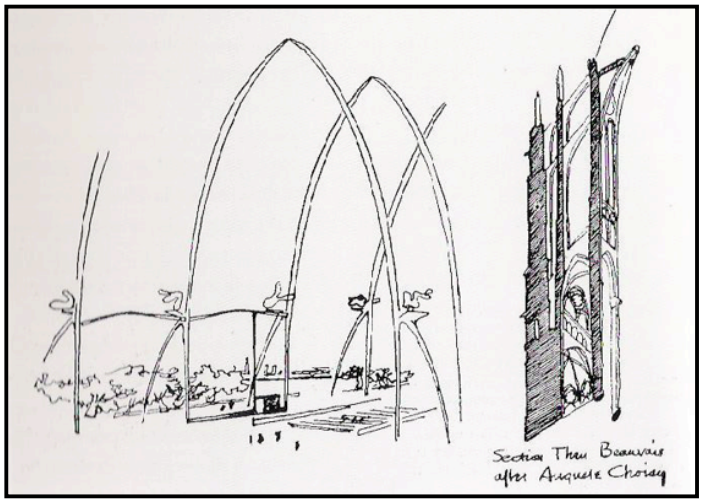


Figure 2.6: Louis Kahn "A Cultural Center" and tracing of Auguste Choisy's axonometric section of Beauvais Cathedral, 1944. (Goldhagen, 2001, p.32)

In this regard, he drew a gigantic ribbed structure, which "completed with modern Gargoyles perched at the top of its buttress" next to "Choisy's section of Beauvais Cathedral" (Fig 2.6). The structure consists of a welded tubular construction, curved to mimic the "graceful forms which the stress diagrams indicated" (Kahn, 1944, p.580-81). Therefore "the ribs, vaults, domes, buttresses come back again only to enclose space in a more generous, far simpler way and in the hands of our present masters of building in a more emotionally stirring way" (Kahn, 1944, p.581). Kahn anticipated that new materials would lead Modern architecture to a new era of "adventures of unexplored places" (Kahn, 1944, p.587). These ideas would evolve with Kahn because he would come to use the "hollow space in tubular structures and the structural continuity and graceful form possible with reinforced concrete" (McCarter, 2005, p.44).

Referring to his drawing (Fig 2.6) Kahn claimed that “the cathedral, the cultural center, the legislative palace…the monuments to commemorate the achievements and aspiration of our time” must not only be built with contemporary materials and technology, but also must be designed by means of modern and rational architectural principles. He also said that “outstanding masters of building design …..have restated the meaning of wall, a post, a beam, a roof, and window” (McCarter, 2005, p.45).

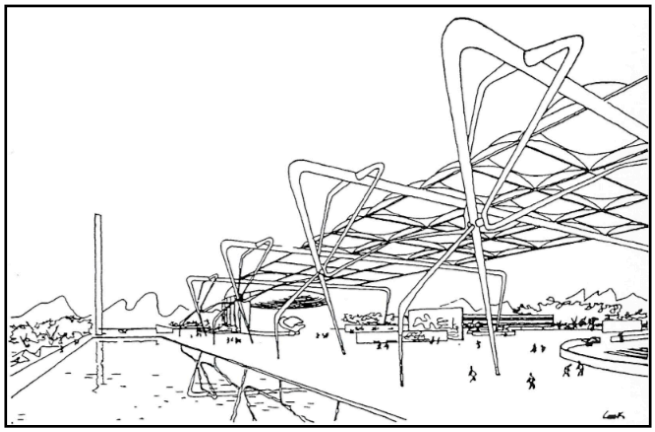


Figure 2.7: Louis Kahn Model cultural center illustrating “monumentality”, Space Frame Exhibition Project 1944. (Frampton, 2007, p.104)

As he had imaginatively modernized Beauvais cathedral, Kahn’s design for a cultural center is also a vivid example of his imaginative capabilities. His drawing shows a welded tubular skeletal structure, which starts from a point and gets thicker as they rise and stiffen by being woven together (Fig 7). This novel framework for the supports of the gigantic roof was completed by a grid of translucent domes. Kahn’s inspiration for designing this kind of column was obviously influenced by Frank Lloyd Wright’s Mushroom columns of Johnson & Johnson Wax Building.

Kahn, by writing about Modernization and Monumentality, wanted to shape his own style as Frank Lloyd Wright and Le Corbusier had developed their own voices in their careers. For example, Le Corb "restated, translated and abstracted the fundamental element of architecture in order to define them in modern terms" Also, Wright in his practice of architecture describes in his "An Autobiography "in 1932, that Le Corbusier expresses his unique approach in concepts such as in his "Five Points of Architecture" (1926).

As with the Beaux-Arts architects, whose buildings were composed of additive spatial units, often axially arranged, Kahn's building plans were more expressive than his elevation. Even though he was not committed to axial design bias, most of his buildings have dominant axes and geometry (Whiffen M & Koeper F, 1984). Kahn's intension was to complement the idea of modernism while asking simply; "what does the building want to be?"

2.1.2 Louis Kahn's Student Project

Although Kahn worked his whole life as a modern architect, his University Beaux-Art training under Cret made a significance impression on his architectural design. Kahn's late work evoked his student projects. For example, his student design in 1924, for 'A shopping Center' (Fig 2.8) had a great influence on him when he later design Family Planning Center in Katmandu, Nepal, which was completed after his death in 1974 (Fig 2.9).

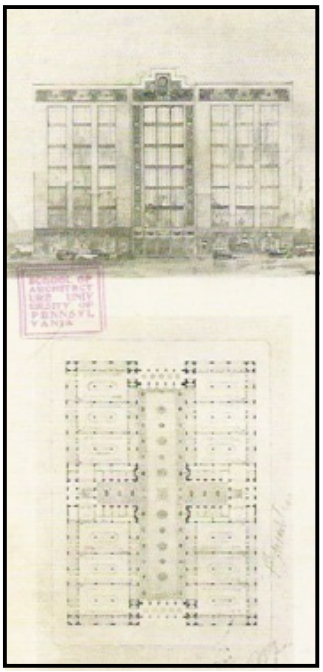


Figure 2.8: Louis Kahn Elevation and plan of A Shopping Center, 1924 (McCarter, 2005, p.22)

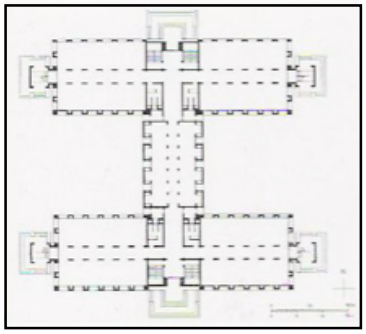


Figure 2.9: Louis Kahn Plan of Family Planning Center, Nepal, 1970 (McCarter, 2005, p.385)

Kahn also referred to the influence of his Beaux-arts education on his method for teaching, especially in terms of the importance on educating perception. As any student of architecture begins to design, they should start with sketches because as Kahn stated, “the sketch depends on our intuitive power. But the intuitive power is probably our most accurate sense. The sketches depended on our intuitive sense of

appropriateness. I teach appropriateness. I don't teach anything else." (Louis Kahn, 1974, p.22-23).

As Scully mentioned in his 1962 book on Kahn, regarding his Beaux-Art education in the University of Pennsylvania "instead of relying upon masonry architecture of palpable mass and weight wherein clearly defined and ordered spaces were to be formed and characterized by the structural solids themselves." This is fore shadowing of Kahn's idea about servant and served spaces. Also, Scully noticed Kahn's student work as reflected in his later work and referred to the "characteristic difficulty with the skin of building, with that is, the element which seemed to him neither structure nor space." As a final point and most significantly, Scully claimed that the Beaux- Arts education encouraged Kahn "to regard the building of the past as friends." (Scully, 1962, p.10-11).

2.1.3 Graduation and a Trip to Europe

Kahn received his bachelor's degree in architecture from University of Pennsylvania in June 1924. He then worked in the office of the City Architect of Philadelphia for three years. After serving as a draughtsman for a year, Kahn was chosen "chief of design for the buildings of the Sesquicentennial International Exposition". In 1926 Kahn had a chance to design-and-build, six massive buildings (Brownlee and De Long, 1997, p.22). These buildings were designed in the manner of Classicism and according to what he had learned from Paul Cret and other important designers of that time. As McCarter describes in his book "with massive square piers and coffered ceiling, the buildings sublime grandeur was captured by Kahn in his powerful rendered perspectives used to present the project to the public in 1925. While these were temporary constructions, steel frames clad in wood and stucco, they allowed

Kahn to make monumental urban-scale spaces far sooner after graduating than would normally be the case." (McCarter, 2005, p.24-25).

Kahn worked in William Lee's office for the next year, while Lee was busy "in designing a building for Temple University". Kahn lived with his parents, and saved an adequate amount of money for his planned trip to Europe; the final excursion for architectural training in Beaux-Art. This experience was similar to the four trips by Le Corbusier "through Europe in 1907, 1908,1910 and 1911 (this last trip documented in the book Le Voyage d'Orient)", and also by Frank Lloyd Wright, who had "traveled to Japan in 1905 and Lived in Europe from 1909 to 1911". These study trips were an education that consequently affected the development of modern architecture (McCarter, 2005, p.25).

Kahn arrived in England in April 1928 and spent two weeks in Britain. He produced many sketches with special consideration to detail and material (Fig 2.10) (Jan Hochstim, 1991). Later he traveled "through the Netherlands, Germany, arriving in Denmark in late June". Before visiting the Island of Saaremaa (where he was born), he passed quickly "through Sweden and Finland". He spent a month experiencing his homeland again where he refreshed his memories of the castle where his father had worked and "while he was there slept on the floor of his great-aunt's one-room dwelling. He recalled with relish eating the simple fare of little red potatoes and flat fish." (Tyng, 1997, p.10). Kahn continued traveling from mid-August to September in the following countries; Germany, Czechoslovakia, Austria and Hungary.

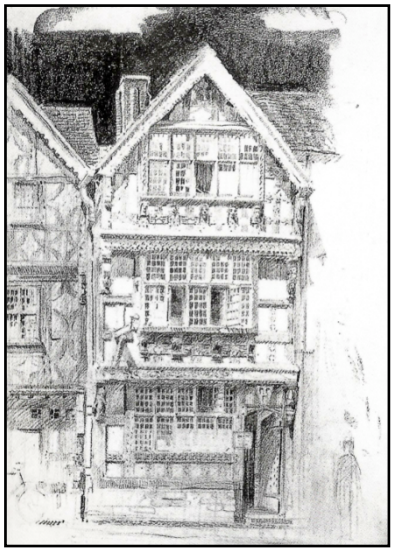


Figure 2.10: Drawing by Louis Kahn of a Tudor house, London, 1928 (McCarter, 2005, p.26)

Figure 2.11: Drawing by Louis Kahn of the Duomo, Assisi, Italy, 1928(Brownlee and De Long, 1997, p.19)

He arrived in Italy in October, and spent the next five months traveling Italy, studying the important integration of “architecture, landscape and life”. As McCarter claims, that “he traveled very slowly making drawings that were increasingly concentrated on the powerful effects of shade and shadow on stonework, and making

watercolors that in few bold strokes captured both the forms of the landscape and their atmospheric coloring". (McCarter, 2005, p.25) Fig (2.11), Fig (2.12)

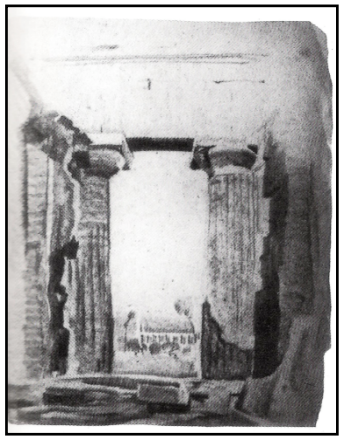


Figure 2.12: Temple of Poseidon, Paestum, Italy, drawing of a Greek Temple by Kahn, 1929 (McCarter, 2005, p.25)

He continued traveling through Switzerland and then France. He spent more than four weeks in Paris, and met with his classmate, Norman Rice, who was employed in Le Corbusier's office. He was the first American architect to work in the office of Le Corbusier. During this time Kahn didn't visit any Modern buildings in Europe, as evident by a lack of sketches. He also made new friends in Europe who were American architects (McCarter, 2005, p.26).

Kahn's first trip to Europe was less eventful than a later trip to Europe, which had major influence on him; that is, the time he spent at the American Academy in Rome (1950-1). His first trip was only a foundation for his later work regarding the re-engagement of "monumentality in the regulation of architecture" (McCarter, 2005, p.25).

It was then (1950s) when the Yale commission was offered to him, and he accepted without any doubt, to give a direction to his work. Although he only spends three months in the American Academy in Rome, yet it seemed to have affected his work afterward (Brownlee and De Long, 1997, p.50). As he produced ninety drawing in three months, which was the amount of drawing's numbers he made on his 1928-9 trip to Europe. This time Kahn not only used charcoal but he also used pastels to emphasis what he later called "Silence and Light" (McCarter, 2005, p.56).

And as Rome had a magnificent influence on him, he wrote after his arrival; "I firmly realize that the architecture in Italy will remain as the inspirational source of the works of the future. Those who don't see it that way ought to look again. Our stuff looks tinny compared to it and all the pure forms have been tried in all variations. What is necessary is the interpretation of the architecture of Italy as it relates to our knowledge of building and needs. I care little for restoration but I see great personal value in reading one's own approaches to the creation of space modified by the buildings around as the point of departure". (Kahn, 1951).

Figure 2.13: Pantheon Exterior and Interior (Left photo taken by Author)

He continued his travels in Greece and Egypt for the next month and by visiting ancient sites he claimed, "The architect must always start with an eye on the best

architecture of the past." (Louis Kahn, 1951). His statements confirm his interest in history when other architects questioned its value. The Pantheon, with its great spherical interior space and its central oculus open to sky and the Baths of Caracalla were two buildings which he always referred to. Although the Pantheon was a building he would always talk about and emphasized that no style and no era could surpass it. For Kahn, the Pantheon was a building he was most drawn towards, but it was the Baths of Caracalla he formally identified as his favorite building and said "it is ever a wonder when man aspires to go beyond the function. Here was the will to build a vaulted structure 100 feet high in which men could bathe. Eight feet would have sufficed. Now, even as a ruin, it is a marvel" (Louis Kahn, 1961). It was Roman architecture of pure geometric volumes and brick-faced which shaped the powerful walls and concrete vault that significantly inspired Kahn. He also studied the stripped patterns of decoration. The brick relieving arches left a major effect on Kahn which showed how Roman buildings were made by exposing their massive brick and concrete structured walls and vaults (Brownlee and De Long, 1997, p.50).

Figure 2.14: Baths of Caracalla (Wikipedia.com)

At the American Academy Kahn spent time conversing with Frank E. Brown (Kahn's fellow Yale faculty member), the resident historian and archaeologist whose own appreciation of Roman architecture paralleled Kahn's. As he said "the last living ancient Roman, so at home in the Roman ruins that he seemed no longer a part

of the modern world." (Brown, 1983, p. 9, 34, 35). It was Brown's understanding of the ancient Roman world, which was represented in its architecture.

Brown took Kahn through Rome, Ostia and even Pompeii. His interpretations of the Roman architecture had major influence on Kahn. As Brown stated in his book on Roman architecture that, "the architecture of the Romans was, from first to last, an art of shaping space around ritual". Also, his descriptions of Roman buildings would affect Kahn's later work as Brown claimed "the basilica …. An augustly luminous volume, doubly wrapped by shadowed galleries", and "the expertly compact spatial composition, with its running counterpoint of cubical and spherical, dome and cross or barrel vault, gave compelling unity" (Brown, 1983, p 9, 34,35). Another Roman building that was important for Kahn was "Trajan's Market and its multi-leveled basilica space lit at all levels by natural light" (fig 2.15), which had influenced Kahn's later work by its various methods of constructing openings in its brick walls (McCarter, 2005, p57).

Figure 2.15: Trajan's Market and its multi-leveled basilica (Left photo taken by Author)

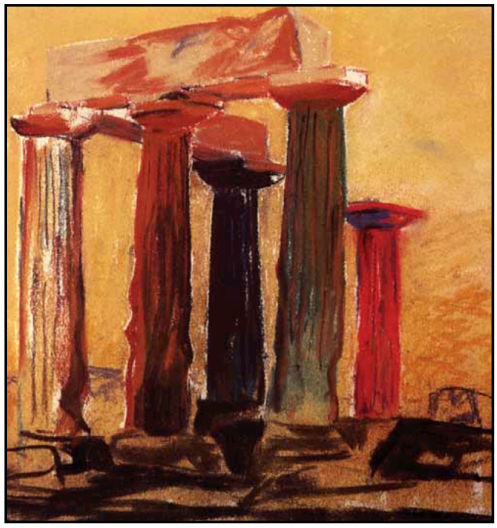


Figure2.16: Drawn by Louis Kahn Temple of Apollo (Brownlee and De Long, 1991, p.148)

Figure 2.17: Drawn by Louis Kahn, Acropolis, Athens, 1951. (Brownlee and De Long, 1991, p.149)

Kahn also, traveled to Egypt and Greece, and tried to render Greek columns by showing their mass as an animated dynamism (Fig 2.16). He also made drawings of the Acropolis, which provides a new representation of the mass and symbolic force of sacred landscape (Fig 2.17). But it was his drawing of the pyramids of Giza, which revealed the abstract, geometric power of architectural form (Fig 2.19). (Brownlee, 1997, p. 54) He not only saw the Pyramid as enormous masses, timeless

and eternal, but also as he said a “vehicle of light …..reflectors of the sun’s rays”. And it was the Pyramid, which inspired Kahn for shaping the roof and ceiling of the Yale University Art Gallery which he designed right after his trip in 1951 (Fig 2.20).

Figure 2.18: Drawn by Louis Kahn, Temple interior, Karnak, 1951.(Brownlee and De Long, 1991, p.147)

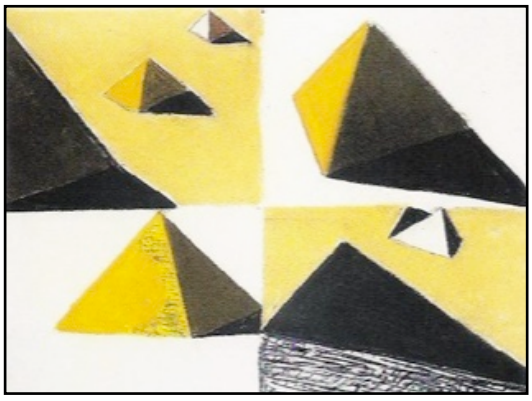


Figure 2.19: Drawn by Louis Kahn, Pyramid at Giza, 1951. (McCarter, 2005, p.10)

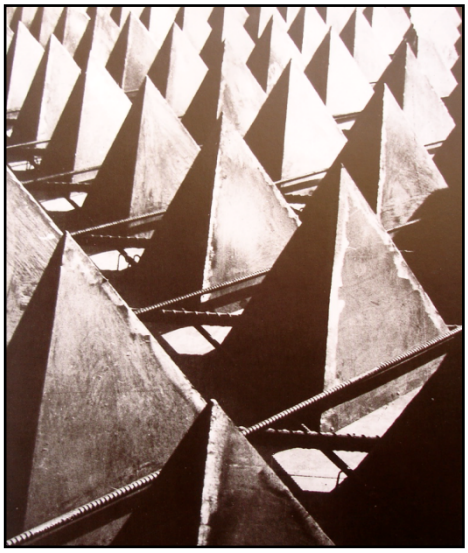


Figure 2.20: Bottom section of metal formwork for the concrete ceiling structure, Yale University Art Gallery. (McCarter, 2005, p.71)

Although Kahn's second trip in Europe was relatively brief, it also had a fundamental effect on Kahn's "development as the most important modern architect of his time". And this can be understood from his statement that "what will be has always been" and this led to his renewed sympathy for the importance of history in contemporary design (Wurman, 1986, p.243).

Although his second trip to Europe was short, this rediscovery of history would prove to be fundamental in Kahn's development as a modern architect, as it renewed his understanding of the importance of history in contemporary design. For example, the lasting impression of heavy construction and the spaces shaped by massive masonry can be seen in his design. Also, after this trip he would never make use of lightweight steel structures and used only reinforced concrete and masonry.

2.2: Modern Influences: Le Corbusier, Frank Lloyd Wright, Ludwig Mies van der Rohe

During the first half of the 20th century, Modern architecture was considered to be revolutionary. It destroyed the existing Beaux-Arts regime and replaced it with the Rationalist order. But "all revolutions are rooted in the past. In perspective, modern architecture can be viewed in the flow of history, but more specifically as the result of the product of its time." As Mies van-der-Rohe said "not of the time but of the epoch." (Peter, 1994, p.12-13).

After his return from Europe, Kahn was employed in Paul Cret's office and worked as a junior designer for several years. Kahn had worked on many projects during that time, including the Folger Library in Washington, DC. During this time, "Cret was engaged in designing both his signature stripped classical"; i.e. buildings as well as structures in a more modernist manner. Cret's cautious exploration of modern architecture came as no surprise, stating at a meeting of the T-Square Club of Philadelphia in 1923 that "Our architecture is modern and cannot be anything else". Also, in 1927, at a club meeting he gave a review of Le Corbusier's "Vers une Nouvelle Architecture"*;* translated as "Toward a New Architecture". Cret, as an Ecole des Beaux-Arts graduate and also as French native, was reasonably aware of this Swiss-French version of Modernism. As McCarter stated "yet the now canonic readings of this period, asserting that modern architecture was imported to the United States from Europe, have overlooked the fact that the work of European modernists- Mies Van der Rohe and Walter Gropius, in particular- had been inspired by the early work of Frank Lloyd Wright. Kahn was well aware of that, while the winds of

change then bringing the Modern Movement to America blew from Europe, they had originated in his adopted homeland" (McCarter, 2005, p.27).

Frank Lloyd Wright had published a "series of essays – five in 1927 and nine in 1928 – published in the monthly "Architectural Record" under the collective title "In the Cause of Architecture". His essay "The logic of the plan" in 1928 had a great influence on Kahn in terms of a better understanding of "the fundamental shared principles underlying all great architecture: A good plan is the beginning and the end… its development in all directions is inherent-inevitable…there is more beauty in a fine ground-plan than in almost any of its ultimate consequences… to judge an architect one need only look at his ground-plan. He is master there, or never. Were all the elevations of genuine buildings of the world lost and the ground-plan saved, each building would construct itself again, because before the plan is a plan it is a concept in some creative mind" (McCarter, 2005, p27).

"A concept in some creative mind", that is Wright's said with regard to a proposal for an architectural plan and is basic for the prediction of good architecture. It took more than twenty years to be evident in Kahn's work and in his teaching this significance of the plan "idea" in architectural design.

2.2.1 Frank Lloyd Wight and Louis Kahn

Frank Lloyd Wright was a very well known architect in his lifetime. His style was unique in a way that no other modern architect could copy (Peter, 1994, P.110). He studied the work of Eugene-Emmanuel Viollet-Le-Duc, because he was influenced by Le Duc's Entreaties Sur L' Architecture. He said about this book: "here you find everything you need to know of architecture" (Wright, 1932, P 77). Though there is no stylistic, structural or programmatic reference to Gothic building in Wright's

works, he referred to the simplicity of the principles of Gothic design. That is, during the twelfth century where French Cathedrals displayed the “Principle of what good architecture and building ought to be, and Viollet-Le-Duc was the guide to what the principles were” (Ford, 1996, p.1).

Even though Frank Lloyd Wright had studied the principles of Neo-Classical Ecole des Beaux-Arts and after that he became a successful architect as a classical Modernist, he admitted the influence of the Gothic Cathedral on his work with Wright’s reference to Viollet-Le-Duc whereby “Viollet-Le-Duc was my master….it was he who enabled me to resist the influence of the Ecole des Beaux-Arts” (Collins, 1959, p.155).

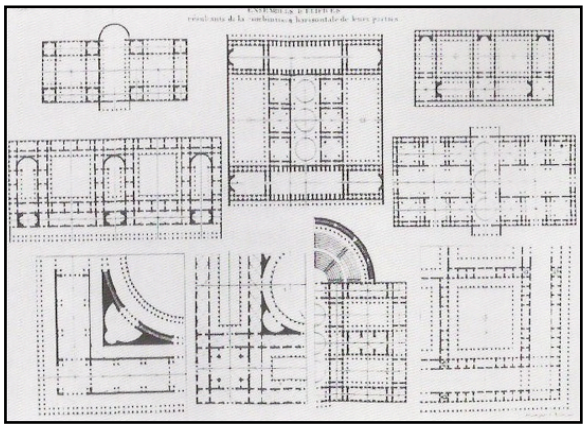


Figure 2.21: Jean-Nicolas-Louis Durand: example of plan composition using tartan grids (a-b-a). (McCarter, 2005, p.20)

Frank Lloyd Wright, who inspired Kahn, wrote in 1908 during his Prairie style Period 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 its 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 stated "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, p.58-59). These ideas were generally sympathetic with Kahn's principles from his Beaux Art training. At the same time as other buildings by Wright, like the Darwin Martin House (1903-05), the Larkin Building (1902-06) and the Unity Temple (1903-05) had great importance for Kahn, because of "the spatial and structural independence of elemental units of composition" (McCarter, 1997).

The Larkin Building and Unity Temple were two great buildings (Fig 2.40) that influenced Kahn when designing his major public building such as the Trenton Bath House, the Richards Medical Center and the Exeter Library, among others. The construction of the Larking Building was finished by 1906, which later Kahn studied in detail. Wright's Larkin building was advanced in terms of its "functionalism, construction and servicing, and progressive in its moral importance". (McCarter, 1997) The building's plan design was started insight-out, from the atrium, where all offices are then placed around it (fig 2.19) (McCarter, 1997). It is exactly what Kahn did in his Exeter Library whereby the design started from the insight-out and he placed all the other function around the top-lit space (fig 2.20).

In the Larkin Building, Wright placed the stairs and servicing towers that includes ventilation shaft, around the corners, which greatly influenced Kahn's ideas about servant and served spaces (fig 2.23). Kahn first used this idea in his Trenton Bath House and then in his later work such as the Richard Medical Research Building (fig 2.22) and the Exeter Library (fig 2.24).

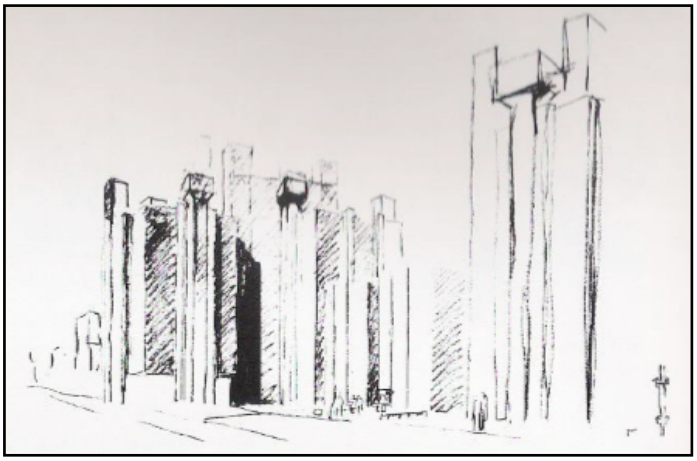


Figure 2.22: Louis Kahn early perspective sketch of the University of Pennsylvania Medical Research Towers, 1957. (McCarter, 2005, p.124)

Figure 2.23: Frank Lloyd Wright Larkin Building, 1902-1906 (De Long, 1998, p.78)

In the Larkin Building Wright formed his structure in brick and concrete towers which housed the stairs and exhaust ducts (Wright, 1932, p.175). Kahn used the same materials and placed the servant area in each corner of the Exeter Library. The structure of Larking building consists of an internal steel frame, which was clad in brick. Also, the outer layer was composed of load-bearing brick walls (Wright, 1908, p.165).

There is plan to section relationship in Larkin Building which are proportioned exactly; the main block of whole building consists of a double square, which has the relation to a double square office floor in section, “the light court is three squares in height in its narrow dimension and a golden section in the larger dimension”, and the piers are set 4.85 meters on center, which creates an exact square in section with 4.85 meters high floors. As Otto Graf clamed, that the whole spatial and ornamental program for the Larkin Building is “a fugue on theme of cube”; “Wright developed the sculpture, light fixtures, furniture, ornament, elevations, plans, section and space from various ways of unfolding the square and cube.” (McCarter, 2005, p.228-237)

This building had a great effect on Kahn as he always tried to start his design with the square and develop all his design process in terms of the square. As he claimed “ I always start with a square no matter what the problem is” (Ronner H & Jhaveri S, 1987, p.98). The construction of Wright’s Unity-Temple was completed two years after the completion of the Larkin Building which is his greatest public building where he left enough detailed description of the design process for Kahn and all other architects to study.

Wright’s concept drawings confirm that the Unity-Temple’s design was developed from inside-out, which was the idea of a space for gathering. As he said that the “first idea was to keep the noble room for worship in mind, and left that sense of the great room shape the whole edifice. Let the room inside be the architecture of outsight” (McCarter, 1997, p79).

Wright’s proposal for this building was considered as the first public building which was to be built “entirely of exposed concrete. As Wright said “too monumental, all

this? It would be simply noble. The wooden forms or molds in which concrete buildings must at that time be cast were always the chief item of expense, so to repeat the use of a single form as often as possible was necessary. Therefore a building, all four sides alike, looked like the thing. This, reduced to simplest form, meant a building square in plan. That would make their temple a cube – a noble form in masonry." (McCarter, 1997, p.81).

He used the modular grid for developing his work whereby the repetition of a single form was applied and as McCarter stated in 1997 that, this method "was used as a method of formal and economic central, and Wright believed pure geometries were inherently virtuous". Also the 19th century poet Walt Whitman wrote about the cube in a poetic metaphor; 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, P559).

Wright's plan for Unity-Temple, which was based on the pure geometries of the square and cube, is closely related to the centralized church for the Renaissance, which was geometrically perfected. Also, there are some other similarities between this building and Renaissance centralized churches, which are "ordered on a rigorous system of proportion; the primary central space of the Sanctuary a square in plan (1:1 proportion) and a cube in volume (measured from the floor to the glass of the skylight); the secondary arms of the cruciform – entrance cloisters and balconies surrounding the main space – are half size double-cubes (1:2 proportion) in plan and section; the four double squares of the secondary spaces are gathered around and open at their center in the overall cruciform volume, while the four square corners, containing the stairs, anchor and band the composition (Graf, 1983). Wright said,

“Geometry is the grammar, so to speak, of the form. It is architectural principle.” (Wright, 1967, p 12).

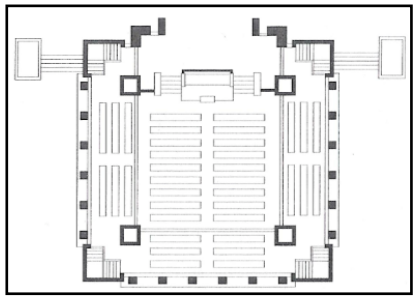


Figure 2.24: F.L. Wright, Unity Temple, Grd. Plan, 1906 (Laseau, p. 1992, p.124)

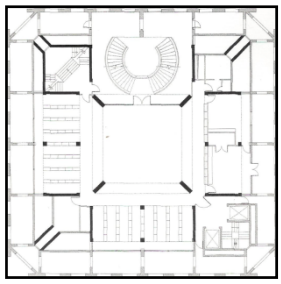


Figure 2.25: Louis Kahn, Exeter Library Ground Plan (McCarter, 2005, p.324)

Although Wright was influenced by the Beaux-Art as with his contemporaries of the time however, he was closer to Renaissance architecture, not in manner of using classic styles or form, but in timeless validity of primary ordering principle, as he said, “principles are not invented, they are evolved by one man or one age” (Wright, 1908, p54).

Unity-Temple’s Ceiling is divided into the twenty-five stained-glass skylights within a grid of beams in a complex pin-wheeling pattern.

