A NEW TYPOLOGY OF CONNECTION: STRUCTURE VS ARCHITECTURE

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Design Report

A New Typology of Connection
Structure vs Architecture

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1 lane - 3.5m... 10 lanes - 40m!

BIG ROADS, BIG SPAN, BIG STRUCTURE

WE SHOULD ENJOY THE SUN!

HUMAN

DON'T HIDE UNDER THE GROUND

I BELIEVE IN FUTURE...
INTRODUCTION

Structure as space, structure as architecture. Structure is perceived as pure functional building elements as support of building and space divider. My study is to investigate the role of structure beyond only structural issue. Structure should be more integrated with architecture in the sense of aesthetics and spatial quality.

Relationship between architecture and structure can be classified into three categories: 'Structure as Architecture' (structural elements dominant), 'Architecture as Structure' (architectural expression dominant) and 'Architecture = Structure' (integration of architectural and structural elements).

Reference of integrated structure and architecture could be recalled from the late Renaissance Gothic cathedrals. Rib arches created unique and tremendous spatial quality of the central nave, celebrating the relationship to the God. The beautiful integration between structure and architecture in the past could be explained by the different role of architect. Architect, the ancient Greek word meaning “the master builder”, does not only designs space and form but also works with the structure of building.

In the development history of architecture, attitude on the architecture-structure relationship changes, like functionalism. And works of the master-builder are separated into many specialists like structural engineer. The engineering approaches focus on accurate calculation and highest efficiency. It's essential to keep a balance between the architect's aesthetic, spatial quality and the engineer's structural accuracy. To avoid building as neither engineering machine nor inerectable sculpture, integration of structure and architecture is a way to achieve the balance. My study would try to find out and categorize different methodologies of the architecture-structure integration.
Structure is an essential component of architecture. No matter what is built, small as a simple shelter for a single person or a family, large as a worship and trading place for hundreds of people, materials need to be shaped and used in certain quantities to make the architecture erect against the gravity and other dangerous forces like wind, earthquakes. However, from the earliest time, a sense of beauty has been innate in human. All construction needs to be conceived according to certain aesthetic quality, which in fact, impose on structure more stringent requirements.

Throughout the long history of architecture, structure has played many different roles in its relationship with architecture. It has been considered as important component and dedicated much to architecture. But in some cases, magnificent buildings were created with a notable disregard of structure. Structure and architecture, stability and aesthetic seem always struggle with each other. It has been argued by some architectural historians and structural engineers that a thorough consideration of structure in the design of building would unavoidably lead to beauty. It seems that there is no modern answer for the true balance between the two. References could be found from different periods in the architectural history.
**Greek and Roman Antiquity**

In the Greek word, the architect was known as the "master builder" who was responsible for the design of all aspects of building including spatial arrangement and structural stability. This means that the architect and engineer were the same individual. He was an artist and a technologist, a designer and a builder. The relationship between structure and architecture was very close that their reconciliation in the creation of the building was carried out in a very positive way.

Different from other kinds of arts, the fundamental aim of architecture was to fulfill the basic human need for security. Buildings provided shelter and protection from animals for human. Since ancient times, religion was a very significant element in the design of buildings and many ancient buildings were built for the gods. The significance of religious buildings had no accident as religion fulfilled the human's spiritual need in seek the truth and meaning of existence. Most religious buildings' spatial arrangements were dedicated to the relationship and contact to the gods.

**Parthenon**

The Parthenon was a temple of Athena, built on the Acropolis at Athens by Iktinos and Kallikrates and finished in 433BC. It is the best known remaining building of the ancient Greece and has been considered as the finest achievement of Greek architecture. In a visit to the Acropolis at Athens in 1911, Le Corbusier wrote "the Parthenon, this dreadful machine makes everything within a radius of three miles pale into insignificant."