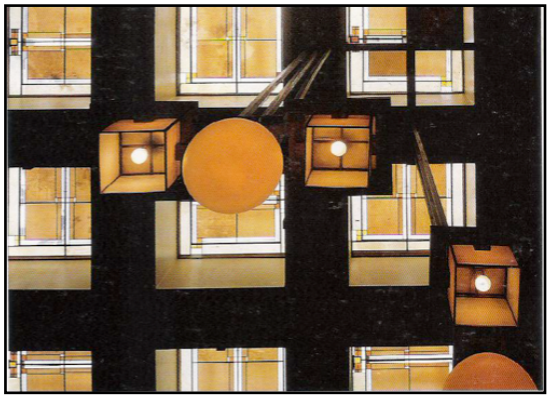


Figure 2.26: Frank Lloyd Wright Unity Temple ceiling (McCarter, 1997)

Wright used vertical square concrete piers at the corners of the building supporting the four sides of the room which include a double layer of balconies and also the ceiling (fig 2.24). The piers were used as structure while housing the service ducts. By designing Unity-Temple Wright understood the expression of concrete as "the highly plastic capacity of this material that allowed space, function, from, structure and construction to be fully united" (McCarter, 1997, p.83).

Wright always believed that a building's identity and the character of a house come from the space within as he said, "What I have just described was on the outside of the house. But it was all there chiefly because of what had happened inside." (Wright, 1932, p.166). This was the only reason that Wright developed a variation on the tripartite plan types to achieve an "embedded, impacted, truncated, extended and pinwheel cruciform plan" which were developed, based on the cube. This was also a theoretic concern in Kahn's design (McCarter, 1997, p.88) (fig 27 & fig 28).

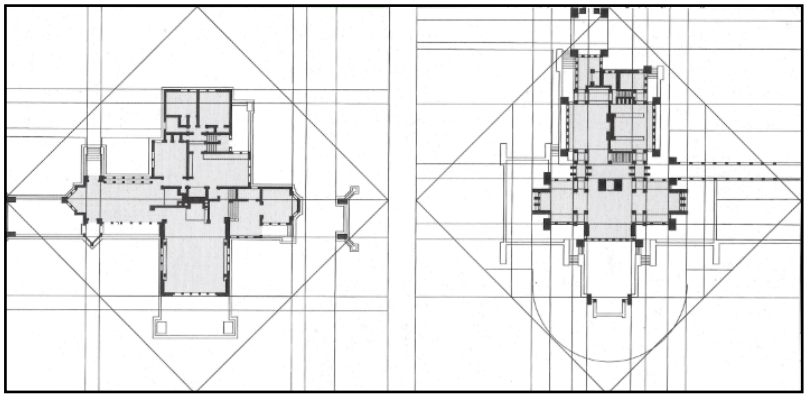


Figure 2.27: Frank Lloyd Wright, Plan of Willits House and Martin House, showing different cruciform plan type (Laseau, P & Tice, J, 1992, p.89)

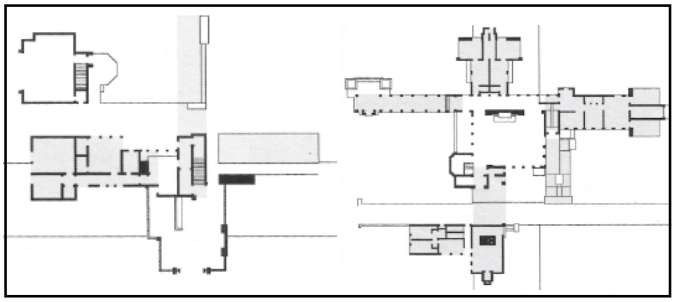


Figure 2.28: Frank Lloyd Wright, Plan of Walter Gerts house and Booth house, showing variation of the Pin-wheel Cruciform type.(Laseau, P & Tice, J, 1992, p.89)

In 1938, Kahn designed the Jesse and Ruth Oser house in Elkins park, Pennsylvania. This design, showed Kahn's maturity as an architect. A two-storey cubic mass was developed in pinwheel form and consists of the stone cladding for the main mass at the front and wood-clad volume cantilevered beyond the main mass (McCarter, 2005, p34). The third volume of house which is glass-enclosed is anchored to the ground and shifts towards the back, along the massive stone fire place. (fig. 29 & fig 30)

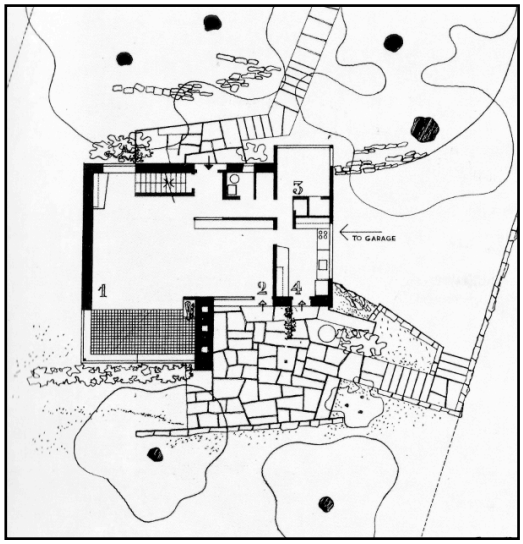


Figure 2.29: Louis Kahn Ground floor plan, Oser House, Elkin Park, Pennsylvania, 1940. (Rose, 2006, p.19)

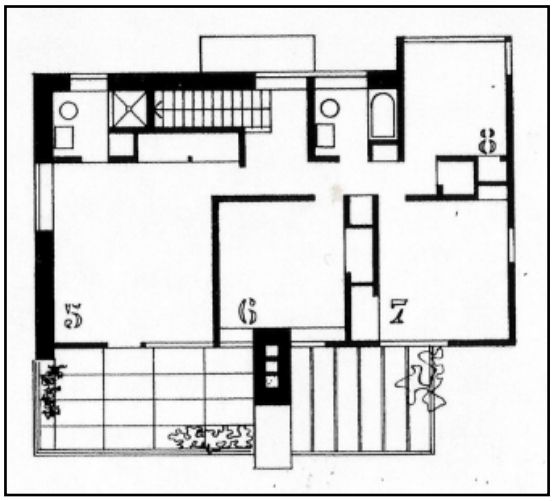


Figure 2.30: Oser House Second floor plan. (McCarter, 2005, p.33)

This design, gave Kahn enough confidence to accept the partnership with George Howe for designing governmental housing projects in 1941. They had contracted to design 500 housing units for Pine Ford Acres, Middle Town, Pennsylvania, and 1000 units at Penny Pack woods (Brownlee and Delong, 1991, p.24). Kahn, by achieving a rhythm in varying scales, used two sizes of wooden siding and provided semi-open spaces to all four units, which were elegantly proportioned and detailed.

And later, for the Carver Court project, they designed 100 housing units in Pennsylvania. The row houses were designed in a way so that the ground floor was raised up in order to create a plot for the car park, storage and other services. Kahn applied the same approach for 300 units in Washington and 150 units in Coatesville (fig 2.31).

Figure 2.31: Louis Kahn Two-unit building, Carver Court Hosing, Coatesville, Pennsylvania, 1941. (Rosa, 2005, p.21)

It was here, that his later conception of the "servant and served" spaces originates, as if the servant area was the storage, laundry and work space, while the served space consisted of living room, kitchen and bed rooms.

Because of Kahn's success with his previous row housing designs, the government proposed the 475-unit Lily Ponds housing project in Washington, DC. He designed an outstanding four-unit, one-storey structure where he placed the grouping of the bathroom at the center, and covered them with a butterfly-wing roof (opposite of the

typical pitched roof) which was defined by four chimneys about the center (Fig 2.32). This type of roof with its exposed unfinished wood, displayed similarities with Le Corbusier's recent work, which was published in the third volume of his Oeuvre Complete (this book came to U.S.A in 1939). (Brownlee and De Long, 1991, p.31)

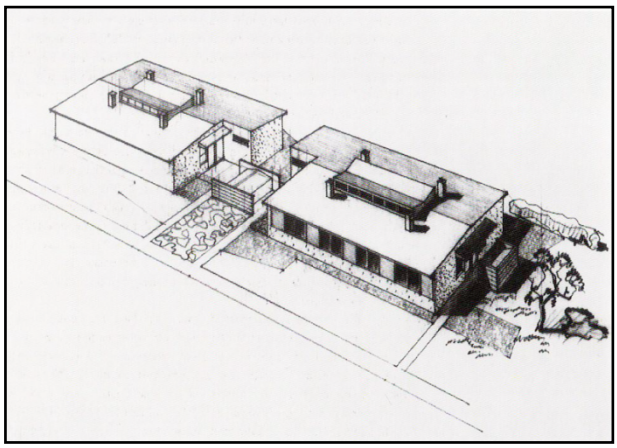


Figure 2.32:Louis Kahn Lily ponds Houses, Washington, DC, 1942.(McCarter, 2005, p.36)

In 1944 Kahn proposed, the Parasol House, to engage with the potential for prefabrication in housing construction. This prefab component consists of a 3.7 meters square, with its steel framed roof supported by single central steel-tube column (fig 2.33). There is an obvious influence of Frank Lloyd Wright's Mushroom column's (Lily-pad or Dendoi form of Johnson& Johnson Wax headquarter Building) (fig 2.34) in Kahn's umbrella-like units, which were proposed by Kahn to achieve a wide variety of volumes for both two and one story designs (McCarter, 2005, p.37).

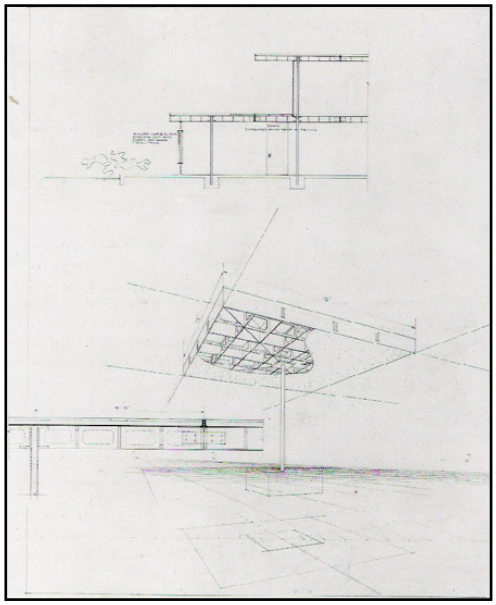


Figure 2.33: Drawn by Louis Kahn, Sketch study, section and perspective of the Parasol House construction system, 1944 (McCarter, 2005, p.40)

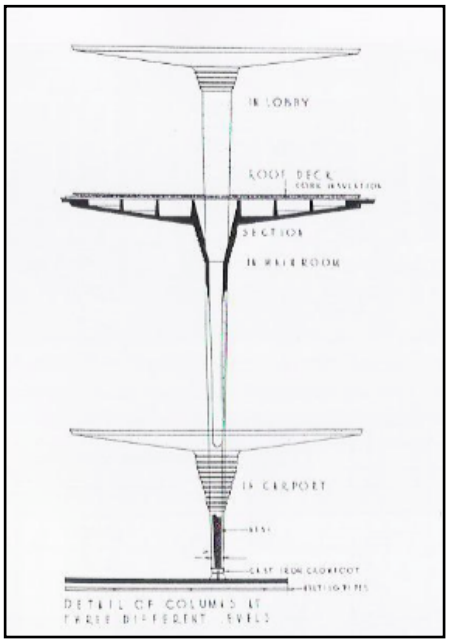


Figure 2.34: Frank Lloyd Wright, S. C. Johnson Administration Building, Racine, Wisconsin, U S A. 1936-39. Section through hollow columns.(Frampton, 2007, p.56)

Also Kahn was influenced by Mies van-de-Rohe's Courtyard House prototypes and Le Corbusier's Domino-type structures (Fig2.56) for joining dozens of separate units, beneath a covering roof, which was interrupted by irregularly spaced courtyards (Fig 2.35). Kahn achieved a Free-plan by placing the grid columns beneath this covering roof, while the non load-bearing walls of the units were distributed in a rather aggressive version of the non-rectilinear free-plan. However they were not asked to develop any of these ideas further. Their next project was the Forty-Eight-State Solar House, which was designed by Kahn and assisted by Anne Tyng, who had just joined the office (Brownlee and De Long, 1997, pp.37-40).

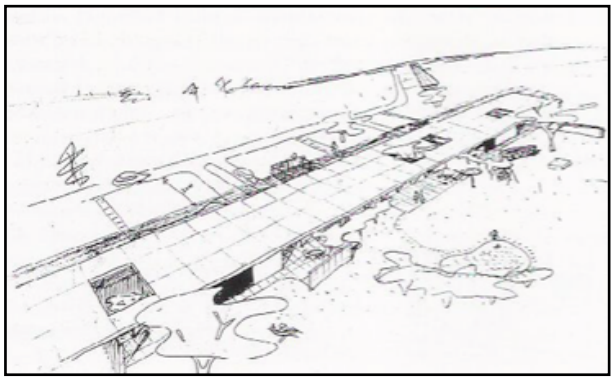


Figure 2.35: Drawn by Louis Kahn, Linear housing block to be built with the Parasol House construction system, 1944. (Brownlee and De Long, 1991, p.32).

2.2.2: Conclusion for Frank Lloyd Wright and Kahn

Frank Lloyd Wright had a great effect on Kahn but has rarely been acknowledged. Wright has been underestimated if not totally ignored regarding Kahn's work who adopted the ordering principles from Frank Lloyd Wright, such as the following:

1) Kahn referred to the "Room as the originator of all architecture", and the appearance of interior volume in exterior form; as Kahn claimed "I think the most inspiration point from which might try to understand architecture is to regard the room, the simple room, as the beginning of architecture". And as Wright 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, p.168)

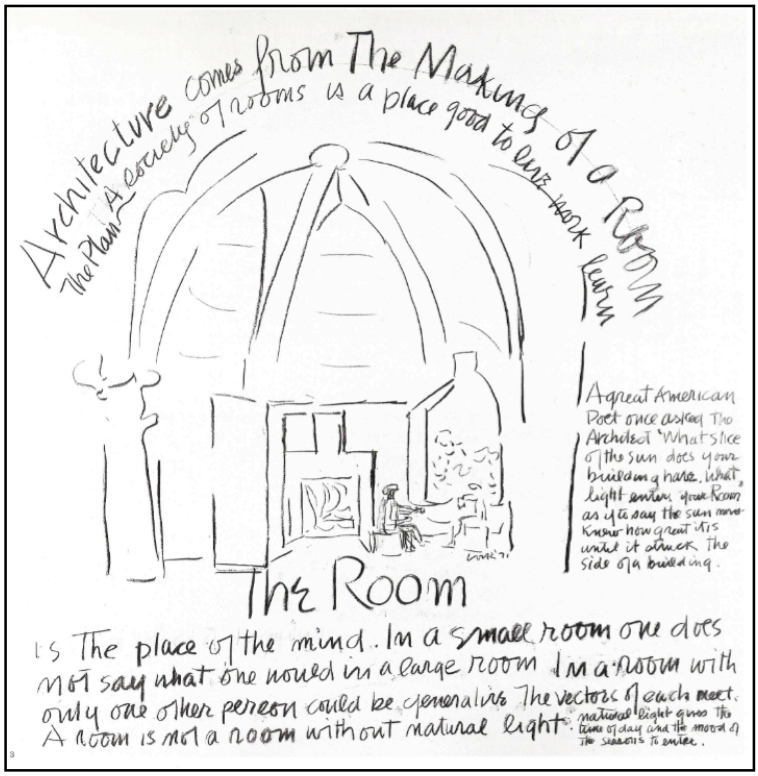


Figure 2.36: Kahn's perception of Room (McCarter, 2005, p. 225)

2) To design from the beginning with square and cube, the cruciform, the double square, and the rotated square, as Kahn said, “I always start with a square, no matter what the problem is”. And as Wright believed that the square is timeless geometry and quoted from the poetry of Walt Whiteman; “chanting the square deific, out of the one advancing, out of sides, out of the old and the new, out of modern as any.” (Ronner H. & Jhaveri S., 1987, p.98).

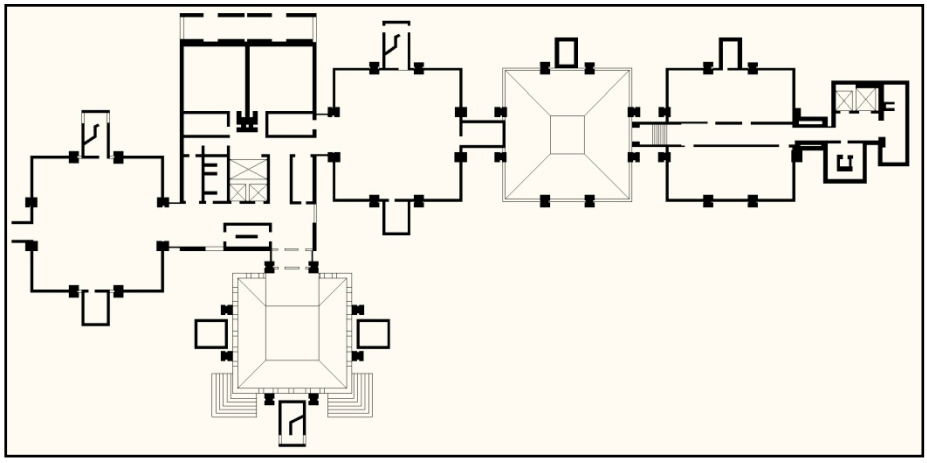


Figure 2.37: Louis Kahn Richard Medical (Re-drawn by Author)

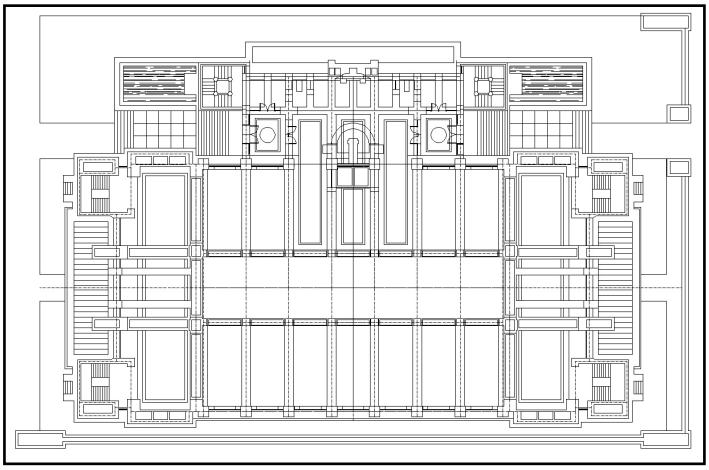


Figure 2.38: Frank Lloyd Wright Larkin Building (De Long, 1998, p.78)

3) Tartan grid planning, and ‘served’ and ‘servant’ space; it was these influences which Kahn applied after his realization regarding “servant and served” spaces and applied to most of his building such as the Trenton Bathhouse, the Richard Medical, the Exeter Library and others.

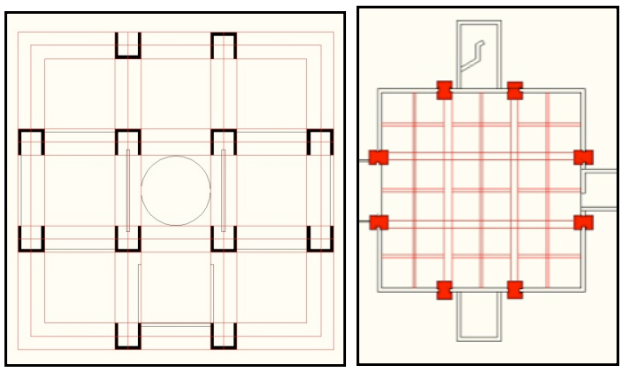


Figure2.39: Louis Kahn tartan grid Bathe House and Richard Medical’s Vierrendal Structural System (Re-drawn by Author)

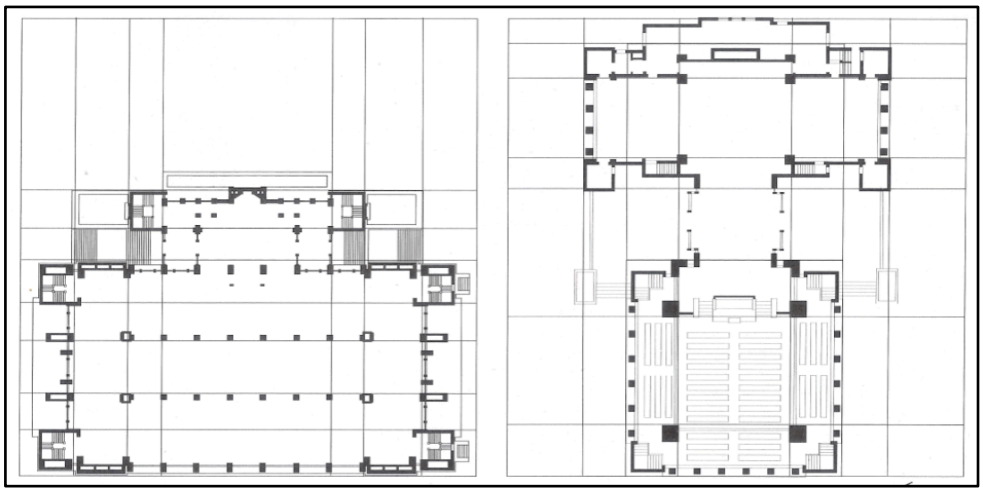


Figure 2.40: Frank Lloyd Wright, Plan of Larkin Building and Unity Temple (Laseau, P & Tice, J, 1992, p.127)

4) Closed centers and opened corners; often requiring circulation along edge rather through centers.

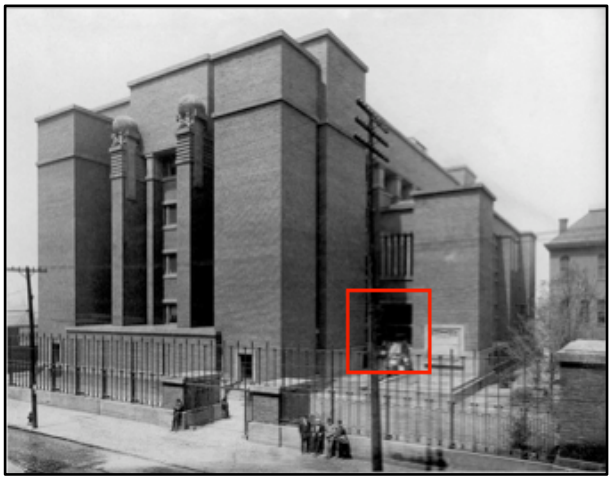


Figure 2.41: Frank Lloyd Wright Larkin Building (De Long, David G, 1998, p.78)

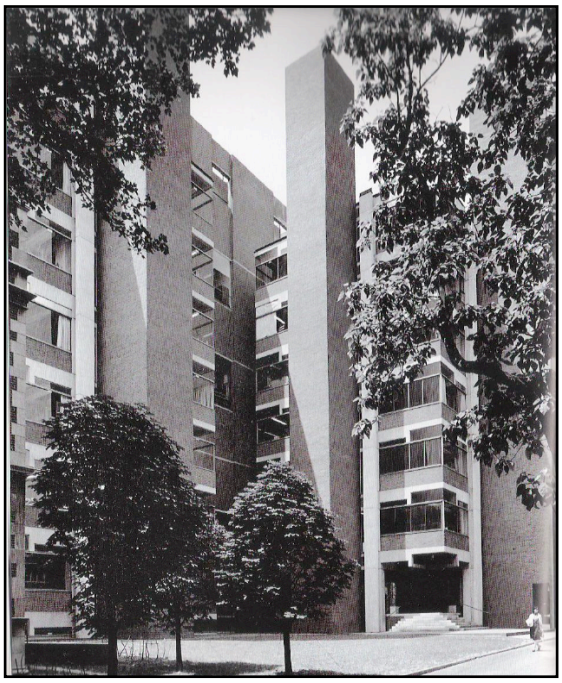


Figure 2.42: Louis Kahn Richard Medical Centre (Rosa, 2006, p.36)

5) Symmetry and axial planning.

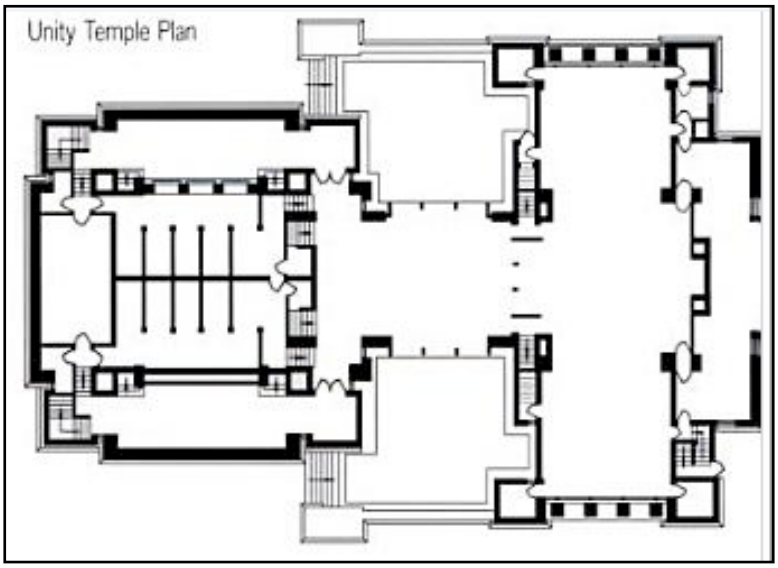


Figure 2.43: Frank Lloyd Wright Unity Temple (Weston, 2004)

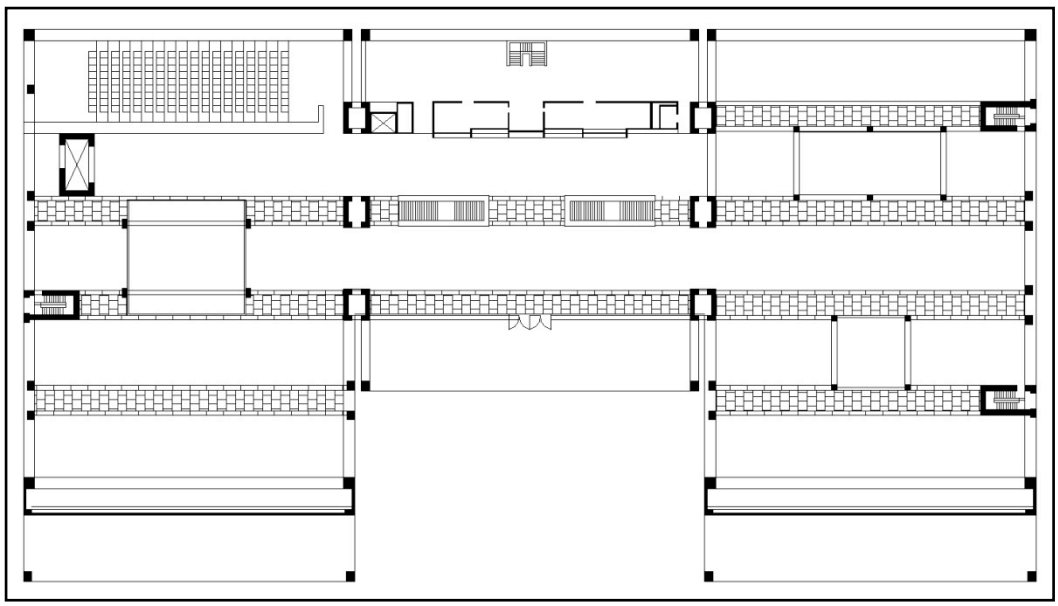


Figure 2.44: Louis Kahn Kimbell Art Museum (Re-drawn by Author)

6) Each room has its own structure, or pavilion; both Kahn and Wright believed that each room must have its own structure, and it should appear as it was made. Kahn believed each room deserved its own structure, light, material, and spatial definition – perceivable in the experience of those who inhabited it.

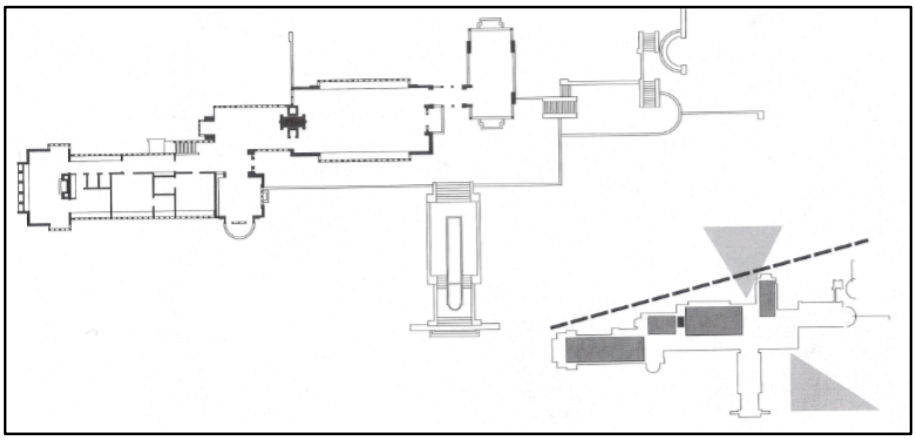


Figure 2.45: Frank Lloyd Wright, Francis Little. (Laseau P & Tice J, 1992, p.105)

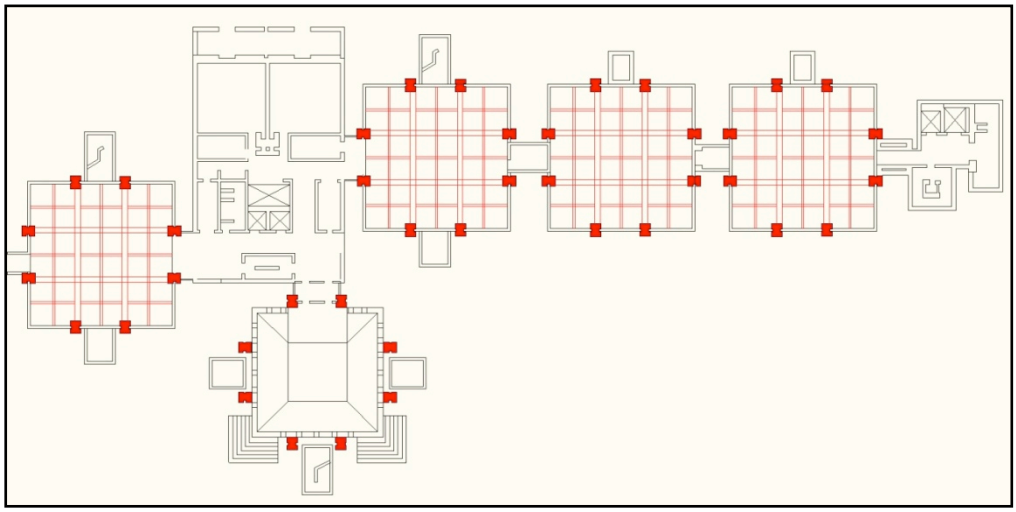


Figure 2.46: Louis Kahn Richard Medical Center (Drawn by Author)

7) History as a source of principles not forms; both used monumentality as inspiration and not as form. Wright's Unity Temple and his other Buildings appear to have been built only yesterday. Unity-Temple was realized as "new and old, ancient and modern". Although he was influenced by the monumentality of the ancient world, his design and structure does not imitate any historic style, which is same for example, Kahn's Trenton Bathhouse.

Figure 2.47: Frank Lloyd Wright Unity Temple (McCarter, 2005, p.22)

Figure 2.48: Louis Kahn Bathhouse (Brownlee, David B & De Long, David G, 1991, p.319)

8) Interlocked and communicating rooms, or the plan as a society of rooms; Kahn believed that each human activity required its own room-as-place and the building plan to be understood as “a society of rooms”.

9) Space of unplanned meeting; both architect tried to design furniture for any room in a way that it can be transformed or used as meeting room, for instance, the working space can be used also as a meeting room.

Figure 2.49: Louis Kahn Salk Institute, Interior of scientist’s study (McCarter, 2005, p.201)

10) Seeking the nature of materials; Kahn’s questioning materials in conversation and appreciation of materials was influenced by Frank Lloyd Wright, who believed design is dependent upon “the nature of materials, the nature of the tools and processes at command, and the nature of the thing they are to be called upon to do” (Wright, 1986, p.14). For example, it is there in Kahn’s conversation with brick “you consider the nature of brick. This is a natural thing. You say to Brick “what do you want, brick” And brick says to you, “I like an arch”. And you say to brick, “Look, I want one too, but arches are expensive and I can use a concrete lintel over you, over the opening”. And then you say, “what do you think of that, brick?” Brick says, “I

like an arch", it is important, you see, that you honor materials that you use" (Kahn, 1973, p.323).

11) Hidden entry followed by entry sequence of dark, low, dense space leading to a light, tall, open central space.

12) The top-lit central room as heart of all institutional buildings.

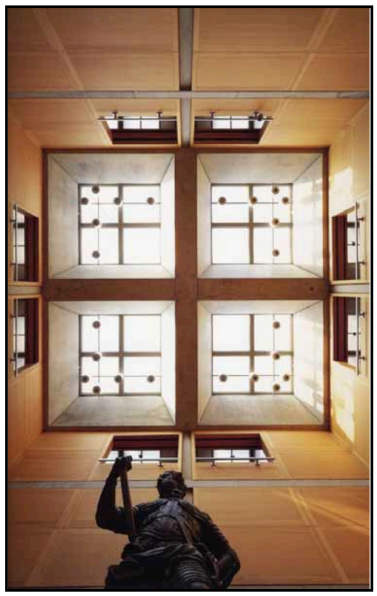


Figure 2.50: Louis Kahn Yale Library (Rose, 2006, 85)

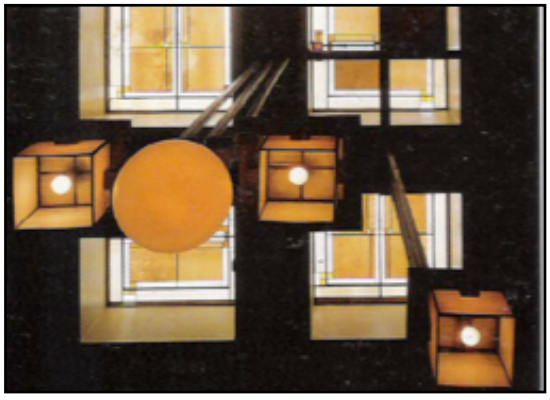


Figure 2.51: Frank Lloyd Wright Unity Temple (McCarter, 1997, p.81)

13) Pinwheel Plan organizations

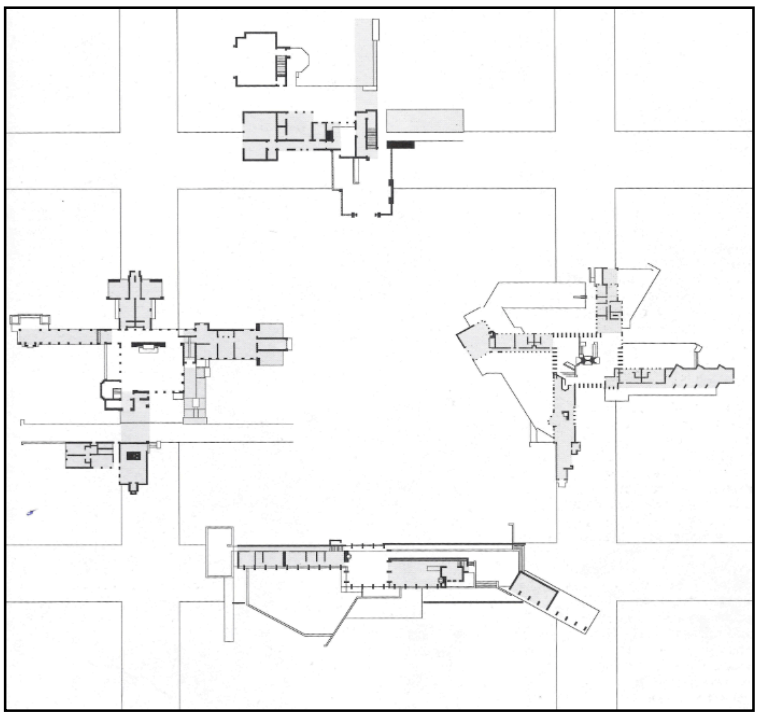


Figure 2.52: Plan array showing variation of the Pin-Wheel Type, Frank Lloyd Wright, the Walter Gerts house, the Booth house, the Wingspread, the H.C. and the Price house (Laseau P & Tice J, 1992, p.89)

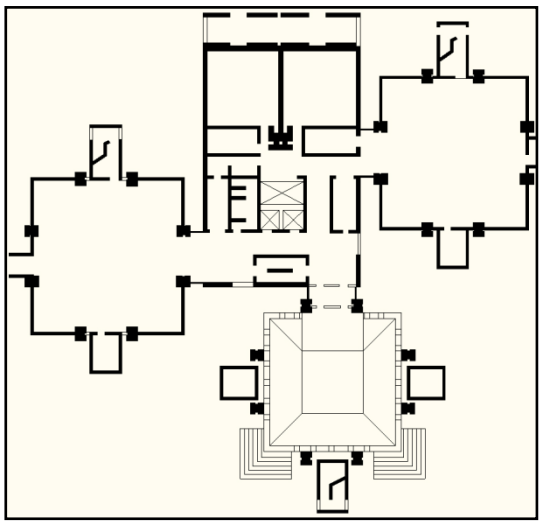


Figure 2.53: Louis Kahn Richard Medical Building, Pin-Wheel Organization (Re-Drawn by Author)

14) Cruciform Plan Organization.

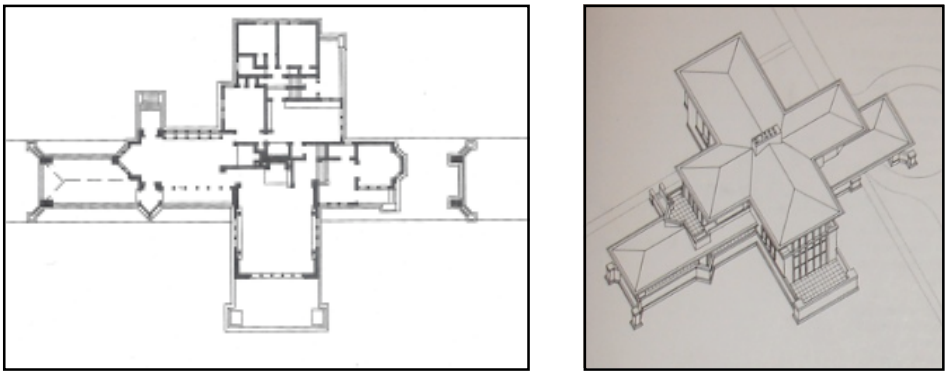


Figure 2.54: Frank Lloyd Wright Willitt's house (Laseau P & Tice J, 1992, p.61)

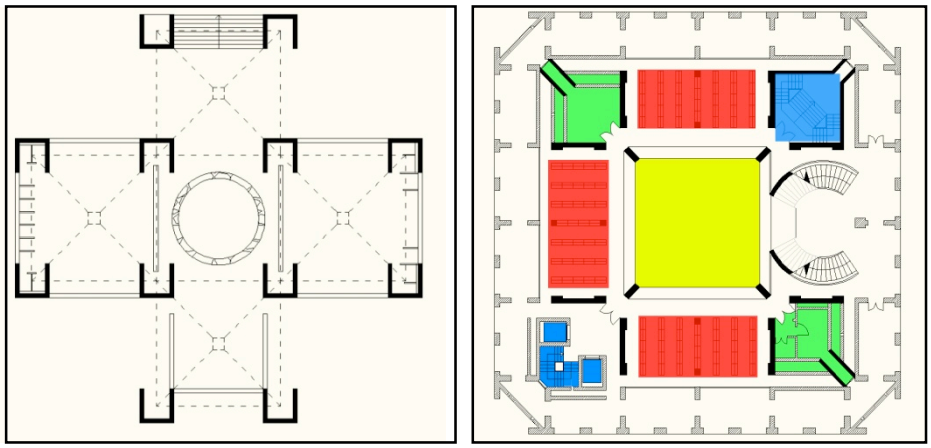


Figure 2.55: Louis Kahn, cruciform organization, Bathhouse, Ground Floor Plan and Interior of Exeter Library. (Re-drawn by Author)

The only significant difference of principle between Kahn and Wright was that of exposing or concealing the structure. In the above illustration related to comparison of design principles use of a significant appreciation by Kahn of Wright's work due to the many limitation regarding use of geometry, structure and structure related to form.

2.2.3 Le Corbusier and Louis Kahn

In an interview with John Peter who asked Kahn "How did you become interested in architecture", Kahn answered; it was really the Classical, like "Greek, Roman, Gothic, Romanesque, Renascence architecture", which inspired me for what I am doing now. But the man who truly inspired Kahn, as he said "that's Le Corbusier, you see, most significant to me. Now the significance, of course, lies in the image that he created. But I always sensed that the image belongs to him, that I' d never copy him, you see. But what activated a sense of architecture in me was really he, you see, and not the old stuff". (Peter, 1994, p.214) Although the "old stuff" existed and was ready to use, however, their precedents were universal ideas applied to Modernism that no one could personalize and therefore regarding Le Corbusier he said, "and he, in his case, there was a personality who said certain thing differently from anyone else. But he was answerable to what would later become the common stuff called architecture". So he always wanted to work for Le Corbusier, but regarding that he must find his own way, as he stated " if I were a youngster I 'd work readily for him" (Peter, 1994, p.214-15).

Auguste Perret was the first person who employed Le Corbusier, whose real name was Charles Edouard Jeanneret (1887-1965) He was born in Switzerland and settled in Paris after World War I. He adopted the alias "Le Corbusier" (Doordan, 2001, p 11), with this first paycheck and then he bought the ten volumes of Viollet-Le-Duc's dictionaries. But Le Corbusier left no testimonial to Viollet-le-Duc in his later life, by contrast to Wright. But he noted this with his comments regarding construction of Gothic Cathedrals (Turner, 1977, p51).

Similar to Wright, there is a direct association with Gothic Cathedrals in Le Corbusier's works. It is obvious that, for these two men, the Cathedral wasn't a style which "ought to be limited but, a principle that ought to be observed" (Ford. 1996, P.2). Therefore, L'Ecole des Beaux Arts enabled him to exploit the elementary method of this style, so that he could assemble larger complexes that embodied monumental civic institutions: for example, Le Corbusier's proposals for the League of Nations building in 1927, and the Palace of the Soviets, in 1931 (Frampton, 2007, p.88). Concrete, at the time, was the only material that facilitated the construction of a wide spectrum of functions within the generic orthogonal volume, which was inspired by the education of the Ecole des Beaux Art. These two aspects had a significant influence on Kahn, especially for his initial works. The influence of Le Corbusier on Kahn was considerable as he said "Every man has a figure in his work who he feels answerable to. I often say to myself, "How'm I doing, Le Corbusier?" you see. Le Corbusier was my teacher. I say Paul Cret was my teacher and Corbusier was my teacher." (Louis Kahn, 1972, p.298-9). Le Corbusier was the only Modern architect whom Kahn admired. He admired Le Corbusier because he was "one in whom the spirit of architecture has not lost its continuity from past".(Frampton, 2007)

Le Corbusier has been considered as one of the most influential architects and architectural writers of the 20th century whose designs were very influential for the development of a new architectural aesthetic. His writings were as important as his architectural design and he developed a writing style of "epigrammatic clarity" as he stated in his book *Towards a New Architecture* "A house is a machine for living in", and also when he wrote "Architecture is the correct and masterful play of forms brought together in the light". There is a similar direct style instatements, which

Kahn was influenced by as evident in the latter's poetic style of writing. Similar to Le Corbusier, he believed in a strong commitment to architecture as a "soul-stirring" visual art (Louis Kahn, 1972, pp.298-9).

Le Corbusier's paintings and his writings were as important as his architecture that he produced as a total influential body of work. It was in 1920s, when he carried out a series of designs for private villas, the White Villas, which significantly contributed to the development of the International Style. Like Frank Lloyd Wright, Le Corbusier studied the classical style and as Colin Rowe, the architectural historian, who compared the formal organization of Le Corbusier's work of 1920s with Sixteenth-centuries Palladian villas stated that "For the Modernist Le Corbusier, abstraction not emulation was the dominant design strategy underlying every attempt at form-making. In the reductive purism of his work, buildings are drained of mass and solidity and appear as weightless volumes hovering over the ground. Citations of classical iconography are replaced by references to icons of the machine age such as ocean liners, and the perspectival construction of space according to Renaissance models is replaced by a Cubist-inspired spatial aesthetic." (Doordan, 2001, p.63). Although, in Le Corbusier's work, the ornament and solidity of classical tectonics are abandoned, the influence of classical architecture can be seen in his work. This inspired Kahn and it was Le Corbusier's "The Five Points for a New Architecture", which influenced Kahn and many other architects. The five points are (1) the structural-formal idea of 'pilotis', that can be seen in Kahn's initial design for mass housing (2) the roof terrace (3) the free plan (4) the free façade and (5) The Ribbon or horizontal windows. These five points, not only influenced Kahn, for deriving his initial design but they also appear in some of his later work. The fifth point, the ribbon window signaled a break with the tradition of square or vertically oriented

openings. It was something that Kahn used for most of his buildings to create a more even distribution of light throughout the interior spaces which depend more upon sunlight, rather than artificial light.

In order to find a cheaper alternative to steel, which was expensive at the time, and to have a more effective fireproof construction method therefore reinforced concrete construction became more common in the late nineteenth and early twentieth century. These two advantages were important for industrial buildings, such as factories and warehouses and also for office buildings. At the beginning, architects and engineers used concrete in the manner of steel-frame construction; columns were located on a regular grid, which supported the spanned beams. But gradually, after about 1910, some architects understood, that reinforced concrete could give them new sculptural opportunities that occurred from the very nature of the material and its method of manufacture. In order to provide the necessary internal strength, without necessarily affecting the outer form, the structural engineers introduced steel reinforcement. Reinforced concrete gave architects entirely new possibilities, which structural steel does not. With this material architects can produce solid three-dimensional forms, and easily create curved lines and surfaces, with the ability to carry loads. Ultimately, architects used load-bearing walls and cantilever floor systems and, most astonishingly, concrete-shell roofs surfaces, such as vaults, domes, or the compound or “doubly curved hyperbolic paraboloid” (Addis B, 2007, p.511).

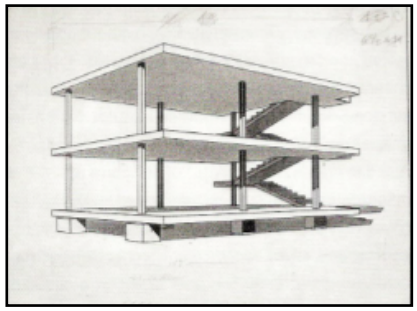


Figure 2.56: Le Corbusier's Dom-ino form-structure, 1914 (Addis B, 2007, p.512)

These opportunities, gave architecture the ability to surpass the achievements of masonry construction. In 1914, Le Corbusier conceived his Dom-ino skeleton as an architectural structured form. In his building he used the architectural expression of the flat slab, supported by concrete columns, which has economical strengths as well (fig 2.56). By the 1920s he elaborated upon this new material in his book "Towards a New Architecture", which was published in Paris (1923) and later in English in 1927. It was this book that mainly influenced Kahn in terms of the use of this new material and building techniques. As Le Corbusier stated in his book about materials and form, "you employ stone, wood and concrete, and with these materials you build houses and places; that is construction. Ingenuity is at work. But suddenly you touch my heart, you do me good, I am happy and I say; this is beautiful. " that is Architecture. Art enters in. My house is practical. I thank, as I might thank railway engineers or the telephone service. You have not touched my heart. But suppose that walls rise towards heaven in such a way that I am moved. I perceive your intentions. Your mood has been gentle, brutal, charming or noble. The stones you have erected tell me so. You fix me to the place and my eyes regard it. They behold something which expresses a thought. This is a thought which reveals itself without word or sound, but solely by means of shapes which stand in a certain relationship to one 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). This is similar to Kahn's appreciation of design in terms of a felt presence of architecture "Form" as an inspiration to "form" as design, which will be discussed below.

It was Le Corbusier's use of concrete that influenced Kahn, since he used concrete for most of his building. The influence can be seen in Kahn's designs for a combined school and community center (fig 2.57), which not only shows Le Corbusier's influence on forms but also, his drawing technique, indicating Kahn's careful study of the first (1929) and second (1934) volume of Le Corbusier's Oeuvre complete (McCarter, 2005).

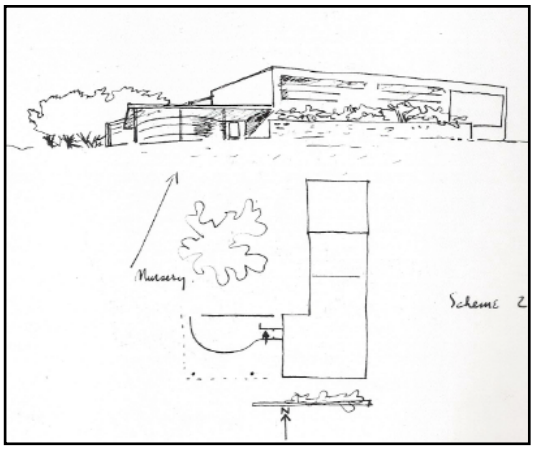


Figure 2.57: Drawn by Louis Kahn, plan and perspective of Jersey Homesteads Community Center and School, Roosevelt, New Jersey, 1935 (McCarter, 2005, p.32)

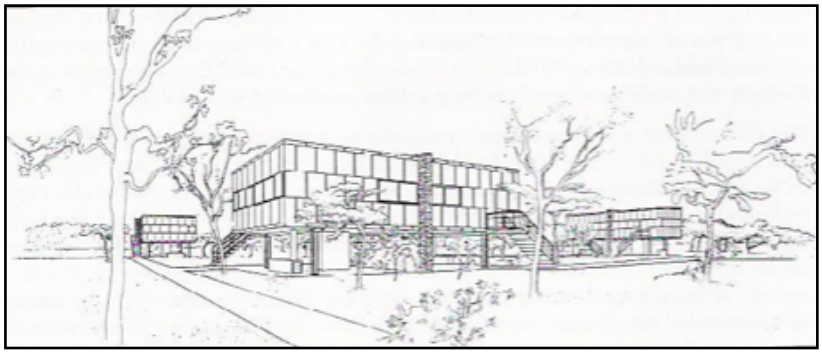


Figure 2.58: Le Corbusier Foundation, Maison Loucheur project, 1928. (Ford, 1996, p.168)

Figure 2.59: Louis Kahn perspective of a Hotel for “194X” (Goldhagen, 2001, p.24)

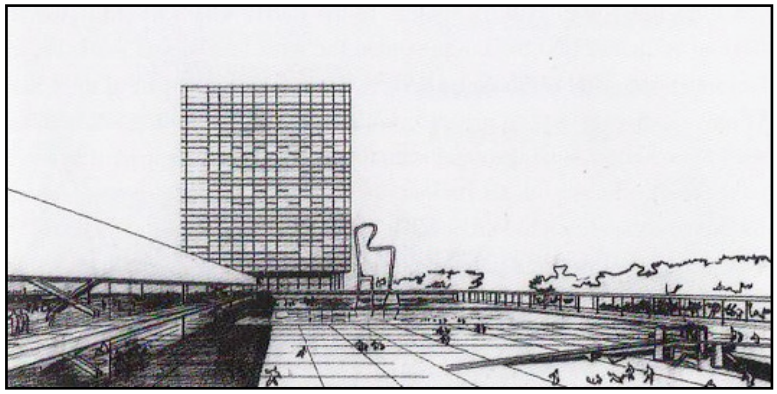


Figure 2.60: Louis Kahn public square looking toward the Laboratory of Education from the UNESCO National Center, with a pedestrian spine to the left showing views to the river beyond, Jefferson National Expansion Memorial, 1947 (Goldhagen, 2001, p.37)

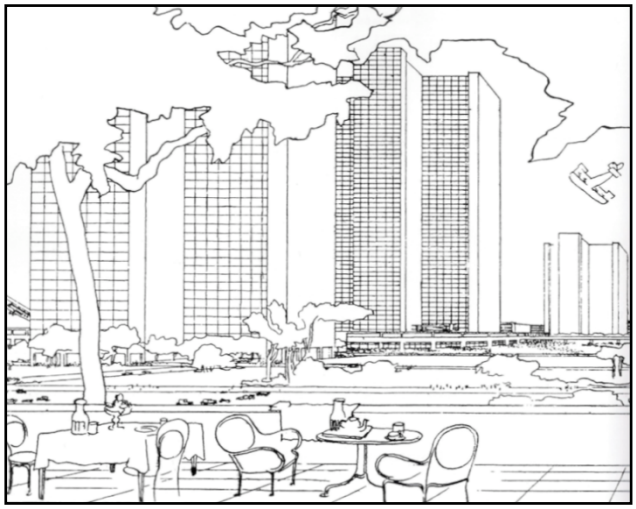


Figure 2.61: Le Corbusier "The City of Tomorrow and its Planning." (Doordan Dennis P, 2001, p.12)

Le Corbusier praised in his book the "*engineer's aesthetic*" and how it was essential to create the "mass-production spirit applied to living in mass-produced houses, this, was like the Hi-tech inspiration derived from the engineering of cars, ocean liners, and aircraft. (Bill Addis, 2007, p.513) The important insight for Louis Kahn was the comparison these technical archetypes with the qualities of great buildings from ancient Greece, Rome, as well as, the Renaissance.

Le Corbusier was ahead of other architects of his time because he claimed that "the modern world made new demands of the architect, offered new materials and tectonic possibilities and, therefore, required a new architectural aesthetic." (Doordan, 2001, p.13) Many architects were influenced by his beliefs and tried to express them in new forms throughout the world, so that eventually the industrialized Modern period eventually developed its own distinguishing architecture.

Although Kahn always admired Le Corbusier his work however came from a very different intellectual tradition. The main elements, which Kahn derived from Le

Corbusier was sensitivity to the nature of materials and how surfaces can be formed to frame light, as Jon T. Lang stated in his book on page 70 *A Concise History of Modern Architecture in India* that "Kahn's influence occurred in much the same way as Le Corbusier's but on a smaller scale. He wrote less about his work and claimed less for it than Le Corbusier did for his own idea and work, and Kahn, like Le Corbusier, had a formal architectural vocabulary that was attractive to and emulated by many architects. His use of scale showed architects that one did have to be monumental to be seen."

Le Corbusier stated in his book *Towards a New Architecture* "this is generally accepted when it comes to painting and music, but architecture is reduced to its utilitarian causes; boudoirs, water closet, radiators, reinforced concrete, barrel vault or pointed arches, etc. These pertain to construction, which is not architecture. Architecture is when there is poetic emotion. Architecture is a plastic thing. Plasticity is what we see." This was an important consideration for Kahn whereby reinforced concrete, gave Kahn the ability to achieve what he said. As Bill Addis states in his book " Le Corbusier was inspired as much by the methods of mass production as by the idea of reinforced concrete as a material. One of his earliest proposals for residential buildings was that they should be built not of steel-reinforced concrete, but cement reinforced with asbestos fibers, which had been developed recently as a cheap roofing material and as a way to provide fireproofing for structural steelwork. He saw the use of asbestos-reinforced cement as the most suitable means of providing mass-produced buildings." (Addis B, 2007, p.516). This was the same idea, which Kahn applied to most of his building, using Reinforced Concrete and other materials instead of steel for his buildings. He not only was inspired by Le Corbusier's material techniques, but also was influenced by his use of Catalan vaults

as Sarah William Goldhagen stated in his book *Louis Kahn's Situated Modernism* that "In part, these developments (articulated room) reflected American architects' assimilation of Le Corbusier's Maisons Jaoul, in which enclosed spaces are created with a repeating rhythm of Catalan vaults. Kahn and Tyng surely knew of these developments. Kahn watched Le Corbusier's work closely." (Fig 2.62) (Goldhagen, 2001, p.109).

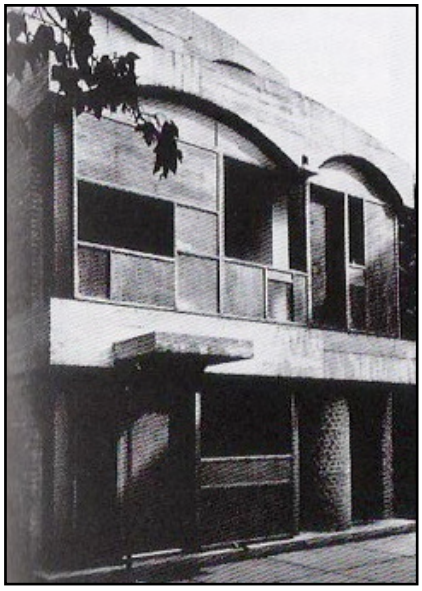


Figure 2.62: Le Corbusier, Maison Jaoul, Neuilly-sur-Seine, France1952-1954 (Ford, 1996, p.111)

Kahn was also influenced in his use of cavity wall from Le Corbusier; a wall construction that he applied to some of his buildings as it is appears in details and sections of Le Corbusier's Maison Jaoul. Also, from Le Corb's Unite d' Habitation Kahn applied the opposite idea in his Exeter Library and the same idea in his Kimbell Art Museum, regarding wall construction.

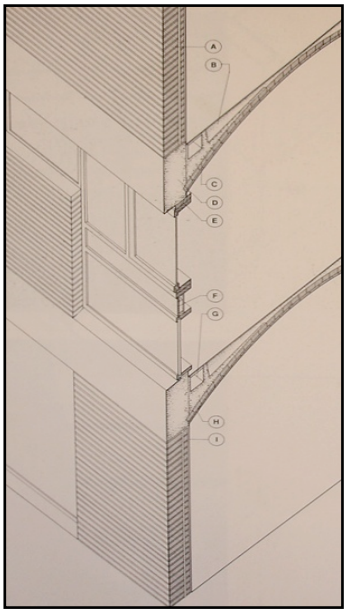


Figure 2.63: Maisons Jaoul, Wall Section, 1951-1955 Le Corbusier's masonry wall consisted of a 22 cm exterior width, 3.5 cm air space, and a 2 cm interior brick and despite their monumental appearance, the walls are cavity walls with an air space to intercept any water and provide insulation (Ford, 1997, p.214).

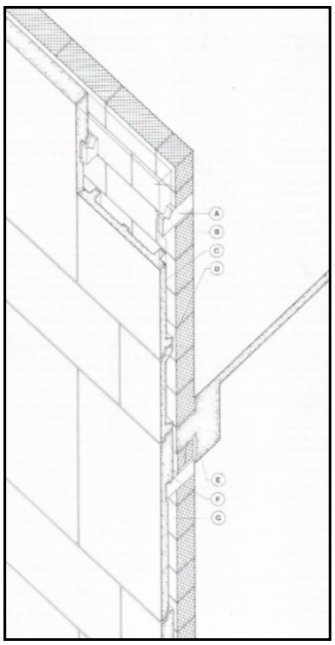


Figure 2.64: Le Corbusier Unite d' Habitation, wall section, Marseilles, 1945-1952 (Ford, 1991, p.188)

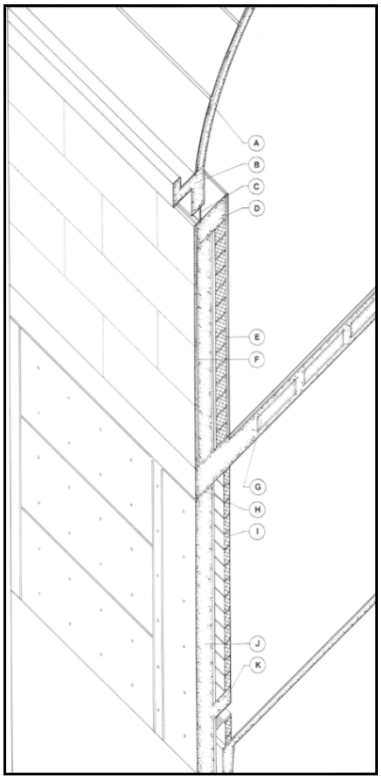


Figure 2.65: Kimbell Art Museum, Section, 1966-1972 (Ford, 1997, p.330)

As referred by Kahn regarding Le Corbusier's use of material and cavity wall, it was Le Corb's Vault type, which inspired Kahn for his design for Kimbell Art Museum (fig 2.68 & fig 2.70).

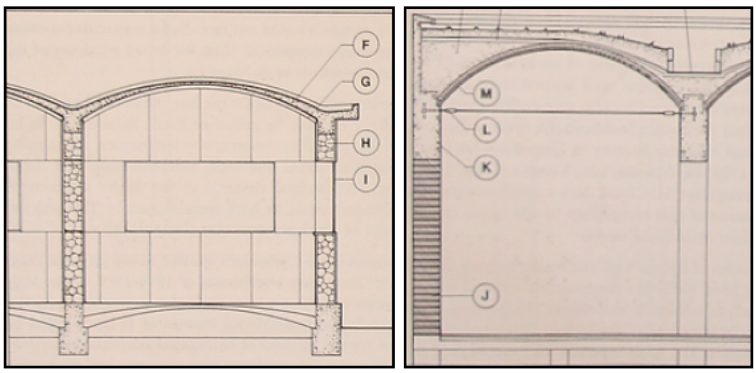


Figure 2.66: Le Corbusier's Maisons Monol and Villa Sarabhai (Ford, 1996, p.176)

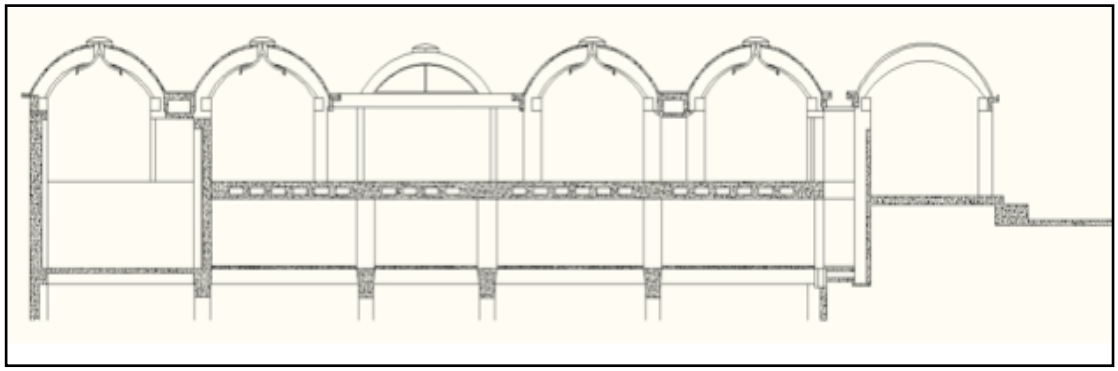


Figure2.67: Louis Kahn, Kimbell Art Museum (Re-drawn by Author)

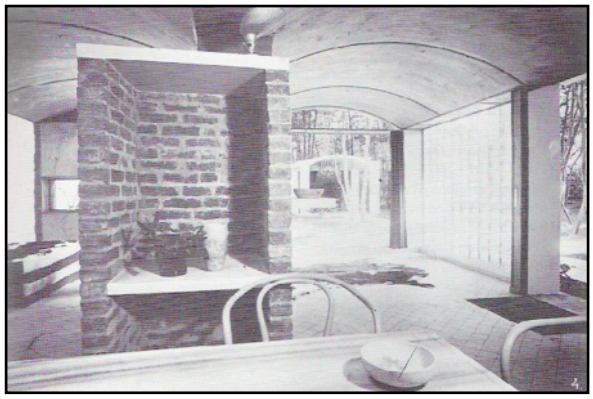


Figure 2.68: Le Corbusier Weekend House at La Celle-St-Cloud, Paris, 1934-1935

(Ford, 1996, p.176)

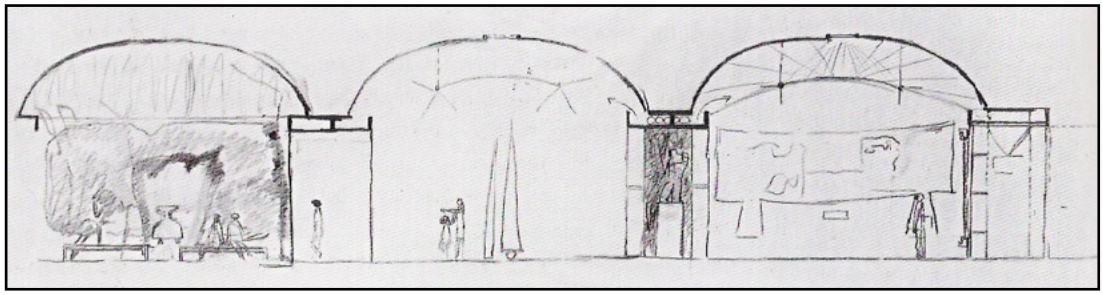


Figure 2.69: Drawn by Louis Kahn, early sketch showing section of the Kimbell Art Museum, with Curved thin-shell roof vaults. (Komendant, 1975, 117)

2.2.4: Conclusion

Kahn's idea of order, which is his most important conception in his design, reflects Le Corbusier's thoughts about order related to geometry and proportion, and explains Le Corb's publication of ideas about the "Modular", in 1948. It was Le Corbusier's appreciation insertion of architectural and historical models as a designers attitude between Historicism and Modernism which was the main influence on Kahn; since all Kahn's work is related to monumentality. That is, as Le Corbusier's principles of order were formed by Beaux-Arts ideas, most of Kahn's work also related to this style. And it was Le Corbusier's faith in the significance of proportion and of the Golden Section, as he said "here the gods are playing"(Le Corbusier, , 1978, p 238), which is similar to Kahn's design of inspiration when he referred to "Form" as an inspirational ability.