The Parthenon, temple of the protective goddess, was constructed entirely in white marble. Its spatially completed structure, for many centuries, represented the embodiment of pure architecture. The whole building was simple post-and-beam structure. However, the structural elements contributed much more than only structural stability. The archetypal form of the building and the spatial quality enclosed by the peripheral columns created the unique cella and treasury inside. A host of symbolic meanings had been attributed to them by later commentators. Also, evolved from the post-and-beam structural arrangement, the Doric order reached its greatest degree of refinement in the Parthenon. The structure and the architectural expression co-exist in perfect harmony.
Gothic

Gothic architecture is a style particularly associated with cathedrals and other churches. It shows a significant move in structural point of view from the classical solid structure to the Gothic skeleton structure. The Gothic style emphasizes verticality and features skeleton stone structures with great expanses of glass, pointed arches with ogive shape, ribbed vaults, clustered columns, sharply pointed spires, flying buttresses and inventive sculptural detail. These many features are all the consequence of the newly-invented use of skeletal structure and pointed arch. The use of skeleton structure which in turns makes it possible the use of large stained glass windows that allowed more light to enter than the old styles using solid structures. Besides, to achieve this new “fill with light” style, flying buttresses were used to create higher head room and slender columns.

In Gothic architecture, new technology stands behind the new building style. The Gothic cathedral was a microcosm representation of the world, and each architectural concept, mainly the loftiness and huge dimensions of the structure, were intended to pass the message “the great glory of God versus the smallness and insignificance of the mortal being”.

As a defining characteristic of Gothic architecture, all the technical innovations had significance beyond their structural functions. There were symbolic and mystical significance in each detail. Visually, the verticality of the pointed arches suggests an aspiration to the Heaven. They were intended to convey the impression of steep arrows pointing to the Heaven. Structurally, the pointed arches channel the weight onto the columns at a steep angle and hence a higher ceiling could be created.

Abbey Church of Saint-Denis

The abbey church of Saint Denis near Paris is acknowledged as the building which launched the Gothic style. It originates from the 7th century and was converted from 1137 onwards by Abbot Suger. Suger wanted to create a building with high degree of linearity that was suffused with light and colour, a physical representation of the Heavenly Bethlehem. The first truly Gothic construction was the choir of the church. Suger replaced the old narrow choir with a new one. The new choir was more spacious, free, dynamic, colourful and bright. With its thin columns, stained-glass windows, and a sense of verticality with an ethereal look, the choir of Saint Denis established the elements that later be elaborated upon during the Gothic period.
INDUSTRIAL ARCHITECTURE

Industrial architecture refers to the style of buildings influenced by the Industrial Revolution in the 18th and 19th centuries. Industrialization is a process of social and economic change whereby a society is transformed from a pre-industrial to an industrial state. This change is closely intertwined with technological innovation, particularly the development of metallurgy. The industrial revolution brought a great advance in building technology. The price of crude iron was greatly decreased and steam engine was well developed to produce increasing volumes of iron. This provision of large iron member made it more usable and common as building materials. Other building technologies, like pre-fabrication and standardization, effectively increased the speed and efficiency of building construction. The using of metal materials marked the onset of the most significant technical revolution in architectural history. Solid structures could be replaced by skeleton structures which are possible to erect buildings of almost unrestricted height and width very quickly, using pre-fabricated elements.

During the Industrial Revolution, many huge buildings were built to demonstrate the advance in building materials and technologies. Hence, the design of buildings was structurally dominated. Lightness and transparency became the main aesthetic features of metal structures. In the 19th century, all these structures were not considered as architecture at all. Factories, department stores, exhibition halls, railway sheds and large spanning bridges, typical tasks of buildings at that time, were classified as "functional buildings".

CRYSTAL PALACE

Crystal Palace in London was built to house the first Great Exhibition of 1851 by Joseph Paxton, embodying the products of many countries throughout the world. Joseph Paxton, made use of his knowledge and experiment in the creation of large greenhouses, built this tremendous large glass and iron structure: 600 metres long, 120 metres wide and 34 metres high. Planners of the exhibition looked for strength, durability, simplicity of construction and speed. All these could be obtained from Paxton's proposal. The Crystal Palace was the first building to be constructed using pre-fabricated and standardized elements exclusively. Only this level of standardization made it possible to erect the building, by about 5000 labourers, in only seventeen weeks. Building elements, including 3300 columns and 2300 girders, were manufactured simultaneously by different factories. The Crystal Palace itself was a demonstration of the capabilities of the latest industrial processes and techniques of mass production.