It was in 1961, when Kahn realized that he didn't have to work for anybody and his concept of the "servant and served" spaces gave him enough confidence to say "when I realized there were servant areas and there were areas served, that difference, I realized I didn't have to work for Corbusier anymore. At that moment I realized I don't have to work for him at all". (Kahn, 1961) This is seen in Kahn's monumental and historical designs that he used modern materials and structural system sympathetic to modern need and functions in relation of architectural form.

2.3 Post Modern and Robert Venturi Complexity and Contradiction in Architecture

Postmodernism is a complex style, as it only increases the confusion by redefining and expanding the notions of modernism as an architectural and cultural phenomenon. The prefix "post" refers to phenomenon that comes after, and in this context, it is a notion of Modernism extended to include that architecture function to 'speak' as well as to 'shelter'. However, the word 'modern' is still used to describe the present epoch and the concept of a post-present condition is hard to understand. That is, post-modernism became a style of architecture during the mid–1970s in an effort, by critics, to deal with a crisis in modernism whereby modern architecture had became too mechanical and unrelated to the totality of the needs of a society.

In general, post-modernism tried to identify new work by architects who rejected the International Style as a universal culture style unrelated to particular societies. Moreover, Postmodernism expresses a particular design orientation that depends upon the original exploitation of symbols and references drawn from history or popular culture. Robert Venturi, whose book "Complexity and Contradiction in Architecture", provided the first theoretical discourse regarding post-modernism in architecture. (Doordon, 2001, p.207) This book was published in 1966 and revealed Venturi's sophisticated understanding of the history of architecture that as a friends and co-workers Venturi also influenced Kahn.

2.3.1 The Influence of Venturi's Use of Layered Space: An Interest in Natural Light and the Role of Monumentality on Kahn's Work.

Vincent Scully observed in the introduction to Venturi's book that "like all original architects, Venturi makes us see the past anew." As Venturi stated in his book, "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, p.22-23). In this regard Kahn had struggled with the logic of Modernism, so that Venturi was, to a degree a significant influence on Kahn.

It was in 1962 when Venturi applied many of his concepts in "Complexity and Contradiction in Architecture", to design of a house for his mother in Chestnut Hill, Pennsylvania. For example, he created contradiction with a simple gabled silhouette of the architectural house, the obvious symmetry of façade to balanced fenestration pattern and the offset from center of the chimney (fig 2.76). He creates multiple possibilities to read the composition by sudden shifts in scale and use of wood molding on the planar stucco surface (Doordon, 2001, p.207-08). This idea also appears in Kahn's sketch for Philips Exeter Dining Hall, where he used the same concept to create contradiction to his symmetrical building (fig 2, p.74).

There isn't enough evidence to prove that Kahn was inspired by Venturi, who was younger than him, but there are some authors, whose writing makes relevant insight. David Brownlee and David De Long wrote books about both Louis Kahn and Robert Venturi, and claimed "Kahn's letters of recommendation for Venturi document close ties and deep appreciation, and it was surely Venturi's perceptive comprehension of personal mannerisms and specificity in architecture that came to loosen Kahn's growing inclination toward highly controlled, even compulsively ordered designs. Within the very shadow of the pure logic cast by the City Tower project, Venturi, in his sketch of the plaza, invoked the emotionally charged spirit of Michelangelo's Campidoglio. If Anne Tyng can be said to have strengthened Kahn's tendencies toward abstract geometric order, then surely Venturi provided the means by which that order could be made poetic." (Brownlee, David B & De Long, David G, 1997, p.72)

Also, there are some authors who reject the idea that Venturi influenced Kahn in certain areas and especially with regard to the historical dimension of his work. Venturi may have only encouraged him to look at history to create his work. As Eugene Johnson wrote in his book "*Drawn From the Source in; The Travel Sketches of Louis I. Kahn*" "Denise Scott Brown has argued that Kahn's contacts with Robert Venturi in the 1950s led to Kahn's interest in layering: 'Through Bob, he investigated the layering of enclosed spaces and the layered juxtapositions of walls and openings, and he discovered that windows could be holes in the wall again.' The evidence of the Italian drawings of 1928-29 demonstrates that Kahn had investigated these issues much earlier. … As for his realizing that windows could be holes in the wall again, to use Scott Brown's words, his drawings of interiors from Stockholm

and Ravello and of the Bargello in Florence demonstrate this concept forcefully." (Eugene, 1996, p. 64).

But Venturi himself stated that Kahn was influenced by him, and said this only after Khan's death. Venturi believed that Kahn's architecture represents characteristics found in the work of Denis Scott Brown and himself (Venturi). In addition, he adds "I shall note here that Kahn learned from me concerning the elements of layering, holes in walls…; his use of inflection in the case of the pavilions in the Salk Center complex derives also from my critique". Also he thanked Kahn, when accepting the Pritzker Prize, in that way "Louis Kahn, profound teacher of mine, and ultimately, in some ways, as all teachers become, a student of mine" (Venturi, 1996).

Kahn never admired Venturi as being an inspirational model for him, but Venturi admitted that, he was inspired by Kahn. He admires Kahn for his "double hung window", which he used in his final version of Vanna Venturi residence, which was influenced by Kahn's Shaw Townhouse project in Philadelphia on1957 (fig 2.70 & fig 2.71). As Venturi Claimed " The house started out more like Kahn. After all, I was young, and he was influential." (Schwartz, 1992, p.24). It is obvious from his design process for the Vanna Venturi House, which took five years to build, that he definitely was inspired by Kahn.

Figure2.70: Louis Kahn, Shaw Townhouse, 1956-57 (Rodell, S, May 2008, p.11)

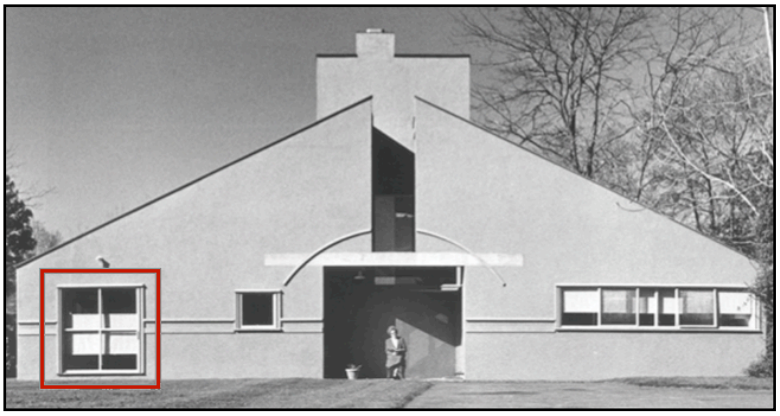


Figure 2.71: Louis Kahn, Shaw Townhouse, 1956-57 (Ford, 1996, p.350)

Also, this influence is apparent in terms of Kahn's use servant & served spaces which had a great influence on Venturi's diagonal elements in his early plans. As he stated "The idea of servant space was beautiful idea that influenced me much. The influence went both ways (Sam Rodell, 2007).

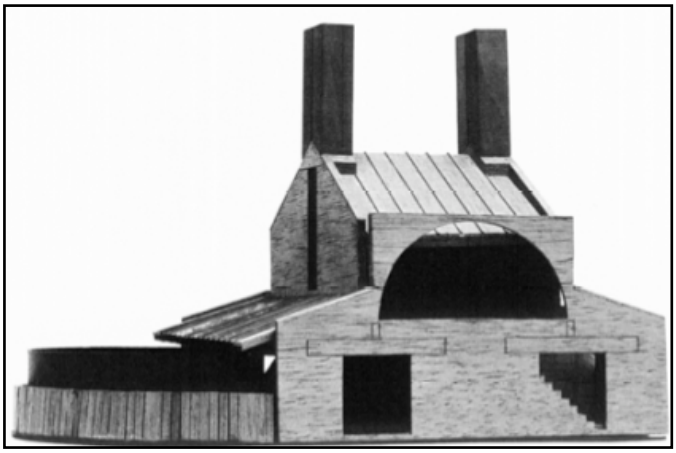


Figure 2.72: Robert Venturi, Mothers House Study Model, 1959 (Rodell, May 2008, p.11)

Figure 2.73: L. Kahn, Philips Exeter Dining Hall, 1965-71 (McCarter, 2005, p.321)

It is apparent in Venturi's projects that he used manipulated iconic architectural elements such as an over-scaled chimney, which dominated the architectural composition, which were often perceived as either free standing or integrated with the composition as an architectural anchor. There is a small probability that Kahn was influenced by Venturi for example by his use of vertical massing relative to horizontal elements in his design. But it's most likely that Frank Lloyd Wright inspired Kahn the most for using a vertical element as servant component in his design.

Figure 2.74: Louis Kahn, Philips Exeter Dining Hall, 1965-71(Rodell, S, May 2008, p12)

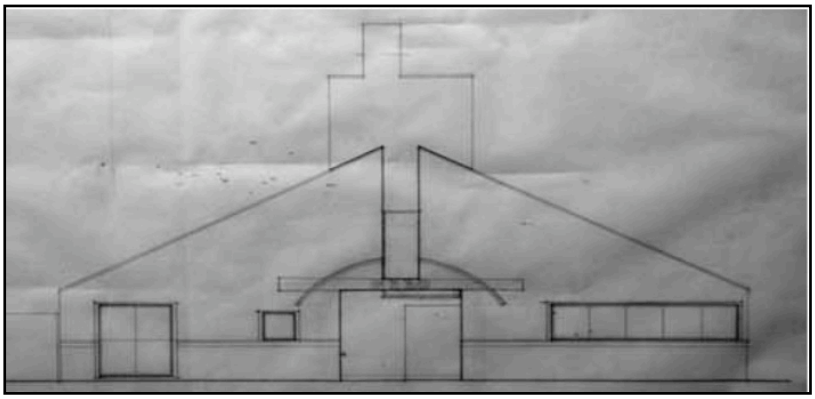


Figure 2.75: Robert Venturi, Vanna Venturi House, 1959-64(Rodell, S, May 2008, p12)

As Carter Wiseman stated in his book "*Louis I. Kahn; Beyond Time and Style*" in 2007; the main elements which illustrated the Exeter Dining Hall were, over-scaled gables and a chimney that stands free of the building's wall. There is a possibility that was inspired by Venturi's Beach House in 1959 and his Mother's House, where there appear strong resemblances with Kahn's design elements. As Venturi said "There's no question it is Mothers-House-influence, and the chimney separate from the wall he got from me, too". Also Kahn applied the same idea in his Esherick House in 1963, with its main dominant element as distinctive chimney. As Venturi told Sam Rodell in an interview in 2007 that "The window/chimney in Esherick house was actually my idea." (Carter, 2007, p.202).

Figure 2.76: Vanna Venturi House (1959-64) (Ford, 1996, p.350)

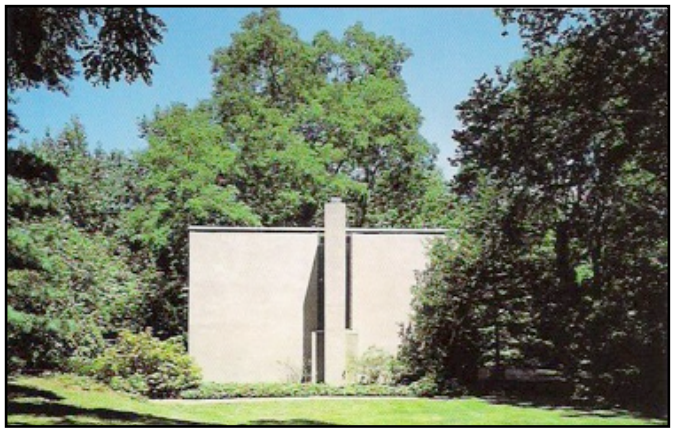


Figure 2.77: Louis Kahn, Esherick House, 1959-63 (Brownlee& De Long, 1991, p.154)

Considering another work, there are some similarities in Venturi's office building for the North Penn Visiting Association and Kahn's Salt Institute, which to a certain degree confirms Venturi's statement that he influenced Kahn's form for the Salt Institute.

Figure 2.78: Robert Venturi and Short, North Penn Visiting Nurse Association, 1960

(Rodell, S, May 2008, p.14)

Figure 2.79: Louis Kahn, Salt Institute, 1960-65

There is strong evidence that Kahn developed his "Ruins-wrapped-building" concept, as a shading device thorough Venturi's "Layered-Space" concept. Since Venturi didn't have a chance to apply his idea on a real project, then Kahn, when he had the opportunity to apply these ideas, developed them through his design. The "Layered space" refers to architectural walls layered behind or inside each other, to provide shade for the inner space. This idea, which Venturi had not invented, but he was inspired by the Italian architect Armando Brasini, especially derives from historical precedent. (Scully, 1992, p. 46).Venturi applied this idea in the Pearson

House (fig 2.80 & fig 2.81), which was his first project of 1957, but remains unbuilt. It appears in his drawings where he used spatial layering for indirect light, and architectural elements for effect, which are not structural. Also, as mentioned above, his special use of over-scaled chimney elements, as compositional elements, is applied to this project.

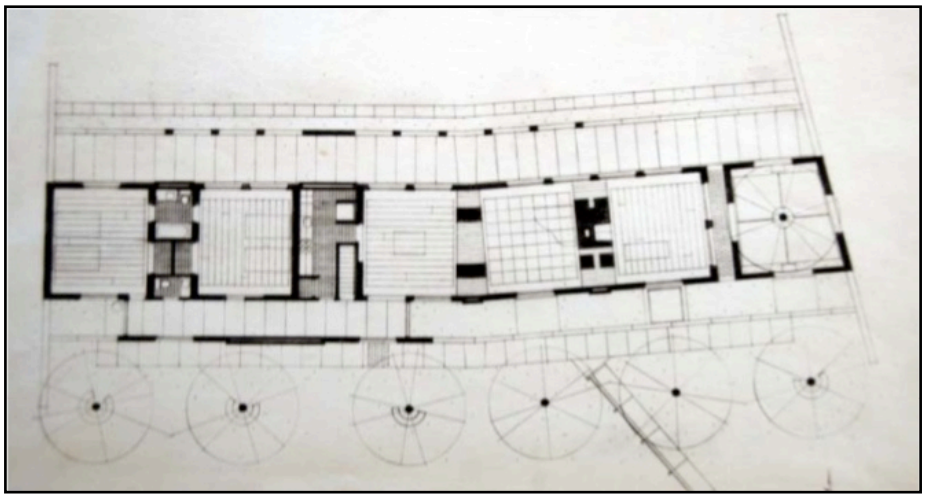


Figure 2.80: Robert Venturi, Pearson House, first floor plan. 1957 (Rodell, S, May 2008, p.15)

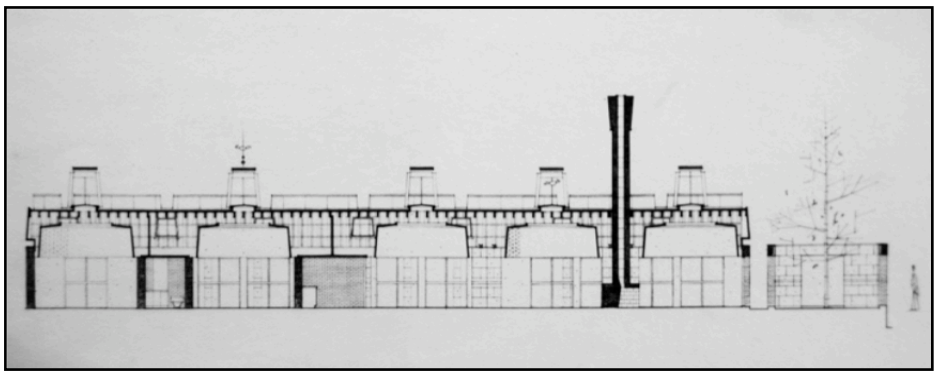


Figure 2.81: Robert Venturi, Pearson Residence, Section, 1957(Rodell, S, May 2008, p.20)

Kahn first applied the concept of a “ruins wrapped building” in both the Fleisher House, and an unbuilt project for Elkins Park (Fig 2.84) in Pennsylvania in 1959.However, he went further than simply developing a shaded zone as the relationship between sunlight and space. The Fleisher House was Kahn’s first complete symmetrical house design in which he designed four cubic room-bays. Two rooms were near the entry court and the other two projected to the rear, into roofless “rooms”; i.e. a garden open to the sky. Originally he had a different proposal for the Fleisher House as the first model indicates, which was to have each cubic room-bay of the house to be given a large semicircular sun-window, set above a smaller slot-like view-windows (fig 2.82).

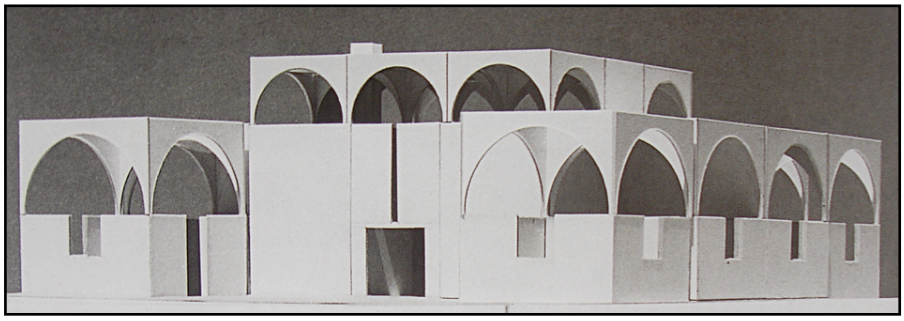


Fig. 2.82: L. Kahn, Model of the Fleisher House (Brownlee & De Long, 1991, p.65)

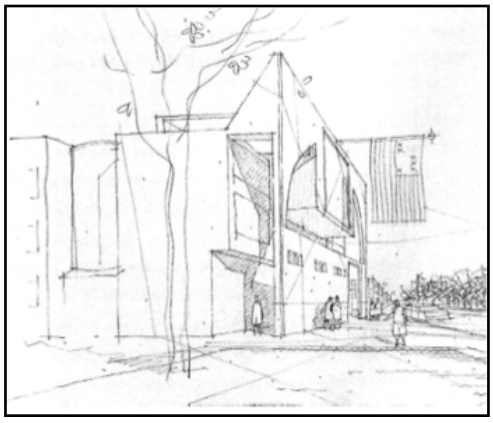


Figure 2.83: Robert Venturi, North Canton, Ohio, Redevelopment Plan, 1961-62

(Rodell, S, May 2008, p.17)

The ‘built-ruins’ design theme may be considered Kahn’s first attempt to have a walled exterior space which was a structural component, to receive and adjust the sunlight for the interior spaces at the rear. (McCarter, 2005, p180) As Brownlee described in his book “*Out of the Ordinary*”; although Kahn adopted the idea from Robert Venturi, he made the idea his own, by using his double-skinned design for warm climates. Brownlee tried to make a connection between Kahn and Venturi by describing Venturi’s North Canton redevelopment plan and the Pearson House with Kahn’s Salk institute, the Exeter Library, and the Indian Institute of Management in the Bangladesh, where Kahn was inspired by the perforated screen walls from Venturi’s Pearson house. He also applied them in more recent designs like the Salk Institute which, as applied by Kahn, gave monumental stature to his work.

Kahn also used his “wrapped ruins” concept, for an unbuilt project for the Bristol Township Offices, Bucks County, Pennsylvania, of 1960-61. In the plan for the Bristol township offices, Kahn gathered various units of the local government into a long narrow rectangle as independent building (fig 2.84). The public entry was adjacent to a plaza as well as an amphitheatre and opposed to the entry for the police station. As usual, Kahn organized the building around a square, central courtyard which is surrounded by a perimeter corridor. He placed the entry for the meeting room, which has a solid rectangular volume, through a porch flanked by “light courts” similar to those at the front of the Fleisher House. This is similar to the idea, which he later applied to the entry portico of the Kimbell Art Museum (McCarter, 2005, p180).

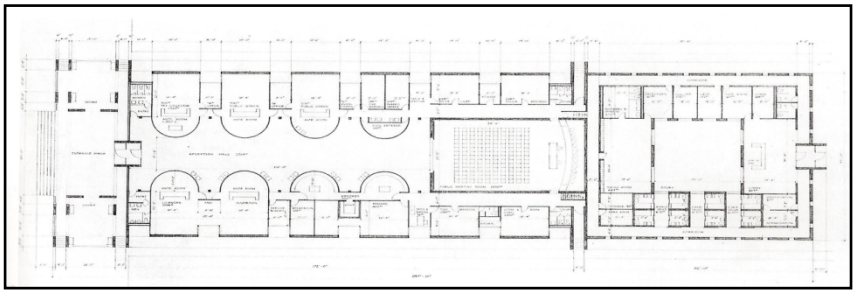


Figure 2.84: Louis Kahn, Plan of the Bristol Township Offices, Bucks Country, Pennsylvania, 1960-61 (McCarter, 2005, p.181)

As explained above, natural light and layering are connected to each other as a design principle for both architects. Urs Büttiker described, in his book *Louis I. Kahn – Light and Space;* it was in Kahn's late work, where the skylight plays an important role. He develops more sophisticated solutions for light control and modulation. As it is appears, Kahn's use of light takes place in his late work while Venturi applied them much earlier. Venturi designed architectural elements to prevent direct daylight entering into the space in his Pearson House of 1957. Kahn uses this idea in the manner of a baffled light screen, or as a roof element, for shading in U.S. Consulate in Luanda.

Scully claimed in his book "*Everybody Needs Everything*"; that Venturi believes that overhead lighting and the sectional preoccupation are his own and they were thermal windows of Rome and his personal experience of the oculi, which inspired him. And it can be assumed from Kahn's works, that the idea, to light spaces from above, indeed to design in section, can be seen only in his late works especially in his later museums. But it can't be disregarded that it was Kahn who first used oculus in his Trenton Bath House in 1955 (Fig 4.2).

Figure 2.85: Robert Venturi, North Canton, Ohio, Redevelopment Plan, 1961-62

(Rodell, May 2008, p.17)

Figure 2.86: Louis Kahn, Salk Institute Meeting House, Computer rendering, 1965

(Larson, K, 2000, p.21)

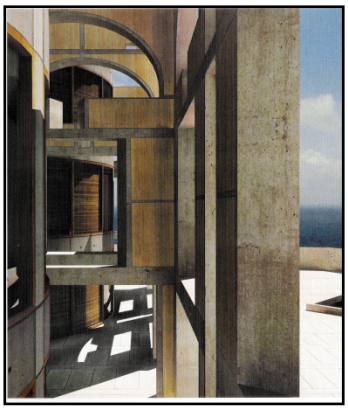


Figure 2.87: Louis Kahn, Salk Institute Meeting House, Computer rendering, 1965

(McCarter, 2005, p.185)

There are some scholars who believed that Kahn's use of monumentality was inspired by Robert Venturi. He started to work for Kahn after Kahn returned from the American Academy in Rome. This wasn't for a very long period since he started his own practice in 1957, where their collegial relationship was initiated and continued for eight years. Since monumentality had a strong influence on Kahn's work after the 1950's, some historians believe that his trip to Europe couldn't help influence him that much, and most probably it was Venturi whose interest in history inspired Kahn. Anne Tyng published Kahn's letters which stated that "Bob (Venturi) is a very good architect. He looks for the right things and is very well back grounded historically which helps his judgment. …. I believe [Venturi] is going to be one of our best if and when he gets the work" (Tyng, 1997). Other artists, like Nicholas Gianopulos believed that, when Venturi came to Kahn's office, Kahn started to be inspired by him, as he was inspired by Tyng. But as Kahn's paintings reveal from his second trip to Europe, he only made one sketch of a Modern building and as McCarter stated in his book "Kahn drew ancient Italian Greek and Egyptian sites, alongside vernacular buildings and landscapes; his drawings from this trip include no example of modern buildings. Except for a brief visit to the construction site of Le Corbusier's Unite d' Habitation in Marseilles, it appears that Kahn did not attempt to visit any examples of the modern architecture which had so influenced him, and to which he was no so completely committed in his own work." It therefore appears that Kahn developed his own interest in monumentality before he met Venturi.

2.3.2: Conclusion For Rober Venturi and Louis Kahn

As explained above, there isn't enough evidence to decide whether or not Kahn was influenced by the younger Venturi, but it is obvious that both helped each other to find their ways in architecture as colleagues and friends witnessed in the years

between 1950's to 1964. There is no doubt that Kahn was a talented architect, and an aspect of his talent involves the ability to see, observe, and combine other's work as his own, which to a great designer is what architecture is all about. In general, the main influence from Venturi upon Kahn was that he helped Kahn to move past the limitations of International Style.

The use of structural elements as more that just structural form, but as design (i.e. servant and service spaces) concepts is evident, in Kahn use of shaded layering of concrete elements as "ruin-wrapped" forms. Structure, for Kahn is applied structurally as well as functionally (Servant spaces) and as formed elements (i.e. the geometric cut-out and for shading in Dacca buildings). With regard to Venturi and the historical dimension in his work as an influence upon Kahn use of structure that is inconclusive as, structure was perceived by both architects in a more complex relationship with space and form.

Chapter 3

THE INTEGRATION OF STRUCTURE AND FORM IN THE ARCHITECTURE OF LOUIS I. KAHN: A PHILOSOPHY OF DESIGN

3.1. A Philosophy of Architecture in the Work of Louis Kahn

Kahn was not only a great architect, but he was a poetically inclined philosopher. What makes philosophy different from science is that it is more conceptual and less empirical than science and, consequently, tends to be both more of a concrete and applied knowledge. Philosophy and science use rational analysis to prove their arguments or propositions, but philosophy provides an underlying or foundational way of thinking (i.e. metaphysics) rather than experiment and proof; i.e. an understanding of cultural bias towards knowledge. Therefore, Kahn had the innate ability to apply both philosophy and science as a total way of understanding in aid of design.

From the beginning of any work Kahn applied a higher knowledge, or wisdom, about architecture by means of certain concepts he derived by himself; such as notions of 'Order', the 'Institution', 'Silence and Light', as well as 'Servant and Served' spaces. These concepts expressed his understanding of a metaphysics regarding design in culture, such as the unity between form and structure as well as between form and function in the service of Architecture. For Kahn, the idea of Form (with a capital

'F') was conceived as both a metaphysical and inspirational insight in-forming the physical and built-work of architecture; i.e. an insight applied to function and structure in the service of design by the thoughtful use of structural systems and materials.

3.1.1 Order

As described above, Kahn was educated in the Beaux-Arts tradition. This manner of education was dominant in North America until the 1950s, when the Modern movement began to displace it. In the1930s Kahn became involved with Modern architecture but he was never totally comfortable with it. It was his education that inclined him to find a deeper order beyond Rational Modernism but, he also knew that he couldn't find it by returning simply to an old Classicist style.

Kahn had struggled over the years to find "Order", that is, an understanding or guiding principle for his work. Ultimately, he came to understand that he must look for only one general principal, an intuitive insight that would apply to all aspects of a developing society, including Architecture. It was at that time, he begins to speak of "Order".

Kahn never said what Order is, but he discovered that it is the underlying shaping principle, or foundational principle, implicit to all cultural artifacts. This idea of 'Order' involves a deep insight, or revelation, available to everyone but not totally describable because it is a subconscious cultural influence. In other words, there is a gap between this collective subconscious and art whereby, the latter eventually provides an expression of this hidden cultural order. Architectural design, for Kahn, was filling this gap between the subconscious and culture as expressed in Art and Architecture. 'Order' is the essential formative dynamic between them; that is,

‘Order’, affects not only the things that exist but also the things that do not yet exist, because it is not only an underlying principle and a quality of things but, the active creative ability whereby things that do not exist come into being. Order, in the human psyche, is the creative force that plays an in-forming role in the making of artifacts, which is the nature of the arts (i.e. Architecture as Art) and includes all that nature does not make. Although Order is an essential intuitive ability and basically indescribable Kahn could only therefore go so far as to say “Order is” (Kahn, 1955).

Order can be found in everything and to quote Kahn it is “of wind, of materials of our being”. Kahn conceived of Order in two ways. The first was by questioning. It can be seen from the example of his poetic conversation with a brick; “Brick, what do you like”. But it doesn’t refer only to the brick. It can be applied to any materials, or anything in nature. He also initiates his design with a similar question; e.g. “What does this building want to be?” (Lobell, 1979, p.63).

A second way for discussing order was by looking into oneself. As Kahn realized, this ‘Order’ presides over the making of all that is made, and there exists a record of this making which is tradition. The record of our making is in our perception as expressed in the historic and current styles of a culture. Therefore our styles, as ways of seeing, reflect a sense that intuitive designers express though their work, and in Kahn’s work this was within the context of the Western Tradition and of the Beaux-Arts.

Kahn discovered that the “genesis” of his perception, or intuitions about his own origins, does not only take place in the past, but that the past as tradition exists in every moment (the past as felt presence is a form of intuition). In view of the fact

that tradition takes place at this moment, therefore it is a human ability to have direct access and it is something we can participate in as the order of things (Lobell, J, 1979, p.63). As the author Gast stated that the "genesis of the design is presented in cumulative "sequence" of steps in figurative geometry - as circular, square or rectangular figures. "This method lets us take a fresh look at Kahn's work from very different - and vivid - point of view. This method – plan analysis – focuses on ways in which design ideas can be implemented rationally, following guiding principles, alongside intuitive development of solution in the design process. But both these approaches – intuition and rationality – are seen as interdependent processes, each affecting the other" (Gast, 1998, p.9). "Genesis", or the way the past is retrieved intuitively, sustains our heritage; i.e. a heritage of emerging influences for new "beginnings" in design, which was something that Kahn found from surrounding himself with what he referred to as the "Joy of Silence and Light".

For Kahn, Silence refers to that which does not yet exist, and Light refers to that which exists. Silence is the desire to be, it is the unmeasurable. Since Light is the giver of presence it is the measurable and there is "a doorstep between Silence and Light", whereby movement takes place from one to another. And in Kahn's opinion, this is what he referred to as the "treasury of Shadow", which is where art existed and human creativity discovers the source of self-expression.

Art refers to the emergence from insight or intuition to Form (with a Capital 'F') as a conceptual insight, which directs the design or emergent form (with small 'f"); i.e. the design concept which occurs as a new experiential event or artifact in the world. Therefore, the play between "Silence and Light" involves a "genesis", or an act of creativity with a consequent production of artifacts and Art; this includes both the

work of architects and/or artists. The only job of an “authentic” architect is to bring the new work from Silence to Light, which means to bring it to realization into the realm of the measurable. This is our world as a material reflection of intuitive insight grounded by means of an awareness of ‘Order’ which can also be referred to as the metaphysics of cultural being.

Kahn always considered Silence and Light as “brothers” because he realized that the duality of Silence and Light is one of the perceptions of unity and of relationships and are not of separated things. He would say that. “Beyond duality is oneness” and still there is something beyond oneness that guides the knowledge or insight derived from ‘Order’. That is, “a Form emerges from the structural elements inherent in the form. A Dome is not conceived when the question arises how to build it” (Kahn, 1955).

3.1.2 Institutions

Kahn learned from his own philosophy of architecture, in terms of Silence and Light, how a building comes into existence. But his understanding of human institutions taught him what a building serves. In Kahn’s opinion, Institutions exemplify the desire for humans to learn, which occurs in human relationships as defined by societies and communities. Kahn believed that the only way to serve human desires is by means of current or contemporary forms of institutions. It is architecture that can serve those desires. Architecture in Kahn’s opinion, and in terms of his philosophy, is the art whose concern is the expression of experience, through form which represents human institutions. As Lobell stated “Building are not mere abstract forms; they are always for an institution; the house is for residence, the school building for learning, the laboratory for science, etc, a building can be meaningful only in serving a vital institution” (Lobell, 1979, p.65).

It is institutions, which have been the defining quality of human beings during all historic periods. Therefore, since the only thing that makes us human is desire, he stated “Desire - the qualities of the not yet said and not yet made - is the reason for living. It is the core of the expressive instinct and must never be stymied.” (Kahn, 1973)

In Kahn’s opinion, desire is the path of expression, which is described in terms of three kinds; (1) the desire for learning, (2) the desire for gathering together and (3) the desire for well-being. Historically people wanted to meet these desires therefore they formed the primary modes or forms of institutions which, according to Kahn, are “the School Room, the Street, and the Human Agreement” (Kahn, 1971). Contemporary institutions as expressed in terms of an architectural heritage that reflect those desires so that when Kahn uses the term “beginning” he does not refer to a historical “beginning” chronologically rather, it is a quite endless beginning of universal desire to be outside of time in the act of creativity (Lobell, 1979, p.66).

Kahn suggests that a building must house the character of its institution, which is the kind of desire to be satisfied, even if its users have forgotten it. For example, the architectural square or plaza can always be there to facilitate people towards gathering together. Also, the halls of the school can be there to allow people to exchange ideas, and the vaults of the church can be there to facilitate one’s communion with God. It is only by means of the architect’s comprehension of the starting point or the aim of the square or the school or the church which affects design and that has the Institution’s human-serving purpose as more fundamental for design than the list of functions and spaces, which a client might require.

Kahn also stated that “The institution lives in the spaces. Everything we build we build for an institution. It’s the institution of home. It’s the institution of learning, institution for government, institution of recreation, institution of health. They are all institutions. Every single thing that we established as part of a way of life is an instituted thing. It’s supported thing”. (Peter, 1994, p.220)

Kahn’s most significant buildings were completed in the process of questioning the nature of the institution, a concept which he realized during the period between the 1960s and the early 1970s. Many architects believed that either the meaning of the “institution” must change or, that architecture must be suspended until the change has been completed. And if neither were possible, then the institution would be ignored functionally. But Kahn rejected both approaches, referring to “one as utopian and other as nihilistic”. For Kahn, architecture was a continuation of the engagement with the world; (i.e. as it exists at the moment), “using the circumstantial, that is the specific building, its uses and materials, as means of reaching back into the eternal to bring new realization into being, thereby enriching the world” (Lobell, 1979, p.66).

3.1.3 Architecture

That architecture expresses cultural desires reflecting the “Institution”, in the manner of the Form, and produces a designed form which has been created by our sensitivity to the subconscious desires of a culture. Architecture provides the physical presence of our institutions, filling the gap between the subconscious and the life of perception or, of what Kahn terms the “measurable” or the life-world of a culture. It is the expression of ‘F’orm that reflects the “Order” of our experience. Architecture is a model that embodies cultural desires in a particular ‘f’orm that provides meaning or shape to space and time. For instance, a Gothic cathedral is a an archetypical model of the Medieval cosmos, representing the nature of material and light, the forces of

nature, the limits or norms of human behaviors, and the underlying spiritual relationship between the human and the Divine. Therefore, architecture provides a particular statement for each culture. It is not a model of some abstract universal culture but nevertheless, it provides an underlying pattern for this derived form.

Other examples are the Egyptian temples which involves a regularly ordered chain of spaces as a master plan. For instance, the avenues of sculptural rams or sphinxes represented the sacred ways which lead to the massive temple gates, and then sequentially through arcaded courts, pillared rooms and halls to an exclusive sacred chamber. That is, in the Egyptian worldview there was no consideration of departure to either side of the path as nothing existed other than the path. This linear bias, embodied by Egyptian architecture, expressed an order found in Egyptian life and mind and, as the historian Oswald Spengler stated "the ancient Egyptian moving along a narrow and prearranged life-path that continued into and from beginning to end with death…. It is his believe that architectures of each of several cultures are expressions of their worldviews." In the same way, the pyramid defined the way across the desert from any direction with its triangular surface. Cultural patterns and social life responded to the flat smooth stone surfaces of a strict formalist architecture. (Lobell, J, 2008)

In contrast to the Egyptian linear directional movements, the Chinese wandered through the world unrestricted by stonewalls, moving through nature, as expressed by the principle of Tao. The Chinese temple appears as self-contained building, but it was its location, as the reference of a complex configuration that included hills, water, trees, flowers and stone outcrops, as well as the building itself which can be configured as a dynamic space flowing like the gentle wind. (Lobell, J, 2008)

In contrast to both Egyptian and Chinese architectures, the Greek experience involves a differentiation or abstraction of the individual from society and from nature. For example, the evolution of the nude sculptures, as natural representation, shows the emergence of this bodily self-awareness as an ideal abstraction. The mysterious forces, apparently inherent to the ancient figures, "give way to anatomical idealism and individual expression in Classical and Hellenic figures." (Lobell, 1979, p.60). For the Greek, presence was instant, not extended or an evolutionary process through space or time. Therefore, there is neither naturalist expression nor depth in Greek vase painting and there is no physical change over time in the characters in Greek drama, while there was no useful interior in the Greek temple. The sense of the natural appears in its Doric columns, perfect in proportion and standing erect, free and apart, while the temple itself was freestanding against the landscape as an abstracted figure (Lobell, 1979).

The Gothic cathedral applied these ancient proportional and linear ideas expressing the emergent Western consciousness of movement through space. Scully has stated in this regard, "The continuous change in the calculus, the elliptical orbits of the planets, the complex tones of Baroque music, and the emotional depth of Rembrandt's paintings could all be seen in the spatial depth of the Gothic cathedral". (Lobell, J, 1979, p.60)

Knowledge of the world expressed in architecture requires that architects of each era turned inward (self-awareness) and outward. The Egyptian, the Chinese, the Greek and the Gothic architects each found what was best for their time so that architecture changed with each historic period; the Renaissance, Baroque, Modern, etc. As Alberti, the Renaissance architect who was also the master of the art of perspective

claimed, “at last I can see the world as God sees it!” Alberti captured the world as pure space, which is defined by continuous lines of perspective vanishing towards point i.e. the world existed as if in contained uniform space. This was a cultural consciousness that prevailed from the 15th century to the beginning of 20th century. Later, “the physics of Einstein, the canvases of cubists, the novels of Proust and Joyce”, as well as, the open plan of Frank Lloyd Wright’s architecture set the world again into flux. That is, understanding or the new metaphysics changed in terms of relative space-time. The architect, like the artist or the poet, is the vehicle that moves forward, repeatedly, into the world to create something anew (Lobell, 1979).

In this regard, art was always something that preceded the world; the artist always made something and dedicated it as contribution to Art. But Art is not creative Art when it is abstract, but rather, it must be a work somewhere and concrete. As Kahn always believed that the architect always lives to express, and this qualified architecture as a human expression. As Kahn felt, a monumental building is a building which is initiated with the unmeasurable (Form) and it must be changed to a measurable means (form) through its design process. But again at the end, it must become unmeasurble or a built in terms that the built-work becomes an experience of Form for the user.

A designer must develop the form of the building through the measurable which involves the way he can build in terms of structure and construction. Therefore, the only way you can design the building is through the laws of nature with involves a felt-understanding of the qualities of materials, methods of construction and engineering techniques. But at the end the building becomes part of the life-world, the spirit of its existence takes over and if it evokes unmeasurable qualities of Form,

this is what distinguishes architecture from mere construction for Louis Kahn. He believed that only 5% of what is built is architecture.

3.1.4 Form and Design

As discussed above, there is a fundamental distinction between existence and presence. Existence is the manifestation of natures Form or essence and the only way to give presence is to consult nature, or experience, which is where Design begins for Kahn. The idea of Form (with Capital F) has no shape or dimension. It includes a harmony of systems and, by means of a sense of 'Order' a distinction can be made between one existence to another in the realms of nature and culture. Form is completely impossible to hear and to be seen and, consequently is realized as the mindful intuition which has no presence. A designer can turn to nature to make "Form" which in turn becomes present and realized as a particular form. 'F'orm leads Design. Design or 'f'orm" is "how". But 'F'orm" is "what". Design is for architects, but Form is impersonal; it belongs to the building and institution. As John Lobell stated in his book "*Between Silence and Light"* that "Design gives the elements their shape, taking them from their existence in the mind to their tangible presence. Design is a circumstantial act. In architecture, it characterizes a harmony of spaces good for a certain activity".

As Kahn always starts his design with this question; "What does this building want to be?" The answer to this question would be defined in terms of a required Form. Kahn never simply started with a program of activities and spaces. Unlike other Modern architects his methodology involved starting with Form, which was quite unique. His first act with regard to the program, as provided by the client, was to change it. He believed that he didn't need the program in order to give him the ability to start designing a building, and in terms of this understanding would be an

offering to its institution. As he said, if a school board requested a space without windows, the architect must refuse to accept this project because Kahn understood that light is vital to life, to learning, and as a result to provide the proper “form” or presence to the School.

The architect can start designing, when the Form is sensed. Design gives the Form precise shape with appropriate materials and structure which brings it into the circumstantial world. Design is the development of new form; i.e. it’s the process, which involves a dialogue of feedback and forward as a means of testing the ‘Form’ through design. So it is impossible to begin design without Form. The architect’s contribution to architecture is in Design, or in revealing intuitive Form. The Modern Rationalist movement abandoned the history or the past. But Kahn’s approach was contrary to Modernist thinking, because he felt that the historical styles have been a source of architecture for two thousand years; which is closer to the beginning of architecture and human institutions. Tradition, for that reason, provides the authentic in design more than modern architecture.

Ancient architecture had a respect for materials that was taken directly from nature and rendered through the human creative ability as craftsmanship and as applied to architecture. This sensitivity to the processes of construction had been separated from architecture since the Industrial Revolution. So, those materials had lost their distinctive qualities. But Kahn’s reintroduction to a less abstract regard for materials is evident in his more aesthetic or philosophic approach. The following are materials that Kahn used in his buildings, i.e. brick, concrete, travertine, oak, teak, slate, lead and steel. He applied them in a way which renewed the strength of quality of these materials in our architecture. Kahn was always concerned for the connection between

form and human meaning in architecture, which was something he learned from the past and, by example, their expression of the identity with place and time.

3.1.5 Structure

For Kahn, structure was revealed in light, so that when he chose an order of structure, for example, the pattern of colonnades that "presents a rhythm of no light, light, no light, light, no light". There are other structural elements that exhibit a particular character or configuration of light, like a vault and a dome. Such ideas, as the place of the column as the giver of Order can be seen from his emphasis on structure as a significant human experience. He also learned from Mies van der Rohe about the richness available in the use of materials and the use of structure to order space.

Khan believed that structure must be used to give light to a space for identity. It must be used to create an opening in the wall and as he claimed, "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). To support his idea he refers to the Parthenon; i.e. the way the light creates a space between the columns and how the building grew out of the wall with openings.

It would expect the light either from above or from its four sides as windows or entrances". (Kahn, 1971)

He distinguished between structural elements and non-structural elements in his design. And in addition he said "when the building stands complete and in use, it

seems to want to tell you about the adventure of its making". Therefore it is clear, where he used structural elements and where he didn't. This idea originates in his mind from his Beaux-Arts training as well as from Le Corbusier. He believed the structure of a building is its identity, as he stated "Monumentality in architecture may be defined as a quality, a spiritual quality inherent in a structure which conveys the feeling of its eternity, that it cannot be added to or changed. We feel that quality in the Pantheon, the recognized architectural symbol of Greek civilization". (Kahn, 1944)

Therefore, Kahn and his civil engineer (August Komendant) agreed on this basic philosophy; "a finished structure, whatever its purpose, is excellent when no questions are asked" (Komendant, 1975, p.166). A building must tell its own story from the excavation to the finished structure; it must tell how it is made, how elements are designed and constructed in order to carry out the function. A building's structure must represent itself; it must have its own identity, which tells what its function is, which is in a relation with the structure. Therefore, in order to functionalize structure Kahn Invented the idea servant and served spaces, i.e. which spaces would help him to use structural elements to not only to carry loads and give identity to his building but also to make them functional (Komendant, 1975, p.166).

Kahn, in order to find a geometrical structure, which he always used in his design, refers to nature and history as his precedents because of the existence of geometrical structure in nature as an image of this order. Kahn found the only way for integrating Form and Structure is a geometrically ordered structure. And to provide order to his own structural system Kahn refereed to nature, as Klaus-Peter Gast stated in his book *"Louis I. Kahn The Idea of Order"* "A system of inherent order, supported by scaled

geometrical figures, is revealed, right down to similar growth processes in nature, from the germ cell to the organism as a whole" (Gast, 1998, p.10).

Therefore all of Kahn's designs were structural and grounded on geometry and geometrical principle, which was the reason he could create complex buildings and as Klaus-Peter Gast claimed "Kahn's work is obviously dominated by geometrical structures which lead one to question their complexity. The key is the search for an inherent order as system that drives the designs and thus the architectures as a whole." (Gast, 1998, p.10).

This was the main reason that Kahn used symmetrical or double symmetrical organizations in most of his designs. It was something he learnt from nature and his Beaux-Arts study; i.e. that structure is inherent in the "figurative form" such as Square, Rectangle, and the Circle. He not only used geometrical structure on the ground plan (two-dimensional), but he also used them in three-dimensions. In this regard the orthogonal structure applied to designs was helpful; "geometrical relations are established – through the relations of the edges of the individual areas, the way in which their corner connected (usually diagonally) – that bind all the parts into the network of the ordering structure as square or rectangle frame" (Gast, 1998, p.12).

Kahn achieved this by geometrical overlaps and with the use of grids that are proportionally interdependent. Also by dividing geometry into the smaller geometries this creates hierarchical stages that make it possible to identify the starting-point of the structure. Therefore, the starting-point in Kahn's design process has a beginning within its structural geometry, which has been prepared in interdependent stages. In this way, by combining his philosophical or spiritual

elements in his design with this figurative geometry makes him an architect whose architecture is “Permanently valid architecture that is not related only to its time.” (Gast, 1998, p.12)

Gast stated that “The structure of architecture is based on rational principles, which reveal their system in a comparative examination of the plan and the realized building, and this system seems sound and comprehensible” (Gast, 1998, p.12). As a complement to this insight Kahn also stated that “As I see a sheet of music, I realize that musician sees it to hear. To an architect the plan is sheet on which appears the order of the structure of spaces in their light” (Kahn, 1969).

3.1.6. Served & Servant spaces

Kahn’s work was based on a conceptual philosophy which helped him to design better buildings by the use of such ideas as the ‘measurable and unmeasurable’, ‘silence and light’ and the principle referred to a ‘servant and served’ spaces. Kahn believed that it was insufficient to work with just the list or the program of the spaces for the building. Rather, he attempts to work within the possibilities and potentials of modern architecture and therefore, he attempted to go further than simply solving for a list of functions and utilitarian needs.

Kahn differentiates between desire and need. He distinguished a space for people and space for service or servicing needs. He claims “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) Therefore, he discovers a hierarchy of spaces, and made what he called “servant and served” spaces. The servant spaces only belong to the MEP spaces (the Mechanical, Electrical, Plumbing needs), which also includes the circulation and structure, while

the served spaces belong to people who experience the space as a derived quality of form. This distinction was made explicit by Kahn and added a more meaningful exploration of experience than had been present in Modern architecture.

Kahn had discovered something which already existed in other buildings and was discovered by others, but he applied this knowledge in a unique way; as he claimed "at the moment, I realized that what I had discovered in the way of the hierarchy of space, of the servant areas and area served, that I had discovered something that belongs to everybody else, but from which I would base my own designs very clearly and strongly as a way of life" (Peter, 1994, p.216). By discovering "servant and served" spaces he started to feel architecture organically as part of a way of life. When he saw this involves "the artful manipulation of spaces appropriate to use" as an insight, he applied these relationships towards generating a design concept. But by discovering this for himself he changed them into to a way of life, as he claimed "as a way of life, something which everybody could use quite freely, like the invention of the ax. At the moment it doesn't belong to you. It belongs to a lot of things, so this thing is of the same nature" (Peter, 1994, p.216). What Kahn means by saying this was that this idea had been found by others, but the way he uses this idea was "to give a life" to his building and design which makes it original for him and his own work.

He developed this idea about applying these design principles for his work and later he would develop them to improve his design; "You might say we are a scientifically resourceful society. There are so many laws we now have by the tail and we're not making good rules to work with them. The law is a completely unchangeable thing,

but rules must always be considered as being changeable. The rules should never be given to anybody cold without telling the law that is back of it" (Peter, 1994, p.216).

His concepts regarding the terms "Served and Servant" areas was his idea, but influenced by Frank Lloyd Wright who used corners of a plan for placing servant areas. However, Kahn's concept of Served and Servant spaces was contrary to Mies' universal space, "in which the structure permits flexible and different uses over time" (Peter, 1961, p213). Kahn's ideas referred to the relationship between spaces in a plan as contained and defined spaces, but Mies was referring to the idea of a "free" and "open" plan as a flexible and less defined space.

Kahn provides a simple example in his biological laboratories for the University of Pennsylvania. He was concerned with recycling of the air in the laboratory, because it contains bacteria and as he said, "if you used it, the law would say you're not in good shape. It's not only waste air, but it's dangerous air." (Peter, 1994, p.217). Therefore, he made a rule which was that the air you breathe should not interface with the air you throw away. In this case he placed the exhaust towers high above the roof line, and the air intake low, which was something that shaped the building and gave it a distinct identity (see case study #2 below).

In his work Kahn made the strong distinction between the servant & service areas, which influenced his further work. And in his opinion this distinction was something that separates "modern architecture from old architecture"; because in every age we have different servant spaces that serve the building spaces. As he claimed "you still have round rooms. You still have great halls. You still have light from above or below. You see, you can't get away from the fact that space enclosed is of nature

quite like other spaces of old. The Pantheon is a beautiful example of a terrific space which you can't surpass no matter what age. It really spells enclosure. It spells a world of its own, you see. And that's what a building is. A building is a world of its own." (Peter, 1994, p.219).

3.1.7 Conclusion for Theory

As discussed above Kahn, in order to create his idea about the "servant and served" spaces, must discover 'Order' in 'Design'. But for Kahn finding Order wasn't easy, for as he wrote this involved a three-phase process of finding "First the Nature of the Space, next the Order and finally Design" (Tyng, 1997, p.71-75). Consequently, he applied this way in order to realize his idea for representing the servant and served spaces for a building and he "began with the phase most introverted and difficult to understand" (Tyng, 1998, p.7). Ultimately, he achieved a simple concept by distinguishing those spaces that are less important (servant spaces), and other spaces which are more important (served spaces). This idea allowed Kahn to design more complex buildings.

Chapter 4

CASE STUDIES: THE TRENTON BATH HOUSE, THE RICHARD MEDICAL BUILDINGS, THE EXETER LIBRARY AND THE KIMBELL ART MUSEUM.

To better understand how Louis Kahn integrated structure and form, four of his buildings are analyzed to illustrate the significant relationship in his work. In this regard The Trenton Bath House complex is considered Kahn's his first meaningful building but remained an only partially realized project. The Richard Medial Research Building was chosen because Kahn considers this to be an architectural and structural success due to technological innovation; i.e. the first use of post-tensioned systems in architecture and the integration is obvious because for Kahn architecture and structure cannot be separated. The Phillips Exeter Academy Library was also selected because it was in this building where Kahn integrated the duality between Modernism and Monumentality by means of the effective use of load-bearing structural systems and materials. With regard to the Kimbell Art Museum, it is used as an illustration of architectural and structural integrity because it applied a novel geometric form (i.e. the cycloid as his first example of non-Euclidean geometry) as the definitive aspect shaping structure and space. This also was last building Kahn saw completely finished before he died in 1974, although some projects, like the parliament buildings for Bangladesh, was completed in 1984.

The analysis is structured into five divisions to help clarify this vital relationship of form and structure which are; (1) “servant and served” spaces, (2) function and geometry, (3) form/structure and geometry, (4) structure and form, and (5) details. The case studies also each conclude with a summery.

The case studies also involve a discussion of the concept of ‘servant & served’ spaces which was major idea directing the integration of Kahn’s design. The relationship between function and geometry was important for Kahn which he used in aid of the concrete realization of functional/formal spaces and not just in abstract geometric shapes; as mentioned above the plan was a means of understanding the light and shadow quality of a space. When Khan considered form and geometry this provided him with a basic understanding facilitating the integration of form and structure. This is because he achieved an integration of form and structure by using geometrical shapes (figurative) which in turn were further subdivided into geometric forms for the placement for structural elements. This use of structure and form shows how he conceived structure as an integrative ability for finding architectural form. Finally, the details provided in each case study, illustrates a particular significant aspect of this integration of form and structure

Case study 1: The Trenton Bath House

Client: Jewish Community

Site: Trenton, New Jersey

Date: 1955

Main material & structure: Concrete Block Masonry and Timber Rafters.

Design Concept:

Kahn's first design for the Trenton Jewish-Community Center consisted of a gymnasium, locker areas, a large auditorium and numerous small meeting rooms organized along a linear circulation spine, but unfortunately none of them were built; except for a small bathhouse (fig 4.4). Kahn idea for the total project involved one of his unique concepts whereby, each room is conceived as an independent room, or pavilion-like structure. Originally the rooms were shaped as octagonal modules, which he later rejected when he designed only the Bathhouse Building. For the Bathhouse he used a nine-square system (this is a Renaissance concept) or Tartan grid, in the manner of the cruciform plan (fig 4.9). He later used this idea for many of all his buildings such as the Richard Medical Center and the Exeter Library.

Figure 4.1: Open Courtyard with Servant Area as Circulation (Peter, 1994, p.215)

Figure 4.2: Bathhouse's roof, showing Rafter, wood beam, secondary beam and cables (McCarter, 2005, p.98)

Figure 4.3: Exterior of Trenton Bathhouse (Rosa, 2006, p.35)

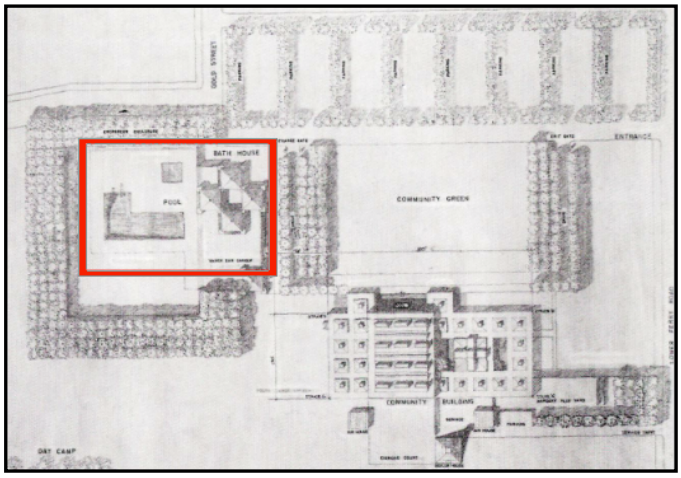


Figure 4.4: Site plan of the Jewish Community Center, 1 July 1957. (McCarter, 2005, p.107)

A: Servant & Served spaces

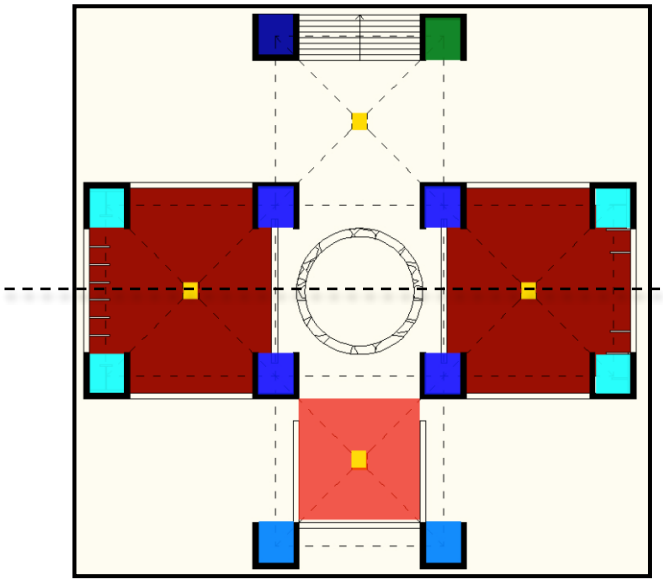


Figure 4.5: Bathhouse Ground Floor Plan, servant and served spaces (Drawn by Author)

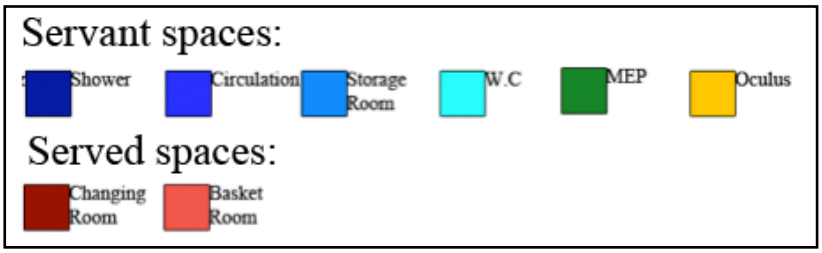


Figure 4.6: Served & servant spaces; Cool color (except yellow) represent servant area and warm color represent served area) (Drawn by Author)

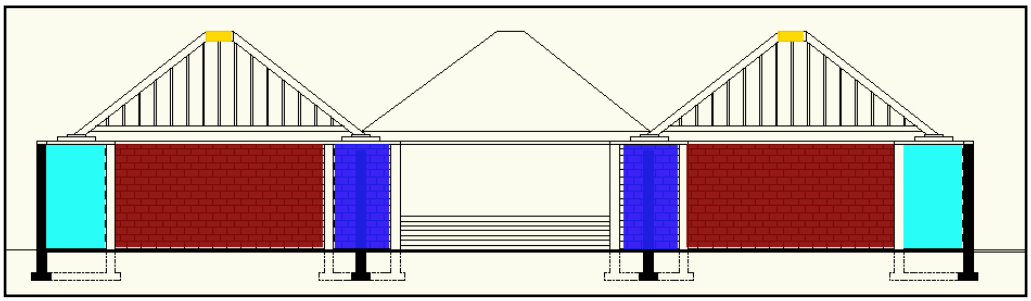


Figure 4.7: Section showing servant and served spaces (Drawn by Author)

Kahn realized that in this building there are some areas that are not as important as some other areas and referred to those areas as servant spaces, which provide service to those spaces that are important (i.e. served space). Therefore, he combined his servant area with the structure of the building to create circulation, storage, MEP utilities and in this way, by identifying the order of spaces in terms of servant and served spaces, he could integrate form, function and structure as a unitary design.

B) Geometry and Function

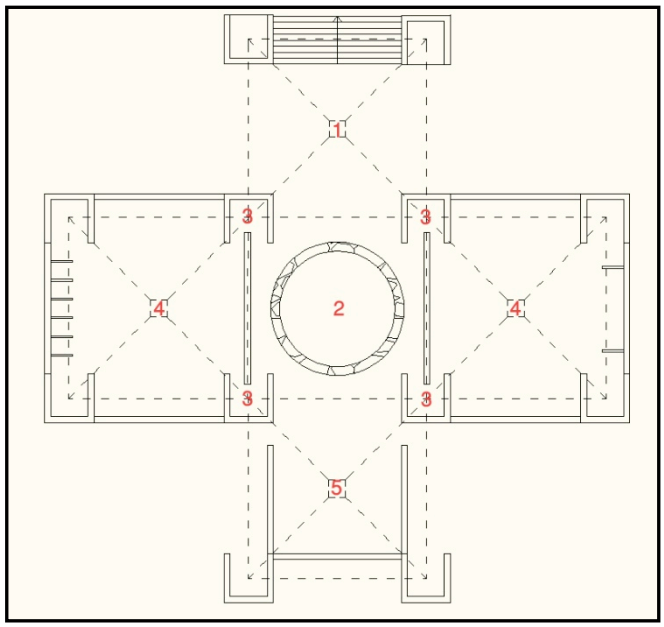


Figure 4.8: The Bath House, Ground Floor Plan (Re-drawn by Author)

1. Entrance
2. Courtyard
3. Circulation
4. Men and Women changing room
5. Basket room(solitary)

Kahn divided the building into four main squares in the manner of a cruciform organization. Four major spaces surrounded the courtyard; two for changing rooms (women and men), one as entrance and the other as the basket room. These latter service spaces are served by the servant spaces such as circulation, storage, WC, Bath, and other areas.

C) Geometry and Form

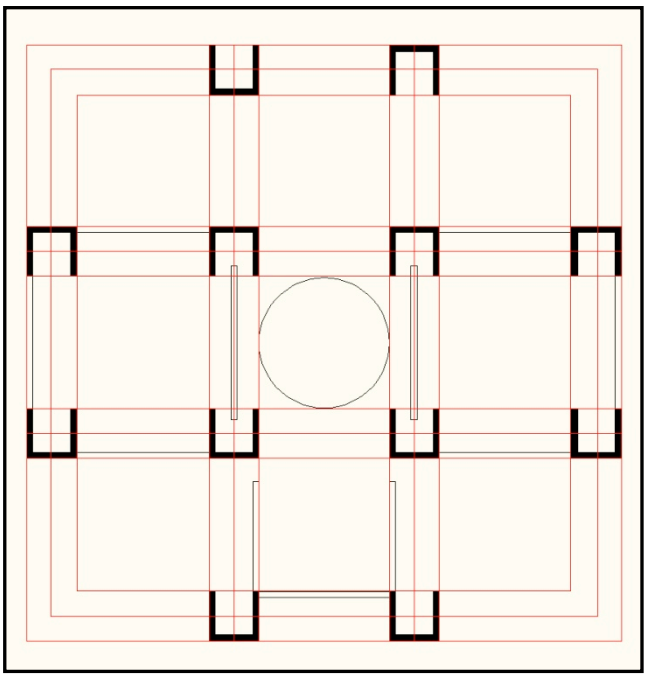


Figure 4.9: 9 squares Geometry (Re-drawn by Author)

The Bath House was designed in terms of 9-Square Geometry, also referred to as a Cruciform or Bay System, the Tartan Plan or the a-b-a grid. As mentioned above this concept appeared in the work of both Frank Lloyd Wright and Renaissance Architects such as Alberti.

In Kahn's plan for the Bath House the design conception consists of four independent equal squares arrayed about a double axial symmetry; the four volumes together configure the total building. Forms are linked to each other by hollow cubic U-shaped columns acting also as servant spaces. By designing this building, Kahn not only follows the principle of "form follow function", he also tried to give the space an identity so that for Kahn "Form is Function". In this way all service squares provide particular recognizable function which are neither simply similar in use nor universal spaces adoptable for after uses.

D) Structure and Form

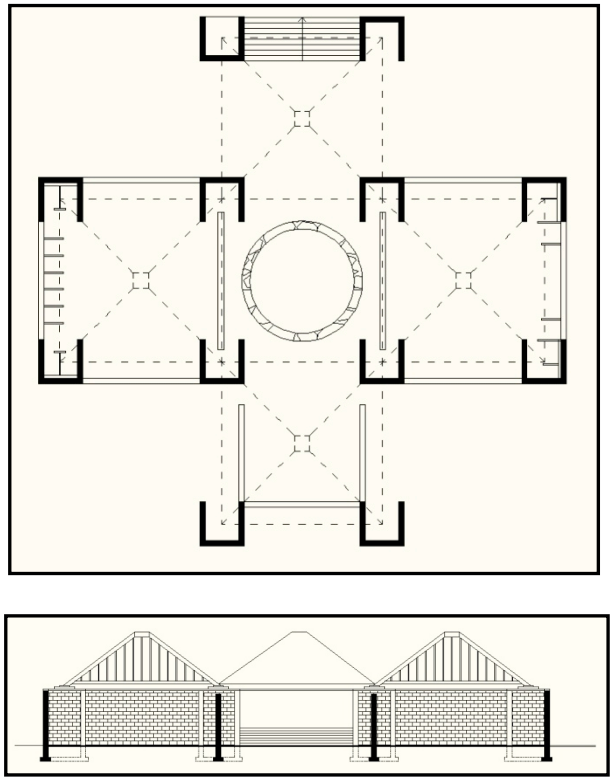


Figure 4.10: The Bathhouse Ground floor plan and Section (Re-drawn by Author)

Vincent Scully described the Bath House as the "starting–point for structural design". What he means is that form is not simply reduced to structure, but in the

way that Kahn integrates constructed space to create a structure this gives order and hierarchy between servant and served spaces; as a result geometry, structure and function serve to create a form with a distinctive identity or sense of place; i.e. form is function. Kahn always refers to structure and function as elements of integration in architecture and that is the reason he integrated servant and service spaces within the structural plan as functional forms.