The Great Exhibition lasted for six months but the life of the Crystal Palace was not limited to that. The standardization made it possible to dismantle at the end of the exhibition and re-assembled on Penstone Place atop Sydenham Hill in London.
After the domination of structure during the industrial revolution, people started to seek for another way of aesthetic standard. Expressionism is the tendency of an artist to distort reality for an emotional effect. It is a totally subjective art form. In architecture, the emphasis on structure, material and function took second place to the architect's personal will to express. The architect's thoughts, desires, emotions and world view were seen as the primary force in driving the building form. Due to the First World War and its consequences, architecture and construction had largely come to a standstill. The unemployed architects let their imagination and ambition run wild in their mind, on paper and designed the most daring projects for the future.

Einstein Tower

The Einstein Tower is an astrophysical observatory in Potsdam designed by Erich Mendelsohn, built from 1920 to 1921. It is often cited as one of the few landmarks of expressionist architecture. The tower rises from the ground like a submarine periscope from the waves. The building took an organic form and was originally conceived in concrete, which Mendelsohn described as "building material of our new will of form". However, due to construction difficulties, its soft contours were based on brick covered with cement.
RATIONALISM

In philosophy and its broadest sense, Rationalism is "any view appealing to reason as a source of knowledge or justification". Rationalist architecture works with the belief that varied problems posed by the real world could be resolved by reason. After the First World War, there was acute housing shortage due to the cessation of building activity during the war, the post-war economic crisis and the flood of refugees. It was generally accepted that the only way to overcome this housing shortage was the application of a strongly rationalized approach to building, which meant methodology with ultimate efficiency and mechanical production. Ideas of production of entire building or estate in serial basis and "mechanization of residential building" emerged.

Open plan was a characteristic feature of the buildings of Rationalism. Closed square and rectangular rooms were replaced by open spaces which allow flexibility for user. Skeleton structure, in specific column-and-slab structure, only needs supports and did not require load-bearing walls allowed this flexibility. Buildings were built as structural frameworks in which users had their own plug-in to specialize the space for different functions and requirements. Structure and architecture started to split.

Barcelona Pavilion

The Barcelona Pavilion was originally built for a temporary structure for the 1929 World’s Fair in Barcelona by Ludwig Mies van der Rohe. The Pavilion soon became well-known for its simple form and extravagant materials. Also, it became a representative of the pure clarity of Rationalism. The structure consisted of eight steel posts supporting a flat roof. The flowing space underneath was partitioned by curtain glass walls and marble walls, which were detached from the structure and hence the partitioning was not limited by structural constrain.
THE INTEGRATION

From the experience of history, certain circumstances are needed for the integration of architecture and structure to happen: human needs and technological breakthrough.

The integration of structure and architecture leads to a change in architectural style. As initiator, human needs trigger the desire of designers/architects to start a new thinking, to seek for a change. From the above mentioned examples, these human needs could be spiritual needs (like the religious representations in Gothic), spatial needs (need for large free space in industrial architecture) and more recently, to express the need of freedom and logic (organic form in Expressionism and rational solution in Rationalism). To achieve the new concept of fulfillment, architects need to be equipped with a technological breakthrough. Skeleton structure (Gothic), mass production of metal (industrial architecture) and invention of reinforced concrete (Expressionism) are some critical technological breakthrough in the past which facilitated the occurrence of architectural style with dominant integration of structure and architecture.

Nowadays

With reference to Rem Koolhaas' idea of 'the Generic City', cities in the world, especially some big international cities, are getting more and more similar. As the cities are developed based on efficiency and economic issues, homogenization becomes more and more obvious. Cities no longer have their own identity, but are composed with several common elements, for examples airports, infrastructures like highways, and office towers. These elements form the 'generic' for human developments to be plugged in.

This homogeneous mode of development leads to some common urban problems appeared in global cities, one of the examples is city fragmentation. As efficiency is the main focus of the development strategy of these international cities, the development is highly traffic-orientated. Networks of multi-lanes highways and railways are put on top of the city map which leads to the fragmentation into islands of buildings. These highways and railways greatly limit the usable land on ground and human movement. References could be made to some of the recent projects.
THE CENTRAL ARTERY / Tunnel Project (Big Dig) is a recent mega-infrastructure project carried out in Boston. The Central Artery, opened in 1958, is a six-lane elevated highway which cuts through the downtown area of Boston. When it was opened, it carried 75,000 vehicles per day. However, with the tremendous city and traffic growth, it now carries up to 200,000 vehicles per day. This causes the Central Artery to have a world class traffic congestion problem of up to ten hours traffic jam a day. Besides traffic problem, the Central Artery also cuts off the North part and waterfront neighbourhood of Boston from the downtown area. Accessibility to these areas is very limited and the city is highly fragmented by the highways.