The Bath House was constructed as a post and beam system with block concrete infill walls and a wood frame and rafter roof (fig 4.3) as four similar pyramid roofs. The structure can be seen from beneath with the square-shape opening, or oculus, at the top-center of the roof, similar to the Pantheon roof opening (fig 4.2). His concern with historical reference involves effectively translating the Form/Structure relationship within his tradition which monumentalizes even the simplest construction.

He not only used the rotated square in section for designing roof (fig 4.10). He also rotated the square (fig 4.2 & fig 4.12) for, (a) bearing the base's wood frame at center of each side span and this was braced to the center of the main frame by secondary beams and for, (b) supporting these two square forms together he used cables crossing right angles from center. The whole roof does not fit on the wall and hollow columns because they were shifted up by the bearing block concrete cap, which makes the roof appear as if it is floating over the space.

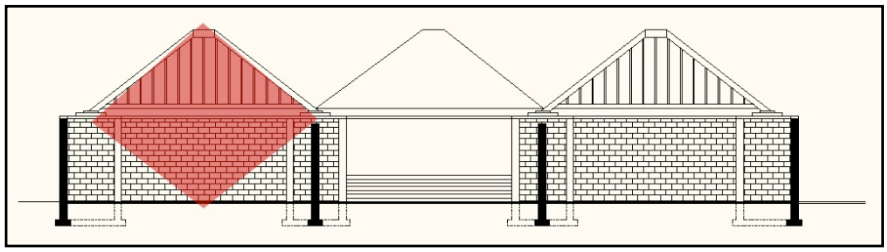


Figure 4.11: Relation of Plan and Section (Drawn by Author)

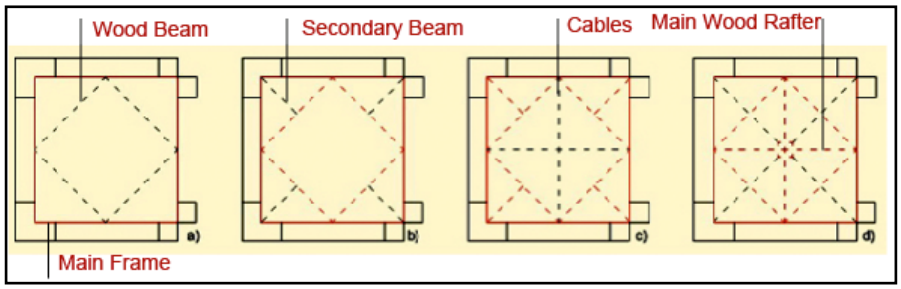


Figure 4.12: Structural Detail of Pyramid roof (Drawn by Author)

E) Summary

The Bathhouse was designed in a way whereby both Modern and Ancient architecture combine in the structure/form relationship to create unique place. Similar to Modern buildings, constructed with the most functional and economical materials such as concrete block and wood frame, this building's pyramid form and courtyard design (central court) and ocular rooftop openings symbolically reference many traditional buildings.

Kahn was influenced by the Prairie style work of Frank Lloyd Wright, such as his Larkin building, which also uses the Tartan grid plan while applying the corner squares as servant spaces for the whole building and the internal, or service space, for work in terms of a free plan.

Case Study 2: The Richard Medical Research Building

Client: University of Pennsylvania, and dedicated to Alfred Newton Richard

Site: Philadelphia, Pennsylvania

Date: 1957-1965

Main material & structure: Brick, precast and post-tensioned concrete Vierendeel trusses

Design Concept:

The Richard Medical Building involved varies stages of design regarding servant spaces such that the stairs shafts were at first cylindrical and later square shapes, but then finally became rectangular. Also, the exhaust shafts evolved through several phases of design; at first they were narrow at the bottom and then became wider as they rose above the building. This was because Kahn believed that they must reflect "the varying volumes of exhausted air"; i.e. which shows that for Kahn form does not simply follow, but more critically, identifies with its function. Unfortunately, this feature of the building never was built because of the expense to the building. In the final design both exhaust and stair shafts were designed as rectangular towers (fig 4.13 & fig 4.17).

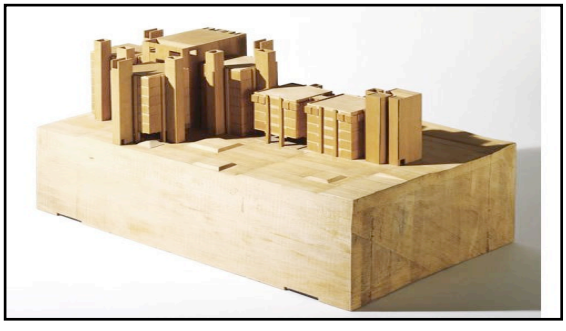


Figure 4.13: Model of the Richard Medical Research Building, which surrounded by Rectangular shafts.

Figure 4.14: Entrance at the Corner of the Building (Rosa, 2006, p.36)

Figure4.15: Entrance to laboratories (Left) and Biological laboratories (right)

(Brownlee & De long, 1991, p.176)

Figure 4.16: ground floor entrance showing Vierendeel trusses empty of servant services such as mechanical ducts (Brownlee & De Long, 1991, p.177)

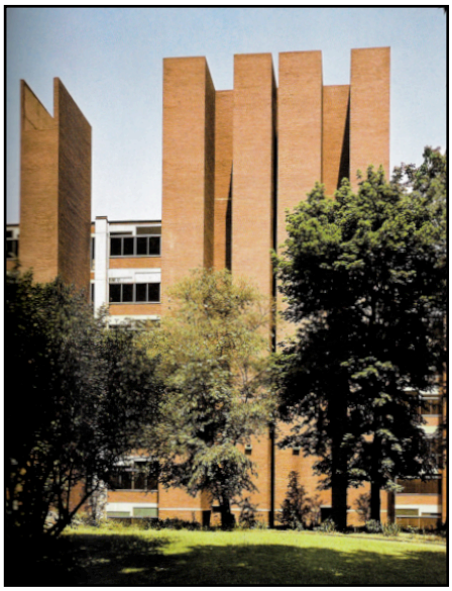


Figure 4.17: Richard Medical building's servant towers reminiscent of Medieval tower (Rosa, 2006, p.39)

Figure: 4.18: Biological laboratory's "building within the building" or carrel for personal reading area.

A: Servant and Service

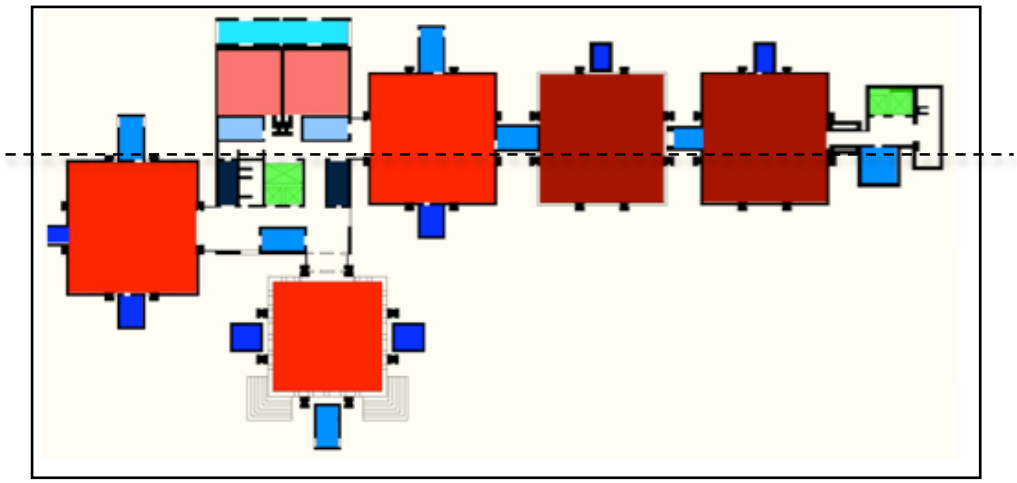


Figure 4.19: Richard Medical Building, Ground Floor Plan (Drawn by Author)

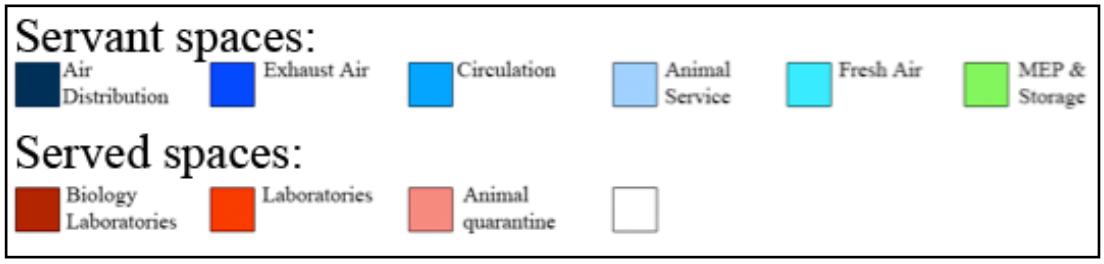


Figure 4.20: Servant & served spaces: the cool colors represent servant area and Warm colors represent served area (Drawn by Author)

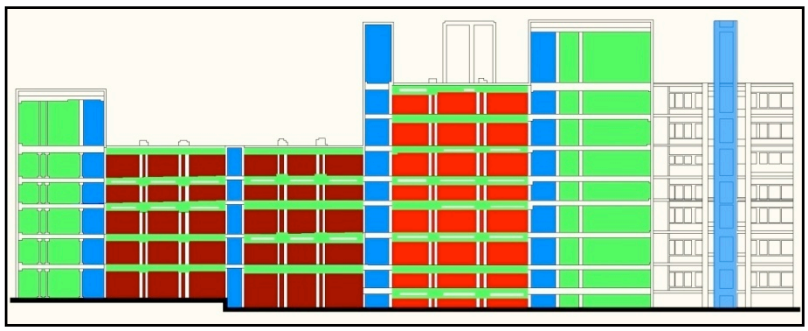


Figure 4.21: Richard Medical, Section (Drawn by Author)

This building shows how important the idea of servant & served spaces was for Kahn, because he divided the whole design in terms of servant areas and

Laboratories as served areas. As he stated “we have to divide the space into researcher’s quarters and servant’s quarters, as simple as that.”(Komendant, 1975, p.9)

B) Function and Geometry

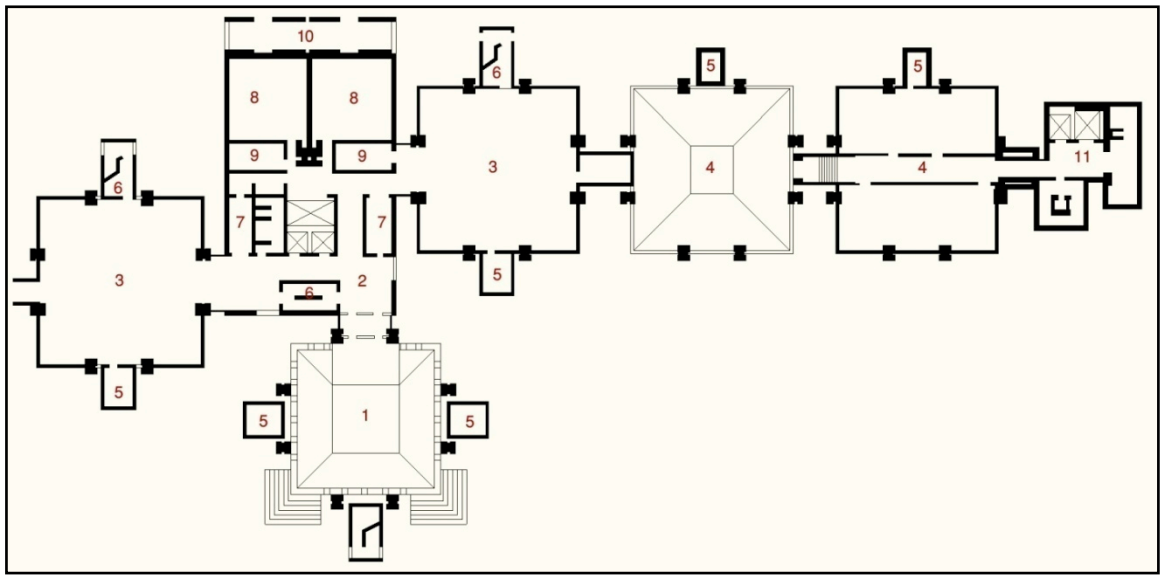


Figure 4.22: Richard Medical Building, Ground Floor Plan (Re-drawn by Author)

1) Entrance
2) Service Core
3) Laboratories
4) Entrance & Biology Laboratories
5) Exhaust air
6) Stairs
7) Air distributor shaft
8) Animal quarantine
9) Animal Service
10) Fresh air shaft
11) Stairs, storage and Other (MEP)

It was in 1957 when Kahn received the commission for the Richard Medical Research Building at the University of Pennsylvania. As usual Kahn started his conceptual design with squares; three individual squares for the laboratories, which were surrounded with stairs and exhaust stacks fig. (4.22). Kahn placed the laboratories at the exposed corners of the building to obtain better natural light and best views. In general, he placed the three laboratories service towers around a fourth servant tower in a pinwheel organization. The fourth tower was used as main servant area of the building complex, and contains of MEP utilities and research animal housing. Later he added two biology research laboratories (blocks #4 in fig. (4.23)) which were also square in plan. The construction started in December of 1958.

Kahn used the same precast structural system for all the buildings but the elements were visually heavier in the biological blocks. Since the latter's MEP requirements were less he only uses one exhaust tower for each biology tower. He placed the research library on the top floors of the biology towers, which represents his first conception of the "building-within-building". This idea was later used in the reading area in the Exeter Library, whereby large windows were used to give natural light to the whole library and small windows used to give natural light only for the reading carrels (the personal reading areas) (fig4.18).

C) Form and Geometry

As with his previous work, the Trenton Bathhouse, he used a similar group of pavilion forms with the double–axial pinwheel symmetry around the main core building. The geometry is a combination of linear and central additive forms that consist of a pinwheel with three square wings of laboratories around the main service core designed as additive rectangular forms. The vertical circulation and exhaust air shafts are servant towers which were added to the main square plan. These servant towers mimic the hollow columns of the Trenton Bathhouse but with a difference. They are not a load-bearing element of the building. This part of the building was constructed in 1957 and the two biology research labs were added in 1958 by applying the Golden Section proportioned system to maintain a unity of the whole (Fig 4.23). The whole building composition was made of same kind of precast structural elements, with small changes, and the geometrical structure was designed with careful attention to their proportion.

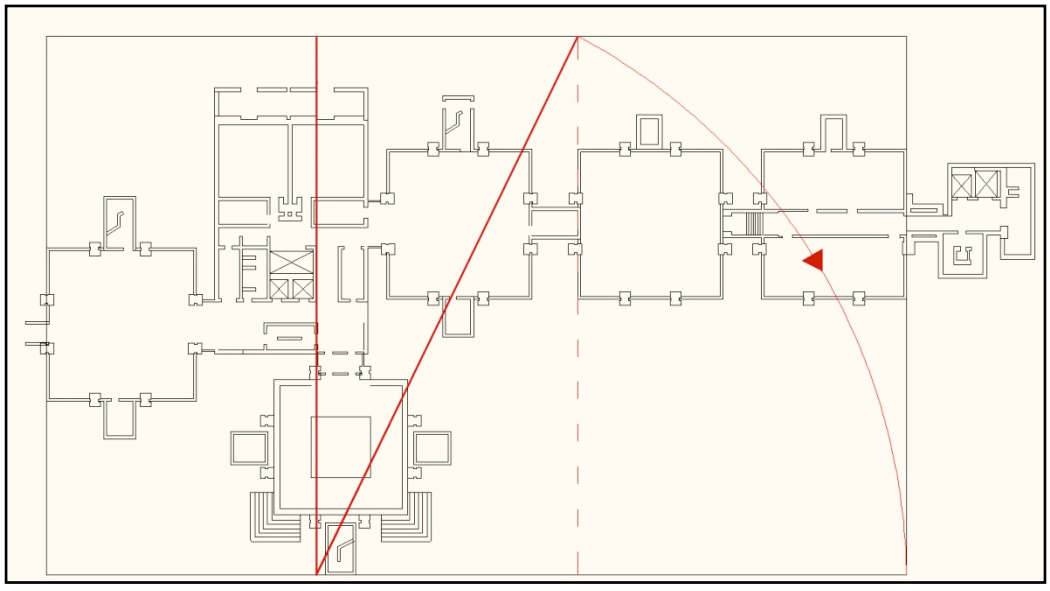


Figure 4.23: Richard Medical Center, Golden Section (Re-drawn by Author)

In the total complex each square lab has additional rectangular towers as ‘servant’ spaces for the laboratories as service areas. In general, every rectangular form around the edges of the building blocks is ‘servant’ spaces and all the square space forms are ‘served’ areas. For instance, the laboratories are square with their adjoining service tower being rectangles. Also, the main service core is a rectangle and in the interior of main service core every rectangular form represents servant spaces, as for example, the space for the storage of animals, while the animal quarantine areas are square forms.

The Influence of Frank Lloyd Wright’s Larkin building can be seen in its vertical brick stair and mechanical shafts and in the use of horizontal bands of glazing and brick. Also, there is a difference whereby the servant shafts are placed on the edge of Kahn’s building, while in Wright’s building they were placed at the corners.

D) Structure and Form

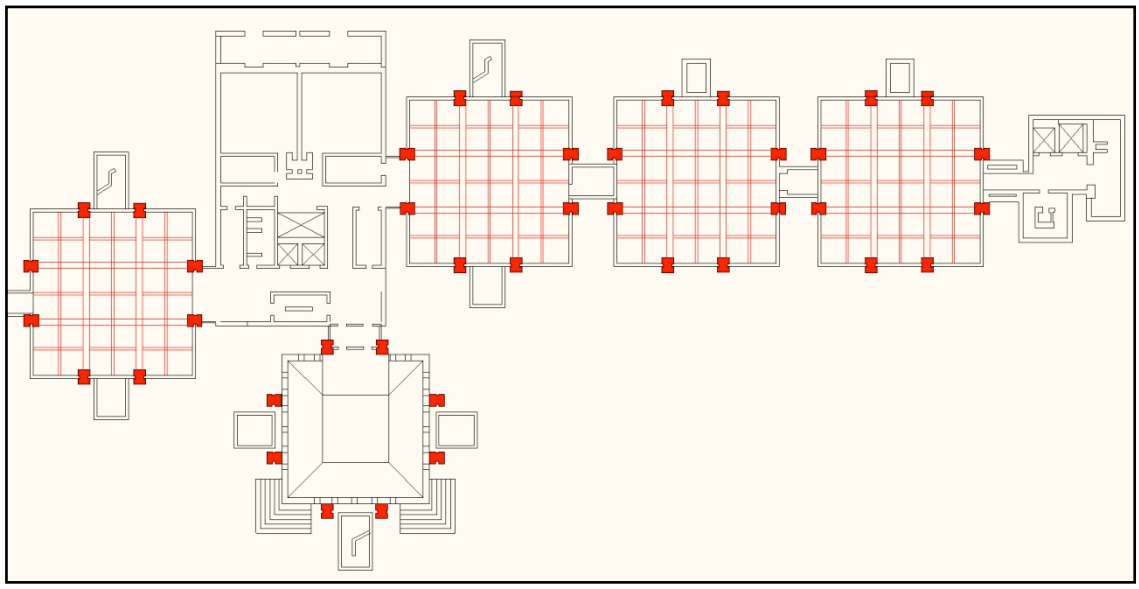


Figure 4.24: Structural Plan (Drawn by Author)

During construction of the Richard's Medical Research Building, the architect Eero Saarinen asked Kahn, "Lou, do you consider this building as an architectural or a structural success." Kahn answered him, saying "Your question is a valid one. The elements and their shapes, like the structure they form, evolve so logically from the architectural requirements that 'structure' and 'building' cannot be separated, the one evolves the other". (Komendant, A, 1975, p.19)

The building consists of precast and post-tensioned concrete Vierendeel trusses connected to a pair of columns on each side of building. This results in supporting cantilever spaces at the corners (fig 4.16). Kahn never wanted to have an entrance at the center of the building but rather, that people should enter from a corner. Also, in the central building he wanted to house all the mechanical units and place the ducting in the floors, which is why he choose thick Vierendeel trusses to achieve hollow

spaces below the floors. For this reason he used shear walls for service tower and pre-fabricated concrete columns for supporting the Vierendeel truss system. Because of the reduced bending moment towards the ends of the cantilevered spans, these beams step towards the corner of the floor slabs resulting in a thin profile at the cantilever corner and thickest at the columns (fig 4.16).

In order to make the structure economical Kahn did not reduce materials but he carved out unnecessary parts of structural elements; he carved out the center of each column to produce an "I" section (fig 4.15). Since the top and bottom edges of the beams take the most stress, therefore the middle can be carved out to form the Vierendeel beam-truss. This also applies to the cantilevered beam where most stress is near the support, so that the end of each cantilevered truss is reduced.

Since there are no steel lintels or arch or stone trim, then the brick walls look like curtain walls (fig 4.14). The brick surface has few openings filled by glass. The towers consist of cavity walls with concrete block on the inside and brick on the outside.

This was the first time Kahn used pre-cast concrete, which is his most structurally expressive building. He referred to this structural texture as the "knuckle and joints" of the Vierendeel trusses, which when exposed helps to understand the logic of this advanced technological form. For instance, it is easy to understand why he made the stepped truss at the corner of the Vierendeel truss system in order to conform with the bending moment as it decreases towards the cantilevered corner. Another advantage of the Vierendeel trusses system, for Kahn, was what he was able to place all MEP systems within the structure throughout the laboratories. Kahn, in this way,

exposed the servant systems at work. However, he leaves entrance's structural space empty of MEP because this is not a work area or laboratory. At the entrance he only shows the building's structural skeleton which provides a preview of what is to come on the laboratory floors (fig 4.16). This was the first and last time Kahn exposes the servant spaces so completely.

E) Details:

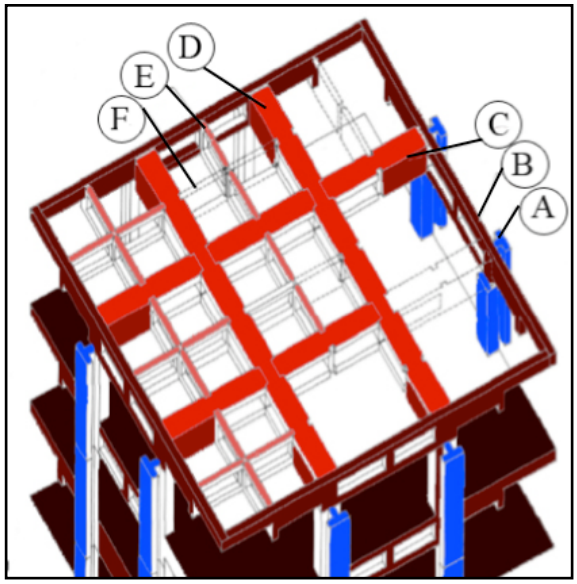


Figure 4.25: Structural Detail (Re-drawn by Author)

A) Precast concrete column

B) Precast pre-stressed edge truss.

C) Three-part post-tensioned truss with three post-tensioning rods. Despite the symmetrical structural arrangement of the system and the fact that in the finished structure the main trusses appear identical; the method of construction differs with orientation

D) One-piece main truss with twelve pre-stressing strands in the top flange and twenty-eight pre-stressing strands in the bottom. These receive a slightly greater pre-tensioning stress to carry the three-part trusses until they are post-tensioned

E) Secondary trusses 34 cm long. The secondary trusses serve no structural purpose other than to support the pipes and ducts.

F) Secondary trusses 15.4 cm long (Ford, 1996, p.313).

The stepped truss at the corner of the Vierendeel truss system, was decreased in accord with the bending moments as it goes towards the cantilevered corner, which is design in the same manner as with natural forms such as trees i.e. a trellis pattern. Features of the structure such as this pattern help Kahn to integrate the form and structure in this building.

Figure 4.26: MEP Detail (Re-drawn by Author)

G) Main supply and returned ducts.

H) Air supply duct.

I) Air return duct

J) Exhaust air duct. Only a small portion of the ductwork is located in the towers (Ford, 1996, p.313).

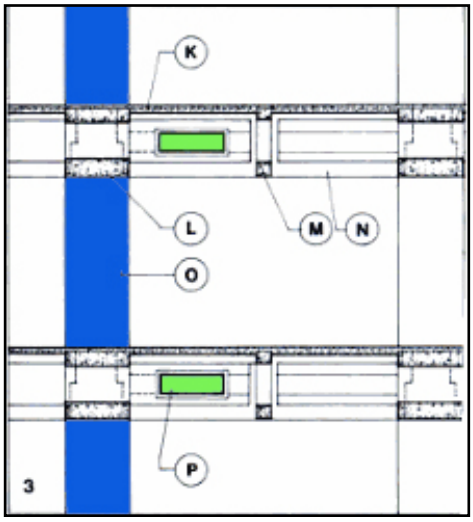


Figure 4.27: Section Detail (Re-Drawn by Author)

K) 10 cm cast –in-place slab.

L) Precast beam

M) Small nonstructural beam to hold ductwork

N) Beam in elevation.

O) Precast post-tensioned columns.

P) Supply air duct (Ford, 1996, p.313).

The integration of structure and servant functions is most evident in the details and this is representative of the total unity of structure, function and form of the building.

F) Summary

Kahn applied the concept of 'servant and served' spaces to each of his buildings. For example, there is no need for servant functions in the ceiling of the ground floor entrance area, so that the structure is empty of MEP hardware. Also, in all of the

servant towers (stairs, exhaust shafts) the spaces are empty of MEP and stair system (providing for flexible planning) because circulation, for Kahn, was a servant space by itself.

This was Kahn's first use of a post-tensioned, pre-fabricated concrete structure. He worked with the engineer August Komendant, who eventually had worked with him for eighteen years. Kahn always consulted his engineer at the beginning of projects in order to acquire structural knowledge for the best possibility of integrating structure/form/function.

Kahn, by using precast members in this building, introduces a principal innovation for constructing multistory concrete building in the U.S.A. It was for the first time that architects and engineers understood how to use the advantages of "precast, reinforced, and pre-stressed concrete members in a multistory rigid-frame building". (Komendant, 1975, p.11) This changed the market for precast materials, which until then was limited to structural steel or poured-in-place concrete construction. In this kind of construction Vierendeel trusses and pre-cast columns were assembled in sections by post-tensioning for rigidity and without welding.

The Richard Medical Building was Kahn's first building to receive international praise. But ten years later he stated that "if the world discovered me after I designed the Richard Towers building, I discovered myself after designing that little concrete-block bath house in Trenton" (McCarter, 2005, p.122).

Case study 3: The Phillips Exeter Academy Library

Client: Exeter Academy

Site: Exeter, New Hampshire

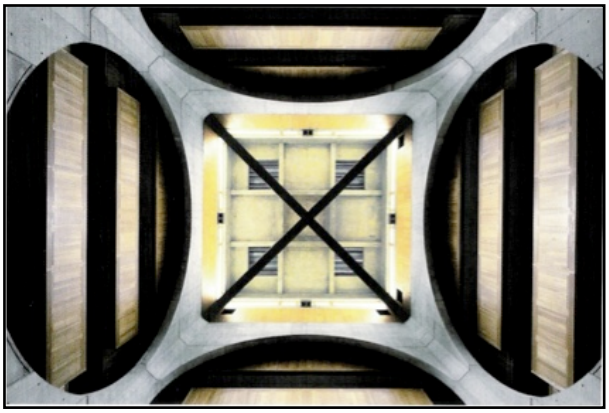
Date: 1965-1972

Main material & structure: Brick, reinforced concrete

Design Concept:

The Exeter library consists of a great central space, which provides a gathering area which symbolizes a vital aspect of social 'institutions'. Kahn wanted to design a modern building that would offset the historical character of the other campus building at the Exeter Academy, which resulted in a design of elegant proportions that are timeless (i.e. monumental) in character. He achieved this by using brick for the exterior reading areas surrounding the central gathering space and archives. But since the library has most of the dead loads consisting of archives, around central multi-level open space, the traditional material brick couldn't handle the archive's dead loads. Therefore, Kahn used a concrete load bearing system as an inner structure of this 'doughnut' building form and brick load-bearing as an exterior enveloping system, which also appears like a curtain wall. In this way, Kahn used structural forms and materials from both Modern and Ancient architecture (fig 4.28 & fig 4.30) so that the result is the "Building-within-a-Building" concept. A concept which he already applied with the Richard Medical Building for the library and study carrels (fig 4.18).

Figure 4.28: Exterior of Philip Exeter Library although the building is eight-stories high, it appears as only a four-story building. (Rosa, 2006, p.76)



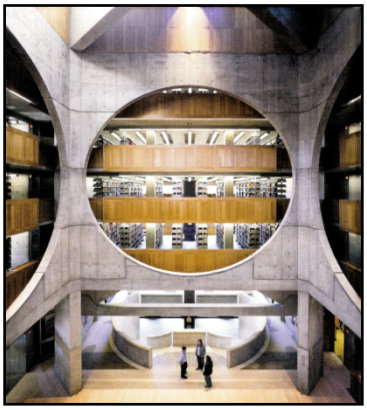


Figure 4.29: The view across the central hall showing book shelve or archival area, which is supported by concrete columns and load bearing wall with crossing roof beams above. This central space is lit on all four sides by clerestory windows, which is connected by The X-shape concrete bracing roof. (Rosa, 2006, p.74)

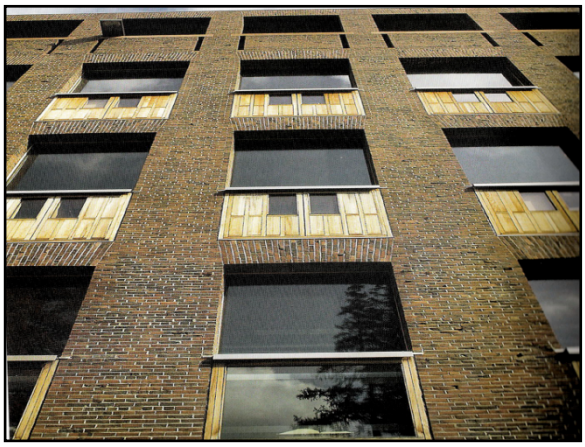


Figure 4.30: The façade of the Exeter Library, showing the decreasing the brick exterior columns as they rise, reflecting their diminishing structural loads. (McCarter, 2005, p.310)

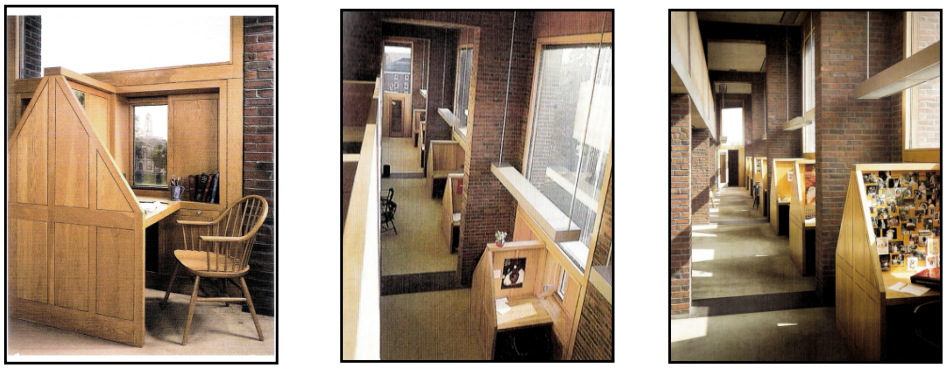


Figure 4.31: Double height reading area or Carrel (Rosa, 2006, p.76 (Left) & McCarter, 2005, p.319)

A) Servant and Service spaces

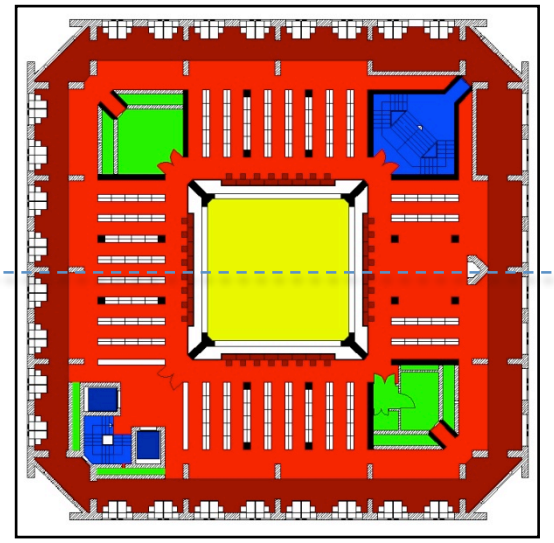


Figure 4.32: Exeter Library, Third Floor Plan (Drawn by Author)

Figure 4.33: Servant & Served spaces; Cool colors (except yellow) represents servant spaces, while warm color represent served spaces (Drawn by Author)

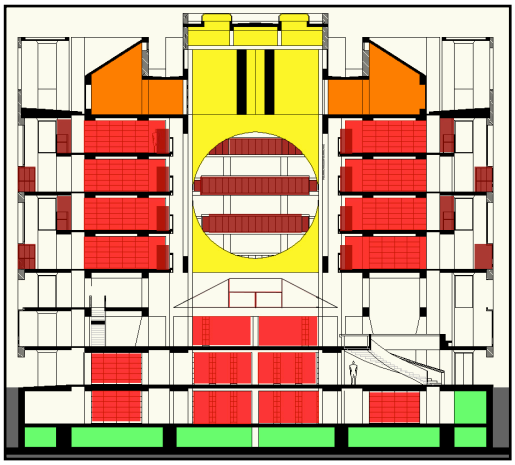


Figure 4.34: Exeter Library, Section (Drawn by Author)

B) Function and Geometry

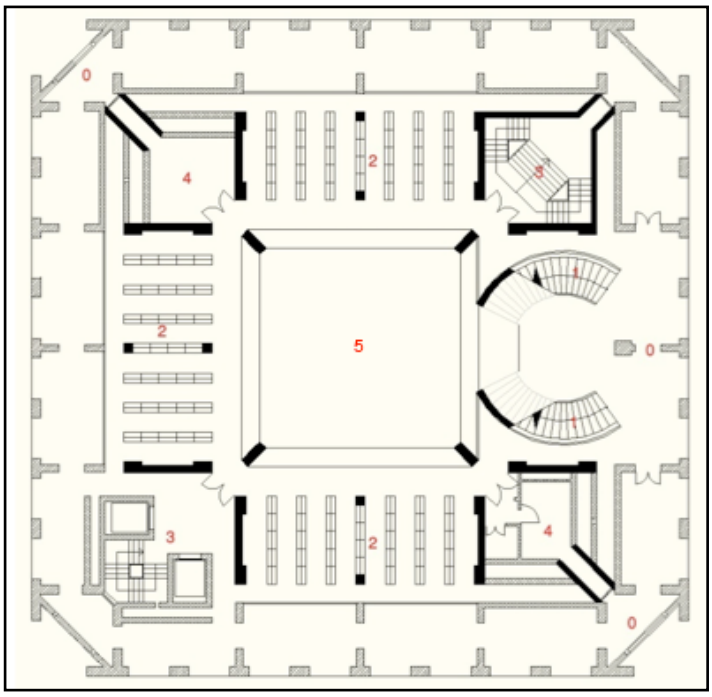


Figure 4.35: Exeter Library, Ground Floor Plan (Re-drawn by Author)

0. Entrance
1. Main stairs
2. Book shelves
3. Stairs and elevators
4. MEP
5. Central Hall

Kahn simply divided the building into three parts, which includes the reading area, the archives bookshelves area and the servant areas, which includes circulation, storage, and MEP utilities.

C) Geometry and Form

Kahn's geometry begins with a double axial symmetry applied to a square. This square represents the innermost part of a doughnut organization, and each quarter of this inner square then becomes the basis of a grid module (Fig4.36). Then, he further divided this building plan into four equal squares, constructed by the ratio of the Golden Section (See Appendix A). This results in shaping the concrete platform that rings the open inner space that becomes the library floors of the Library (Fig 4.37).

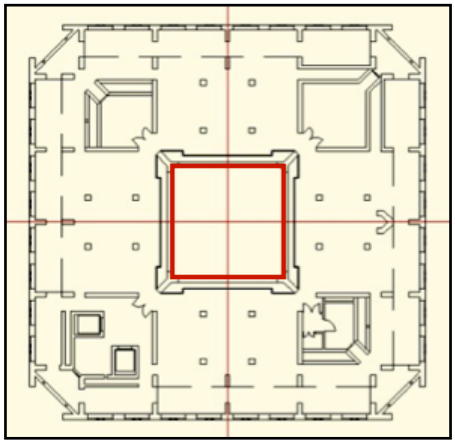


Figure 4.36: Starting with Square Geometry (Drawn by Author)

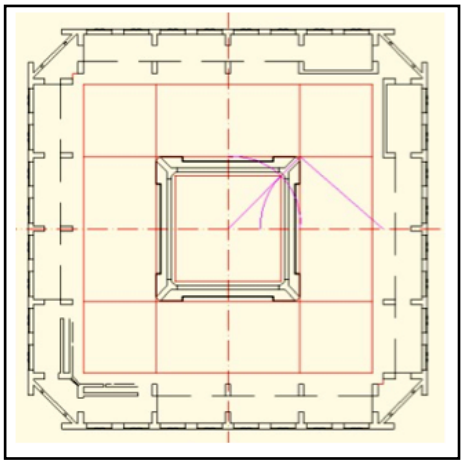


Figure 4.37: Golden Section 1 (Drawn by Author)

For determining the dimension of the inner archival ring he used the same Golden Section to create another center square (Fig 4.38). At this stage it becomes clear why the four columns, on the diagonal are rotated 45 degree, and how he determines their span. The gallery area which was already divided into the 16 equal squares (fig. 4.38) consists of four corner squares (fig. 4.39) that became the servant spaces housing stairs, elevators and MEP utilities.

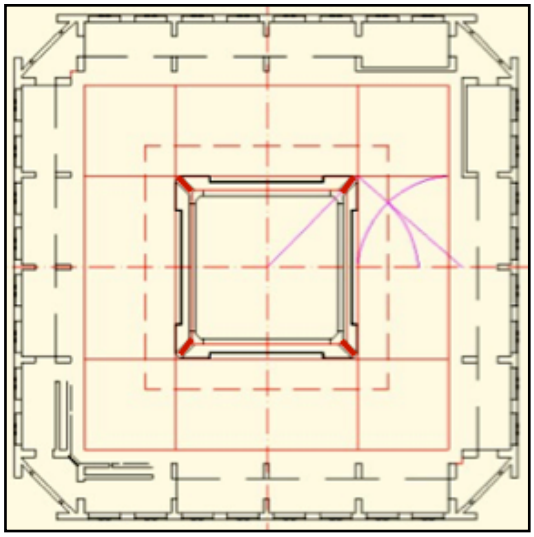


Figure 4.38: Golden Section 2 (Drawn by Author)

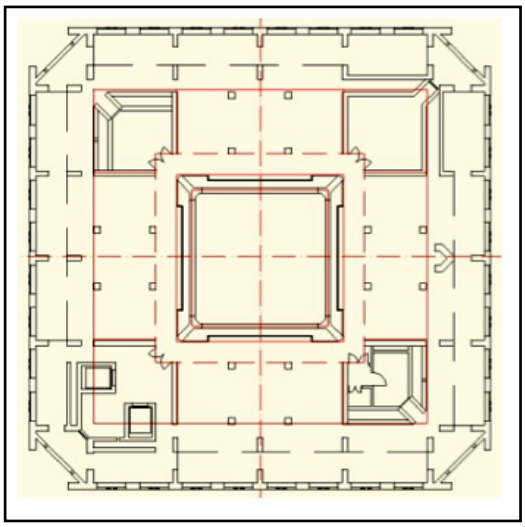


Figure 4.39: Four-servant area (Drawn by Author)

The exterior wall location and dimensions derived from an arc of a circle drawn from the center of the primary square and with a diameter of twice the central hall's square of the library (Fig 4.40). All interior columns are placed in a cruciform pattern between the servant areas (Fig 4.39). In this way the whole building develops outwards from the center and by a geometry that is proportioned and not measured.

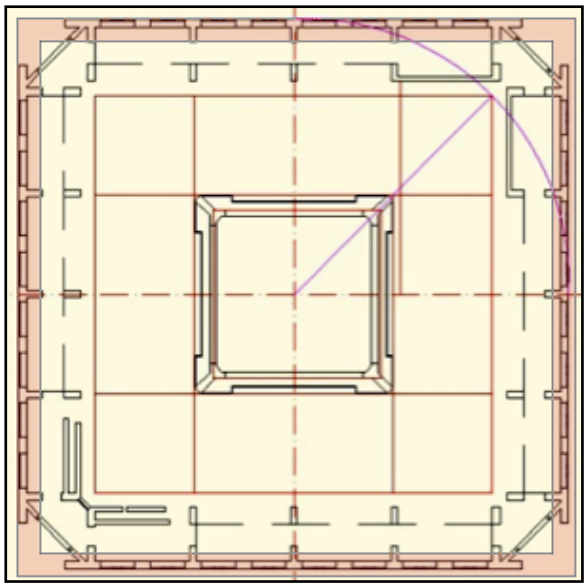


Figure 4.40: Exterior Brick Wall (Drawn by Author)

D) Structure and Form:

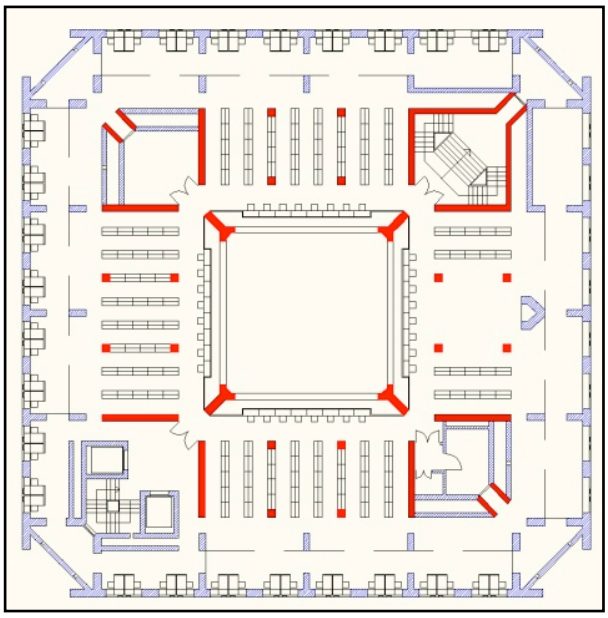


Figure 4.41: Blue hatch showing brick and red showing concrete structure (Re-Drawn by Author)

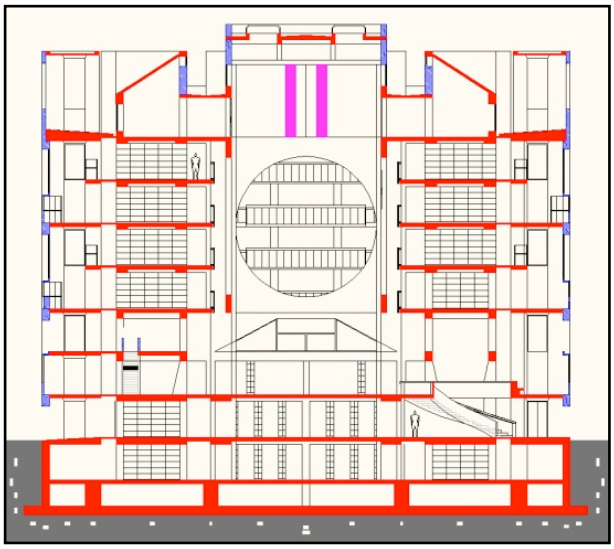


Figure 4.42: Section , blue hatch showing brick, red concrete, and pink showing concrete skylight bracing (Re-Drawn by Author)

The basic structure and material that Kahn used in Exeter library was similar to some of with his previous work, such as the Rochester church. The form and structure relationship consisted of a masonry space on the exterior, and an open Modern concrete-framed space on the interior.

Also, the order of space in Exeter is same as the Rochester church; i.e. in the way that they both consist of a central ring of reinforced concrete load-bearing structure and an enveloping ring of brick load-bearing system that Kahn describes as 'doughnut' form-plan. In the Library, the innermost space is a 9.5 meters cube, as atrium volume, with circular openings subtracted on each side of the atrium walls (fig 4.29) & (fig 4.43). The skylight above is supported and spanned by cross braced concrete beams which are one story deep (fig 4.43 & fig 4.44). In theory, this structure also provides lateral support for the whole building, acting as shear brace structure; "At a glance it seems somewhat structurally excessive for an eight–story building, and perhaps owes more to desire for structural expression than to structural necessity" (Ford, 1996, p.321).

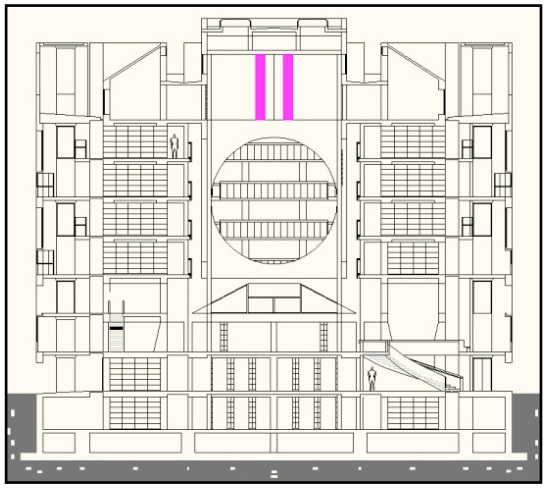


Figure 4.43: Pink showing bracing concrete beam for bracing central hall and supporting the sky light (Re-Drawn by Author)

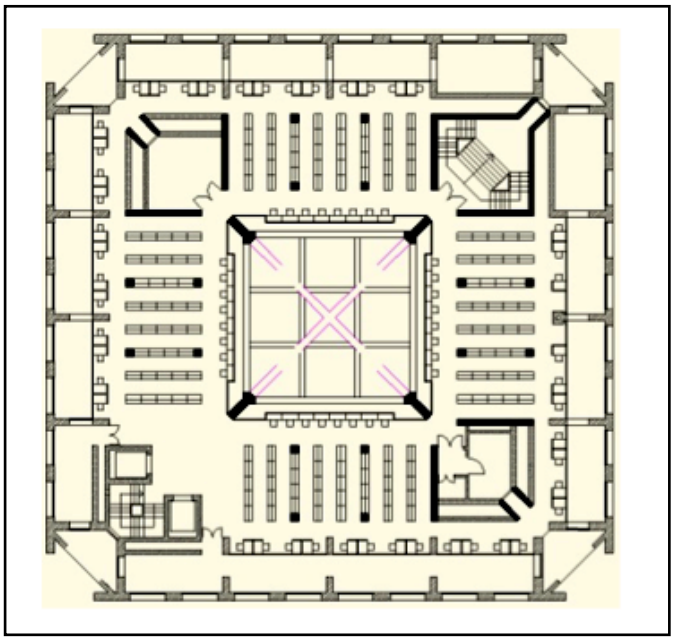


Figure 4.44: Purple dashed line showing diagonal bracing (45 degree). (Re-Drawn by Author)

The reinforced concrete inner doughnut layer consists of concrete flat plates that house the books, and are supported by 4 concrete columns in a square bay between the servant spaces. A total of 16 columns and bearing walls support the concrete plates (fig 4.41) so that "On the ground floor this area is used for the circulation desk, card catalogue and a grand stair, and the 3 square bays on each side are merged into one by means of eliminating the two center rows of columns (Fig 4.45). This requires a transfer structure at the second floor to pick up the load of the lost columns. Here the concept of one structure for one space is carried to extreme, if not excessive limits" (Ford, 1996, p.321).

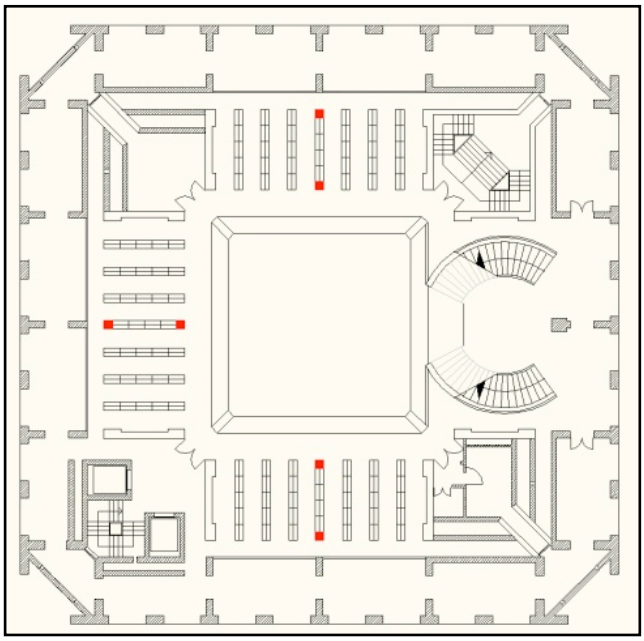


Figure 4.45: ground floor plan showing reduced columns from 12 to 6 for having more space (Re-drawn by Author)

The outer layer of the doughnut is composed of brick bearing walls that support a flat-plate concrete slab of the outer reading areas. This outer doughnut is divided into a series of rooms by brick cross walls that are also used for lateral bracing (fig 4.45). Each of these rooms contains two windows and four built-in carrels (fig 4.31).

The outer walls are composed of two layers, an outer layer of 30cm thick brick and block bearing wall, and a non-load bearing brick wall on the inner layer which looks like a curtain-wall but acts like a rain screen. The cavity between holds insulation, vapor barrier and waterproofing like a traditional cavity wall section; " the outer wall is bonded in a pattern resembling the common bond, while the inner wall, being only one brick thick, is in simple running bond" (Ford, 1996, p.323).

Kahn believed that each person who stands in the space must perceive the structure of the space. For example, the brick wall decreases in width on the outside as it rises.

Each pier is one brick wider than one above, which makes them appear like Egyptian Pylons (fig 4.30). The voids between the piers on the facades are filled with wood panels, and are not brick, in order to show that they are non-structural.

E) Details

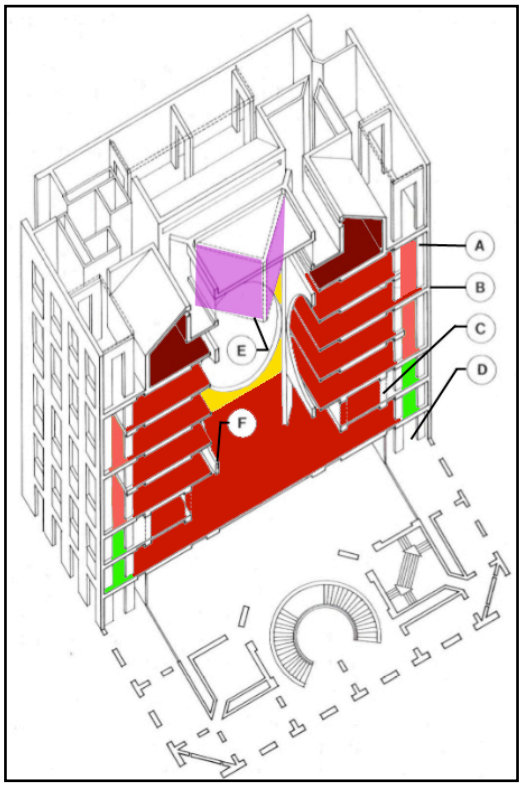


Figure 4.46: the space between interior concrete slab and exterior brick wall in first floor and Second floor is used for servant area which includes storage and MEP utilities (Ford, 1996, p.326)

A) Exterior Masonry wall and cross walls supporting 22 cm flat-plate concrete slab on brick and concrete masonry bearing wall

B) Concrete slab with 30 x 75 cm beams and 45 X 45 cm concrete columns in stack area

C) Transfer structure to allow desk and catalogue area to be free of columns

D) Open air gallery at ground floor. The structure is also open to the weather at the top

E) Diagonal bracing at top of central space.

F) Concrete pier and diaphragm wall with circular opening (Ford, 1996, p.327)

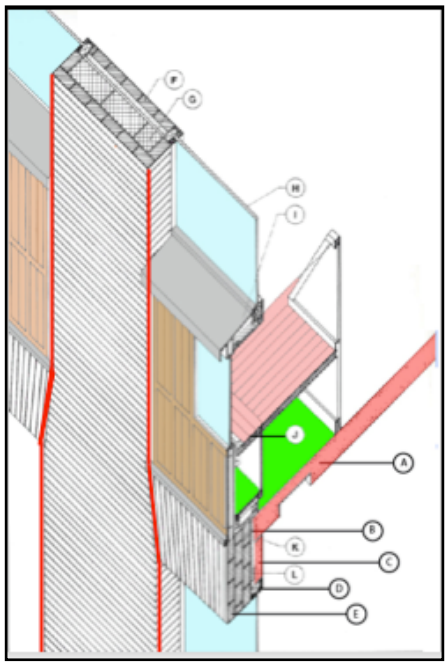


Figure 4.47: Detail of decreasing exterior column as it rise and Carrels (Ford, 1996, p.326)

A) Concrete slab with slot for light fixture.

B) Anchors 30 cm to tie arch back to continuous fit together anchor slot in concrete slab.

C) Sandstone lintel

D) Teak and oak window frame with flashing to divert water out of cavity

E) Brick Beam

F) Inner wall of 10 cm brick with cavity filled with 3.8 cm rigid insulation fastened to 1.9 cm galvanized furring channels.

G) Brick- masonry exterior column.

H) 2.5 cm insulating glass

I) Stainless steel sill on wood frame to drain water off horizontal surface

J) Carrel of 2.5 cm teak boards, 2.5 cm rigid insulation, 1.9 cm oak plywood, and 1.25 insulating glass

K) Compressible filler to ensure that the slab does not beat on lintel

L) Flashing to drain water from cavity to exterior (Ford, 1996, p.327).

As explained above, Kahn used different materials for integrating structure and form; that is, by using a brick wall to create his "building-within-building" or library study area adjacent to the windows. He used small windows under large windows to personalize the carrel as it appears in figure (4.47). The exterior brick columns decrease in size as they rise to reflect how load transfers from the top floor to the ground. In these details are shown the integration of function, form and structure which again is consistent with unity of the total work.

F) Summary

Since Kahn believed that books are literally priceless, as he said, "A book is tremendously important. Nobody ever paid for the price of a book; they only paid for the printing" (Kahn, 1972, p.290). Therefore, he designed this building not only as library but as a sacred place; he designed this building in two quite distinct and separated spaces, as he claimed, "One for people, one for books". He also believed that the "books and the reader do not relate in a static way" (Kahn, 1956, p.69). These ideas supported the main principles forming this building; books placed on the concrete floors and readers placed on brick supported double-height floors near the natural light (fig 4.31).

Case study 4: The Kimbell Art Museum

Client: Mr. and Ms Kimbell

Site: Fort Worth, Texas

Date: 1966-1972

Main material & structure: Reinforce Concrete cycloid vaults, Travertine

Design Concept:

As one of the greatest works of Louis Kahn, the Kimble Art Museum is an integration of many of his architecture conceptions such as, the "Archaic and Modern, Mass and structure, light and shadow, the poetics of action and construction" (McCarter, 2005, p.338). This building was the last completed building that Kahn saw before he died in 1974. Kahn's design for the Kimble Art Museum was developed from his early work such as the Trenton Community Center, where all spaces had been defined by the structural form of the overhead roof. In the Kimbell he designed various geometries for vault forms before his final design, which was the curved section as a cycloid vault. Richard Brown (director of Museum) chose Louis Kahn among other architects including Marcel Breuer, Mies van der Rohe, Pier Luigi Nervi, Gordon Bunshaft and Edward Barnes.(McCarter, 2005, p.338)

Figure 4.48: Kimbell Art Museum

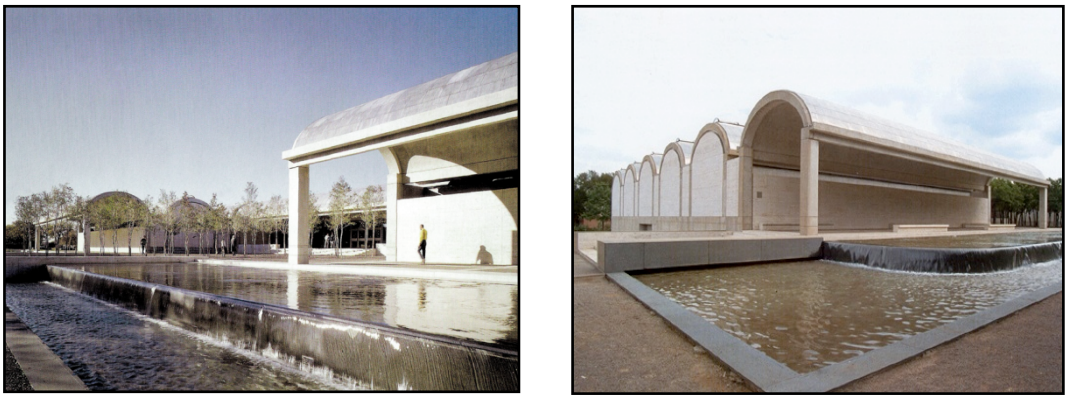


Figure 4.49: Kimbell Art Museum's portico (Rose, 2006, p.81)

Figure 4.50: The Cycloid vault and sky light between (McCarter, 2005, p.359)

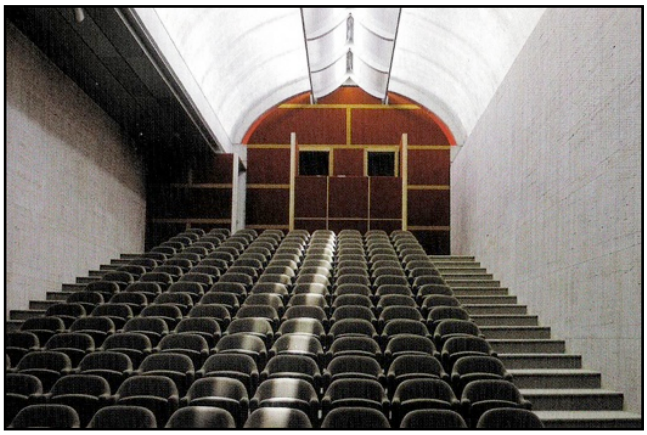


Figure 4.51: Auditorium (Rosa, 2006, p.82)

Figure 4.52: Exterior and interior of cycloid vaults, showing using glass between wall and vault to indicate the non-load bearing cycloid vaults. (McCarter, 2005, p.350)

Figure 4.53: Conservator court yard and south courtyard (Brownlee & Delong, 1991, p.278)

Figure 4.54: light-well (Brownlee & Delong, 1991, p.278)

A) Servant & Service Spaces

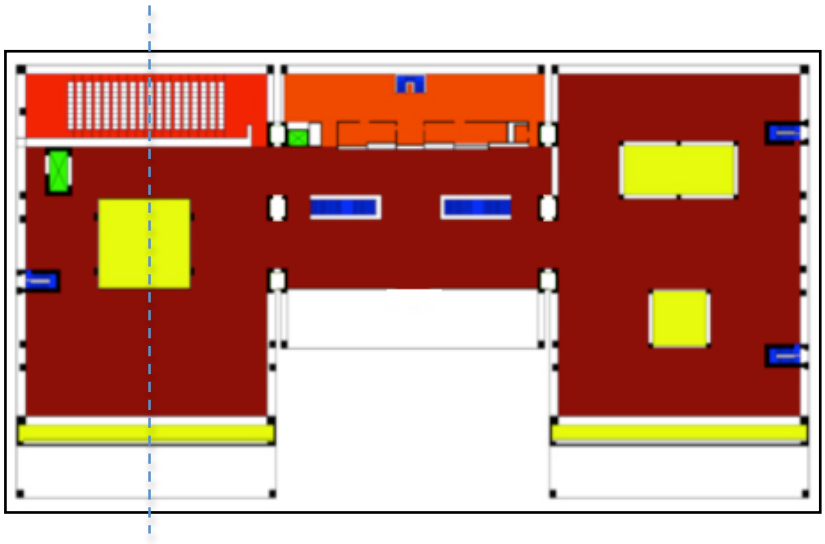


Figure 4.55: Kimbell Art Museum, Ground Plan, (Drawn by author)

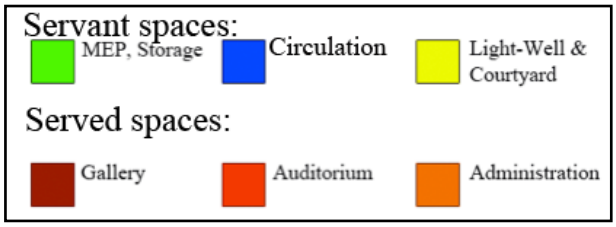


Figure 4.56: Servant & Served spaces, cool color (except yellow) represent servant spaces while warm color represent served spaces (Drawn by author)

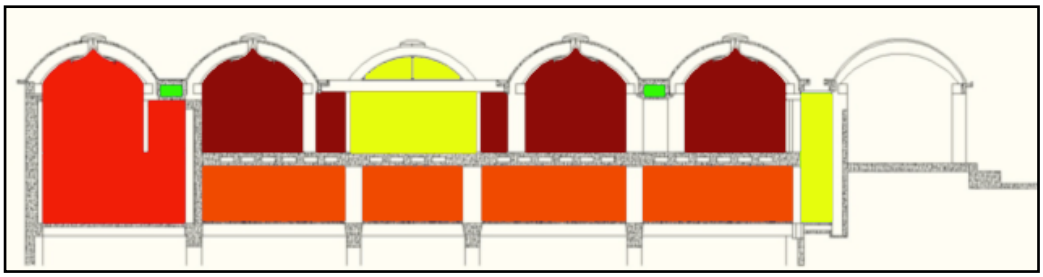


Figure 4.57: Kimbell Art Museum, Section (Drawn by author)

Kahn in this building, unlike his previous projects, placed his servant area only in horizontal spaces between the connections of the vaults.

B) Geometry & function:

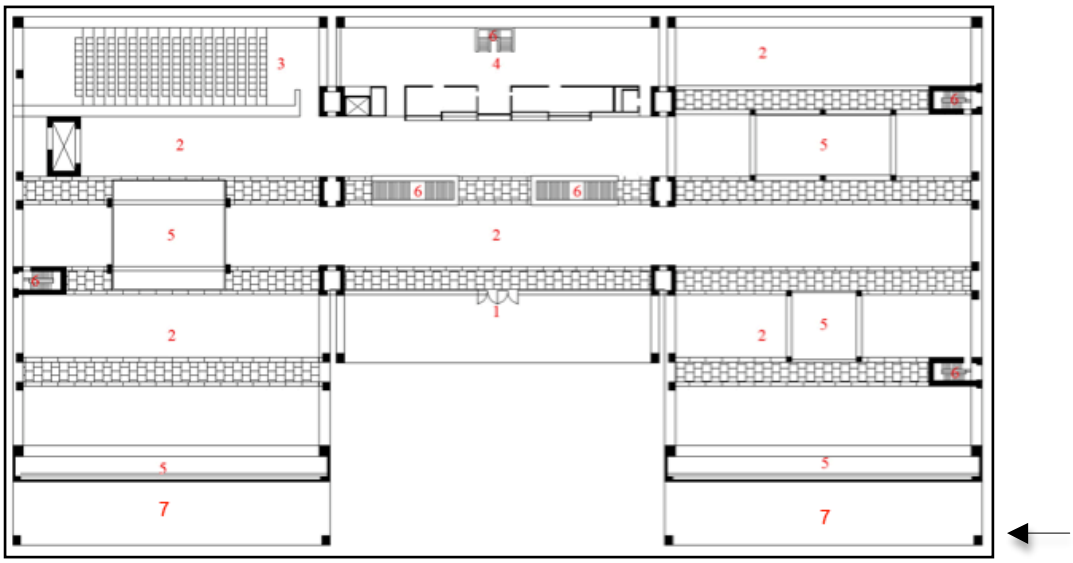


Figure 4.58: Kimbell Art Museum, Ground Floor Plan (Re-drawn by author)

1. Entrance
2. Gallery
3. Auditorium
4. Administration
5. Courtyard and Light-well
6. Stairs
7. Porticos

The Kimbell Art Museum consists of the thirteen vaults, each 30 meters long and 7 meters wide. They are 6 meters tall from floor level and 3.8 meters from floor to spring point of the vault.

The complete gallery consists of two courtyards and three light-wells; one courtyard is an 11 meters square court in the center of north gallery, which is glazed four sides.

A second courtyard is 7 meters square and is located in the south wing, which is glazed on only the East and West facades (Fig 4.53). One light-well is 7 X 14 (double-square geometry) meters and also located in the southern wing while the other two light-wells are each 30 meters long by 2.1 meters wide and located between the entry porticos and galley on the West façade (Fig 4.54).

C) Geometry and Form

As with previous projects above, also in the Kimbell Art Museum Kahn started with the square, but this time he aligned double squares to create a rectangle (Fig 4.59). By layering these two squares slightly he produced an overlap for the served spaces (the width 'O' in figure (4.60)) between the roof vaults of the building as shown in the symmetrical arrangement of the staircases, represented by rectangles, in figure (4.61).

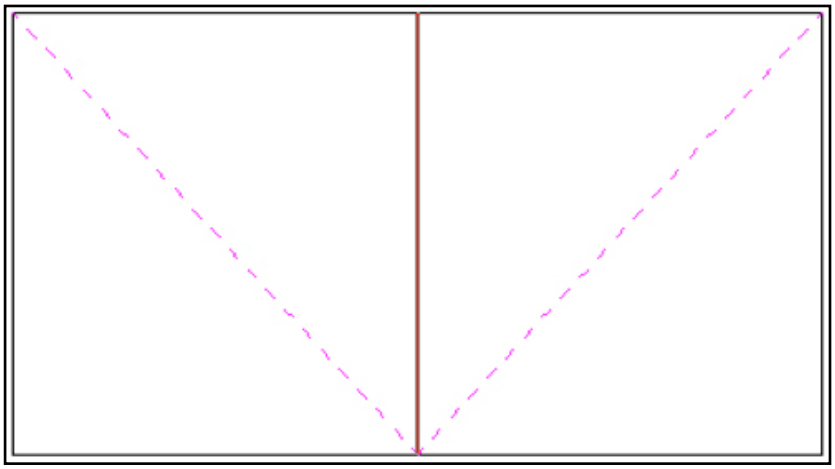


Figure 4.59: Double Square Area. (Re-drawn by Author)

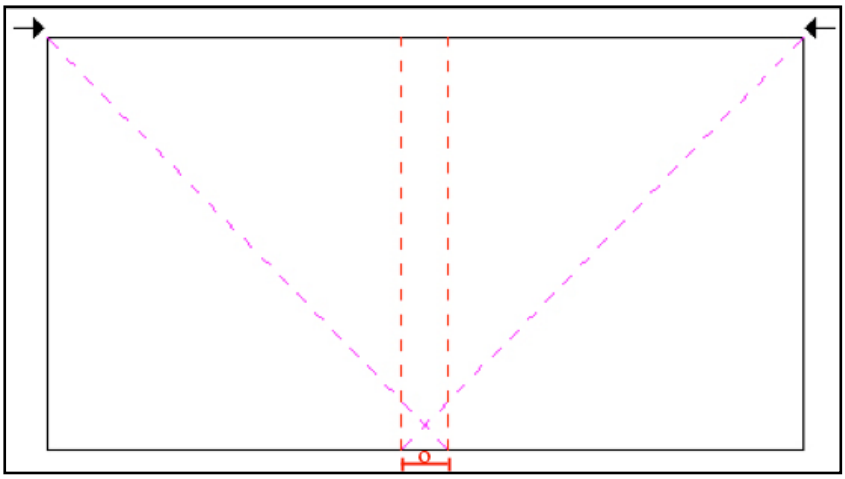


Figure 4.60: Layered Squares with Overlap Distance 'O'. (Re-drawn by Author)

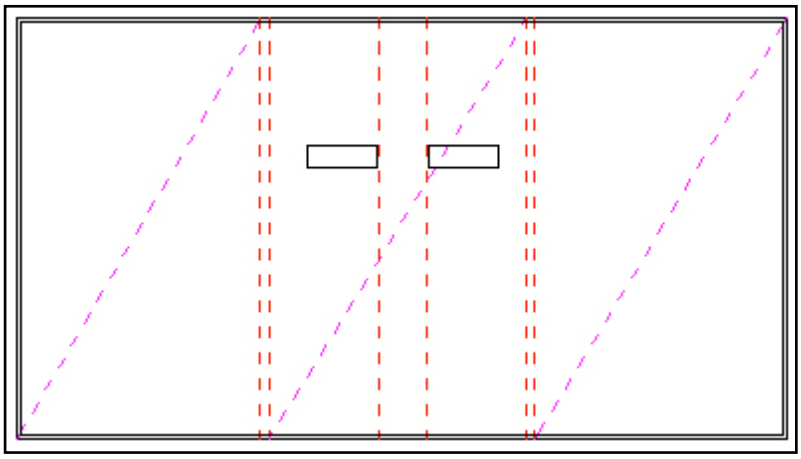


Figure 4.61: Symmetrical Stairs Represented by Rectangles. (Re-drawn by Author)

Then the building was divided into three main parts which fixed the structure, see fig. (4.61). In these three parts by situating central transverse rectangles, symmetrically on each side of the middle rectangle, in a the ratio of 1:1.618 or the Golden Section (See Appendix A), then the space between the narrow rectangles creates an open space providing for the entrance of the building (fig 4.61). In addition the reflected ceiling plan of the gallery space begins with a double square allowing for three golden-section spaces. These three areas are further divided into equal bays of a width provided by the overlap dimension 'O' in figure (4.60). As a result of this distribution the remaining areas between the service areas become servant spaces; i.e. 0.9 meter servant spaces between vaults which provide for the mechanical ducts (Fig 4.62)

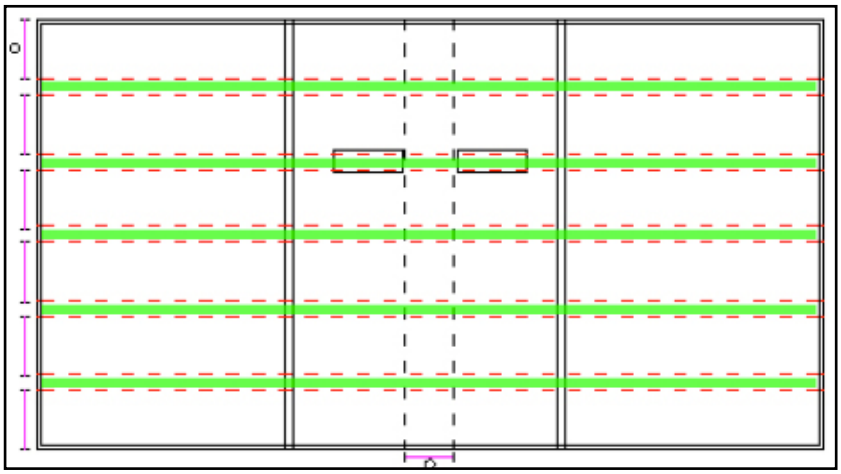


Figure 4.62: Reflected Ceiling Plan. Dimension ‘O’ applied to determining Width of Cycloid Vault and Resulting Width of Servant Areas. (Drawn by Author)

This geometry of service/servant spaces fixes the structural span for the cycloid vault shell structure, which shapes the interior. With this complete the building now acquires its final outline whereby both outside and interior areas are reduced by one vault element. This results in a design with a u-shaped entrance courtyard and two adjacent semi-open vaulted porticos, figures (4.63) and (4.49).

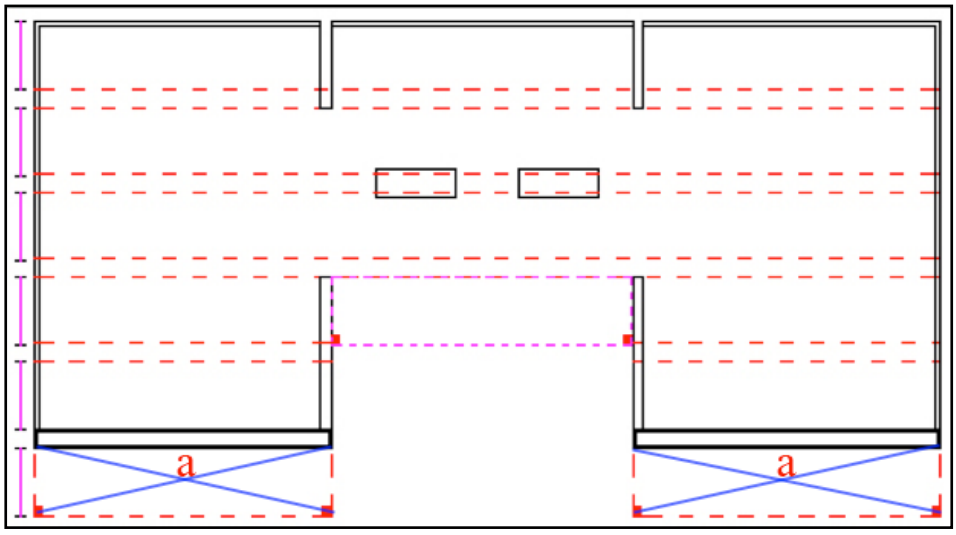


Figure 4.63: Central U-shaped Courtyard and Vaulted Porticos ‘a’. (Drawn by Author)

Also, light-wells are arranged symmetrically about the courtyard at the front of the building, while the rear area includes the administrative (‘a’) in the middle area and an auditorium to the left (‘b’), (fig 4.71). Each of these functions synchronizes with the width of a vault element plus the servant area’s strip, which also includes the light-wells (‘c’).

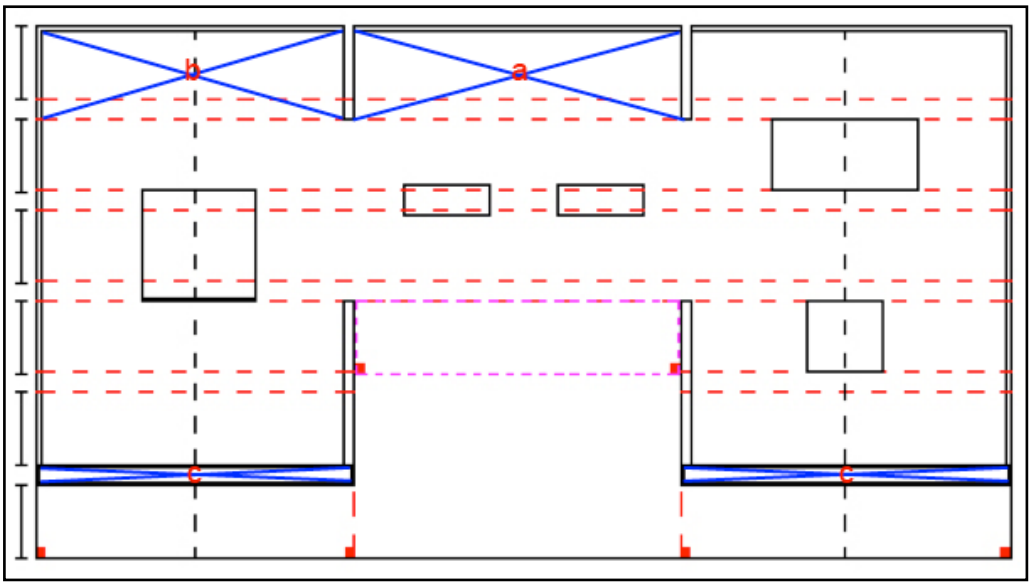


Figure 4.64: (Drawn by Author)

D) Structure& Form:

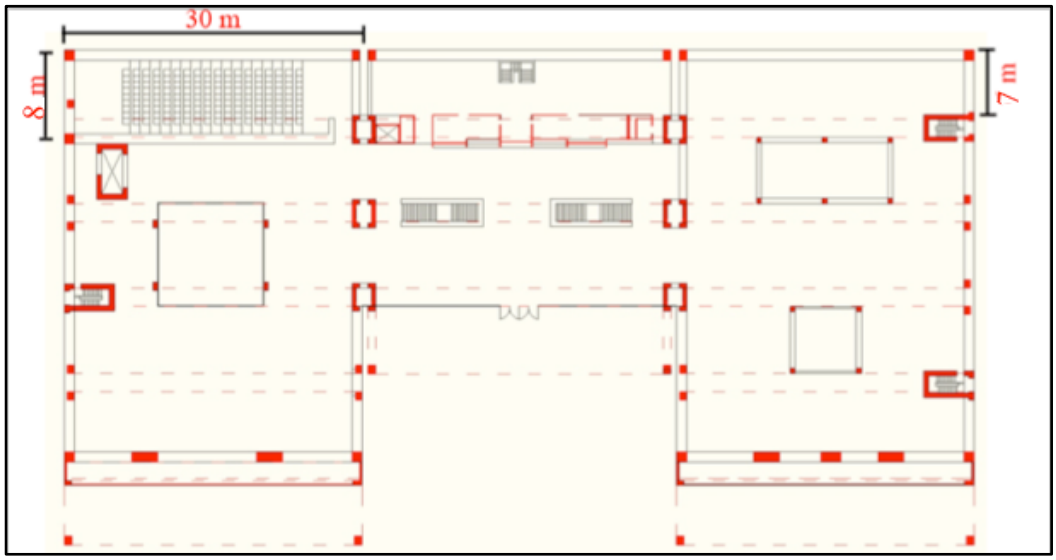


Figure 4.65: structural plan (Drawn by Author)

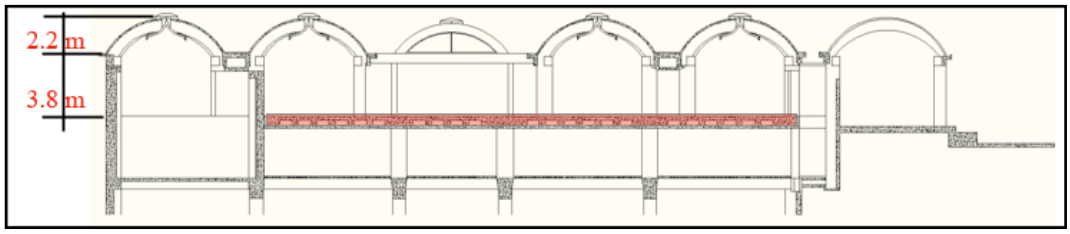


Figure 4.66: Section, showing hollow slabs (Drawn by Author)

The gallery's structure consists of a "lightweight, double skin, pre-cast concrete floor system". This is a system with a space in-filled with sound-deadening foam which, reduces the number of columns for the service floor by lightening the dead load (fig 4.65 and fig 4.66).

Each cycloid vault is constructed as a "post-tensioned cast-in-place reinforced concrete" element which spans 30 meters in length and is 7 meters wide and 6 meters tall from the floor (2.2 m from the spring point of the vault). Each vault is supported

by 0.6 meters square concrete column at each corner, with a 6 meters space between them (fig 4.65). The end of the vault "is stiffened by diaphragms at either edge beam along its side, as well as the flat concrete slab between the vault (where they meet the outer edge of the building and at the court yards and light wells)" (McCarter, 2005, p.349).

The east and west exterior walls are cast concrete but they do not support the vault, and for this reason Kahn separated the vaults from walls by creating 15 cm "horizontal glazed slot under the edge beam of the vault", so that "only a sliver of light separates the cycloid from wall". This non-load bearing sliver of glass shows that the walls are not load-bearing; walls that are decoratively covered with travertine of which there are thirteen interior vault walls. (McCarter, 2005, p.348-50)

Between any two Cycloid vaults there is a flat slab in a manner of an inverted U-shaped form (fig 4.70) for housing mechanical ducts. This is covered by a stainless-steel soffit bellow. Kahn also used stainless-steel for the narrow horizontal air diffusers on either side of this servant form while, "the cycloid vaults were covered with lead sheathing as the roof would be visible from the approach to the museum" (.McCarter, 2005, p.351)

One reason for selecting the cycloid structure for the vaults is for need of flexibility in the exhibition area. Therefore, Kahn used a support-free structure, or a tunnel vault whereby the vault, piers, materials and veranda style at either side of the entrance are reminiscent of the Italian Renaissance style.

E) Details

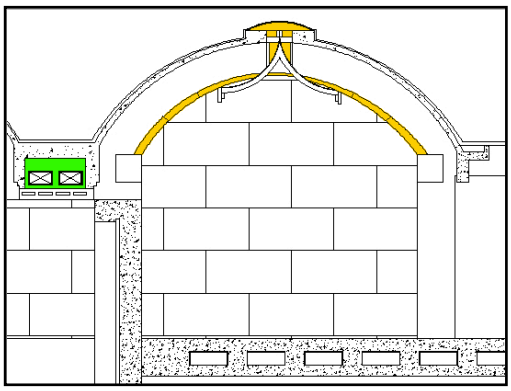


Figure 4.67: Section of Kimbell Art Museum showing skylight with prefabricated reflector; air ducts and MEP utilities in servant beam and hollow slab. (Drawn by Author)

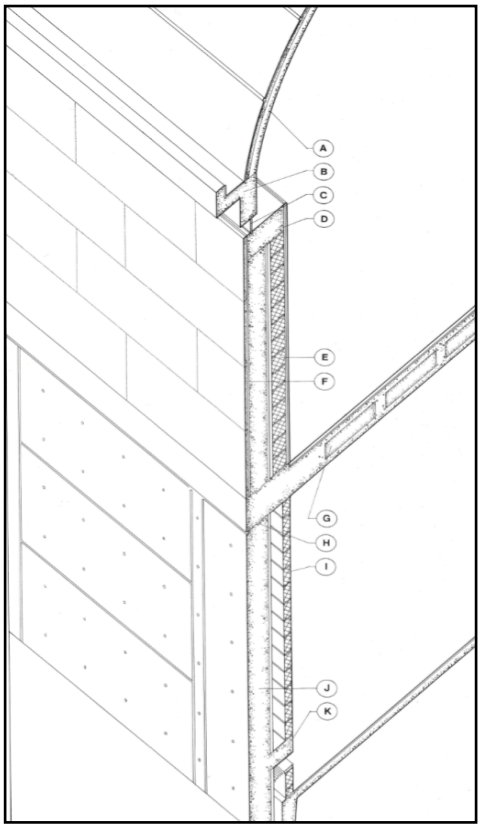


Figure 4.68: section of Kimbell Art Museum's Cavity Wall and hollow slab (Ford, 1996, p.330)

A) Roof construction of lead sheet and two layers of 0.9 cm plywood on 2 x 4 wood nailers of-centre with 5 cm rigid insulation between, on 10 cm concrete shell. The two layers make curve possible.

B) Concrete support with three-ply elastomeric roofing in gutter.

C) 1.4 cm glass, with 6.35 cm cement wash with wire fabric reinforcing on wall below to create still.

D) Concrete beam

E) 20 cm block interior wall with 5 cm rigid insulation behind

F) Outer wall of 2.22 cm travertine on concrete. The backup wall is concrete rather than masonry in order to form a beam over the entry beyond.

G) Concrete slab with foam block inserts finished with 1.9 cm wood parquet floor on 1.9 cm board underlayment.

H) Concrete key and rustication strip, similar to figure.

I) A 10 cm concrete masonry with air space and insulation beyond.

J) Cast-in-place concrete wall with form tie holes and panel joints. A Concrete support to create a slot for air return see also fig (4.70). (Ford, 1996, p.331)

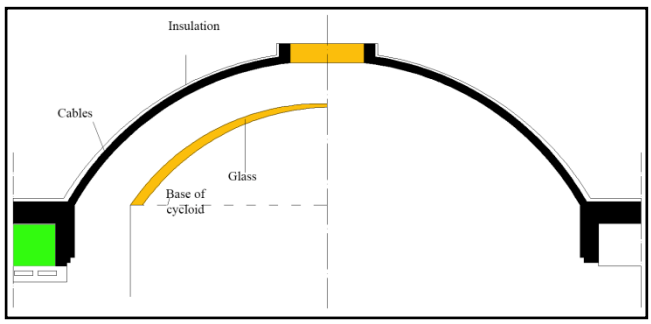


Figure 4.69: Section of cycloid vault, with glass separation between end arch and walls. Showing non-load bearing wall (Drawn by Author)

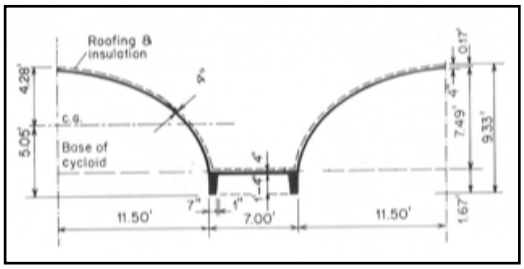


Figure 4.70: Shape and dimensions of the cycloid shells for the Kimbell Art Museum; channel-type secondary beam accommodating servant area. (Komendant, 1975, p.122)

As explained above, Kahn respected the concept for the integration of form and structure. In the Kimbell museum this was achieved by distinguished between load-bearing elements and architectural elements, as non-load bearing components, of a total design. He did this by emphasizing the difference between non-load bearing materials such as travertine and glass where the glass was used in the separation between the cycloid vault and the wall below.

F) Summary

The Kimble art Museum is symmetrically structured in three parts. The entrance was placed in the center which makes this building Kahn's only building with an easy to find central entrance. The foyer contains symmetrically positioned staircases to the basement, near the entrance, and behind the stair is located the administration area with separate stair up to library.

However, in the Kimbell Art Museum the structure does not follow a given geometrical formal law; it also does not set up spatial hierarchies with main servant

and served spaces as in the Trenton Bathhouse. Instead, Kahn tried to develop the structure and space as a whole, so that a series of these unities of vaulted spaces finally form a new higher unity for the overall space (Gast, 1998, p.96).

Chapter 5

CONCLUSION: INTEGRATION OF FORM AND STRUCTURE IN KAHN'S WORK

Kahn died in the New York's Pennsylvania Railway Station, at around 7.30 on the 17th of March, 1974. He made several trips, just before his death, to places where he had ongoing projects. Kahn worked until his last moments for, as he said, "I could never do anything but be an architect because that's all I know how to do."(McCarter, 2005, p.449) Kahn died at the age of seventy-three, but unfortunately he only had a career of a little more than twenty years (Started significant independent work between 1953 and 1974), and few architects became as well-known as Kahn in such a short time.

Kahn created an architecture which related to the past and relied on to the present by applying ideas from Modern architecture. What Kahn did was to design buildings that are not limited to any period of time. They were both Modern and Traditional (Monumental). Also, in the service of his philosophy of "Order" it was important that he integrated form and structure. He used geometrical form, especially the square, which by dividing into smaller geometrical forms he achieved structural placement. That is, Kahn's use of structure was inherent in the geometry he used. Kahn, in order to perfect form, used symmetrical or sometimes double symmetrical axes as his inspiration from tradition or from nature.

Although Kahn died thirty-six years ago, his significance for the future of architecture is only now beginning to be recognized. For example, his concept for servant and served spaces has been used by many contemporary architects; the most well-known is Norman Foster who applied the same idea in many of his buildings, such as the Sainsbury Center for Visual Arts in Norwich, United Kingdom. He applied this idea on his building right after Kahn's death in 1974.

Kahn influenced younger counterparty architects, such as Mario Botta, Moshe Safdie, Tadao Ando, Renzo Piano and Norman Foster. His influence on Tadao Ando was similar to the way he was influenced by Le Corbusier. They both used concrete as the main material for most of their buildings. In addition Tadao Ando used Kahn's concept of the "joint" on concrete as ornamentation of Modern architecture (See Appendix B). Both Moshe Safdie and Tadao Ando worked with Kahn in his office for several years.

He influenced Mario Botta and Moshe Safdie in the use of Monumentality as precedent and not as a form. They also began designs with the use of the square and each room was designed with its own structure, light and material expression. In this Kahn influenced Mario Botta and Moshe Safdie in the same way he was inspired by Frank Lloyd Wright (see Appendix B).

Kahn's simple idea of "servant and service" spaces influenced Renzo Piano and Norman Foster and other contemporary architects. Roger's and Piano's Pompidou Center, which consists of two main areas, an area that served and the area that gives service, is evident in their design. But, they used the idea inside-out, with the servant

area on the outside of the building and the served area on the inside (See Appendix B). This was similar to Kahn who didn't conceal the servant areas, as for example in the Richards Medical Building.

Kahn's buildings redefined Modern architecture in two ways; first by using Traditional architecture and the idea of servant spaces for the design of contemporary building. Therefore, his work was mostly based upon a poetics of function rather than just designing for a list of functional needs. Secondly, he re-established the dominance of the art of construction in the design of contemporary buildings. He was considered as one of the first architects who developed a "tectonic" interpretation of architecture, based upon traditional structures which he adapts and evolves in terms of contemporary materials and building systems.

In considering the role that servant and served spaces plays in Louis Kahn's work, and with regard to the relationship between form and structure, this relationship can also be conceived in terms the theory of structuralism. Structuralism is generally thought of as theory of culture that applies a semiotic analytic towards culture understanding. In other words, culture is described in terms of language whereby the concepts of syntax and grammar can be applied. Analogically, the notions of servant and served spaces can be conceived of as syntactical components in Kahn's work. His philosophy, as described above, helps define an authentic architecture because his syntax, complemented by a vocabulary of historical references, constitutes what he referred to as a monumental architecture. The production of a monumental architecture, that humanize the reductive mechanical nature of Modern architecture and was Louis Khan's fundamental aim and, this objective was realized by the effective integration of form and structure in service of a monumental architecture.

During the mid-20th century many architects felt that architecture had lost its direction and sense of purpose. But Kahn stands alone by bringing Modern architecture back to its moral principles by returning to space-making and reconnecting construction and structure to its archaic origin. He made architecture interesting by means of original geometries and an endless variety of ordering principles. It is exactly what our contemporary architecture needs, i.e. returning to its origin to create meaningful architecture. Louis Kahn was a great architect, whose works can provide examples for achieving a more meaningful sense of identity through design; a design through the integration of form and structure in the service of function. Kahn was engaged with contemporary problems, while being responsive to his exploration of Form, in order to develop his own unique solution for design through the creative synthesis of form and structure.

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APPENDIX

Appendix A: 1 to Root 2 and Golden Section

“The square irrational value **1 to root 2** (equals 1.414) defines the length of the side in relation to the diagonal of a square. Two possibilities offered by the geometrical construction of the root 2 proportion are principally used in this thesis: firstly, the diagonal of the square, when added to the side, leads-similarities to the golden section-to a rectangular figure, secondly, when the diagonal of the square is shifted to the corner position of the external outline, this produces the next-largest "enclosing square". The irrational number values of the small and large line sections of the root 2 proportion are”: (Gast, 1998, p.196)

1:0.707 (minor) and 1:1.414 (major)

“The fascination of this proportional relationship derives partly from the simplicity of its geometrical construction using constantly growing, "pure" squares, but also in the combination of rationality and irrationality in its possible numerical values, as every second number in a sequence -as double the last but one can seem rational. Here for example”: (Gast, 1998, p.196)

5_7.07_10_14.14_20 etc.

“The "**Golden Section"** was defined c. 1500 by Leonardo da Vinci as the "Sectio Aurea" , and at the same time by the Italian theologian and mathematician Lucas de Burgo (1445_1514), also known as Paciolus, later callled Luca Pacioli,in his writings as "La Divina Proportione " _ presumed to have been taken from essays by his teacher Piero della Francesca-; it is also sometimes called "Divine Proportion" in English, and describes the irrational divisions of a line whose shorter part is in the same ratio to the longer one as that of the longer one to the whole; expressed as a formula”: (Gast, 1998, p.196).

a: b = b : (a+b)

Expressed as a ratio of irrational numbers:

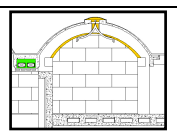
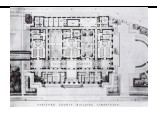
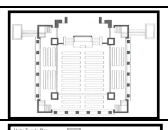
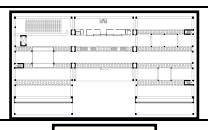
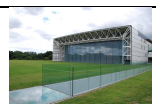
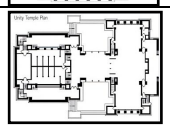
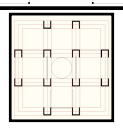
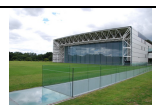
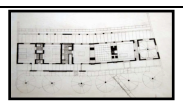
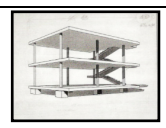
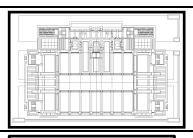
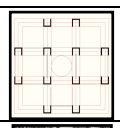
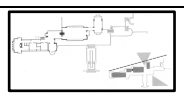
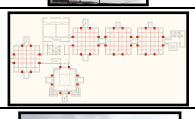
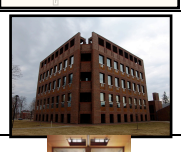
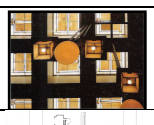
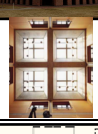
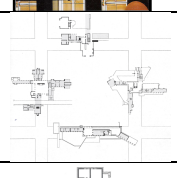
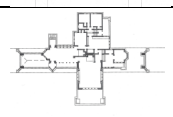
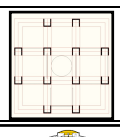
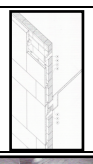
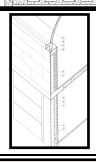
1: 0.618 or 1: 1.618

“The simple geometrical construction of the Golden Section, preferred in this work, relates to the existence, always presumed, of the square whose half diagonal, transferred by circular arc construction to the side of the square, shows the line and area ratio of square to rectangle as the proportions of the Golden Section.” (Gast, 1998, p.196).

“The Golden Section was the object of comprehensive scientific examinations in the 19th century. Adolf Zeising in particular ("Schriften zur Proportionslehre" , Leipzig 1854_1888) and Franz Xaver Pfeifer ("Der Goldene Schnitt", Wiesbadan 1885) looked, like Plato , for evidence in the whole world system, which led to philosophical and metaphysical interpretations, seeing it as the apparent key to the structure of the universe: It is asserted that this proportion appears in the composition and structure of all living creatures, in the plant world, in the ratio of land to water on the terrestrial globe and finally in the relative planet constellations of the earth -solar system and the distances between arms of cosmic spiral nebulae. Therefore Golden Section addresses structural and repetitive systems in architecture as parallels to natural, biological systems.” (Gast, 1998, p.196).

Appendix B: Table of relation of influences

Table of who influence Kahn and whom Kahn Influence.

Influences		Architects							
		Paul Cret	Fran Lloyd Wright	Le Corbusier	Robert Venturi	Louis Kahn	Foster & Piano	Safdie & Botta	Ando
	Nature of Material								
	Axial Planning								
	Symmetry								
	Monumentality As precedent								
	Economic of Material								
	Design Begin With Square								
	Tartan Grid Planning								
	Closed center And open corner								
	Each room with its own structure								
	Hidden entry								
	Top-lit central room								
	Pinwheel plan organization								
	Cruciform plan organization								
	Vault structure								
	Cavity wall								
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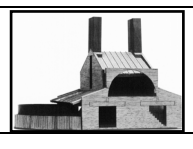
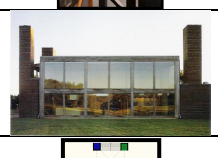
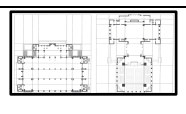
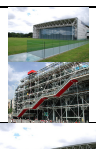
	Layered space								
	Contradiction (over scale architectural elements								
	Servant & Service								
	Structural Form