To tackle this serious urban and traffic problem, studies of possible solutions have been started as early as 1980s. Feasibility study has been carried out for years and the final proposal was launched in 1991. The project involves the replacement of the existing six-lane elevated Central Artery with six to eight-lane underground expressway directly underneath the location of the existing highways. The construction is carried out in a manner of zero-disturbance to the existing traffic. That means the traffic of Central Artery is kept in full operation during the construction period. This forms the major technical challenge of the project. Heavy machineries and deep underground concrete walls are built for temporary support for the elevated highways and excavation reinforcement.

The final ramp connection to downtown was finished and opened on 13 January 2006. In the project, 3.8 million cubic yards of concrete has been placed and more than 16 million cubic yards of soil has been excavated. After the construction of the underground expressway, the existing elevated highway would be demolished and more than 260 acres of new open land would be reclaimed. This provides new parks and pedestrian area for the city. Connectivity between the waterfront and downtown area could be re-established.
ARNHEM CENTRAL, NETHERLANDS, 1996-2007

The Arnheim Central is a constructing project done by the UN Studio in Arnheim, Netherlands. It is expected to be finished in 2007. It is a transportation complex combining a new railway station hall to the existing railway, railway platform, car tunnel, bicycle storage, parking, housing, shopping and office. The dynamic nature of the project creates a clearly organized human-vehicle relationship. The continuous roof platform gives a new ground for pedestrian above the complex vehicular movement underneath.
HUMAN NEEDS AND TECHNOLOGICAL BREAKTHROUGH

From the above examples, human-vehicle relationship becomes a more and more concerned topic nowadays. As the consequence of the highly efficient traffic orientated development, human movement and connectivity within cities become very limited by highways. As seen from many recently built and on-going projects, there is new consideration for the human-vehicle spatial arrangement. A natural human need for reclaiming open ground space for connection and movement experience have been evolved.

In Greek and Roman antiquity, the relationship between the equivalents of architects and engineers must have been very close in order to achieve the creation of buildings in which the requirements of structure and architecture were reconciled in a very positive way. In this period the architect and engineer would have been the same individual — the master builder. This type of relationship between the equivalents of architects and engineers was maintained during the medieval period in which the Gothic buildings. It is significant that throughout this period the principal structural materials were masonry and timber. These are problematic structurally in various ways and forced architects to adopt structural forms which were sensible from a structural point of view. The distance between the architectural and structural agendas was perhaps generally at its greatest towards the end of the nineteenth century and is exemplified by buildings. Architects were still interested in structure, but only as a means of realizing built form which was generated from ideas which were remote from technical considerations. Engineers became technicians, responsible for ensuring that the technical performance of a building would be satisfactory but no contributing creatively to its form or appearance.

A new type of relationship between architects and engineers, in which very positive collaborations occurred with engineers influencing the design of buildings from the very earliest stage develop in the twentieth century. The catalyst which made this possible was the re-introduction of tectonics into the architectural discourse. This drew attention to the visual qualities of the emerging structural technologies of ferrous metal and reinforced concrete. In the later twentieth century, certain groups of architects and engineers evolved highly collaborative relationships, working in design teams of architects, structural engineers, services engineers and quantity surveyors, in which buildings were evolved through a discursive process. The buildings in which the design-team methodology was used are generally regarded as belonging to the High-Tech school. The kind of relationship between architectural and structural thinking which existed in antiquity and the Gothic period has been re-captured.

This recent change in the relationship between architects and engineers sets up a perfect ground for a breakthrough in the combination of structural and spatial elements. With the undoubtedly human need for reclaiming ground space and the potential happening of a technological breakthrough by the close relationship of structural engineers and architects, it is a possible time for structure and architecture to be integrated again, just like our historical experience.
DESIGN EXPERIMENT

Hong Kong, as one of the most important international cities, faces the same urban problem of fragmentation and poor pedestrian connectivity. Human movements are limited in pedestrian sidewalks and road crossing facilities like footbridges. Footbridge serves as pure functional structure provides connection of places above the ground level, but it rarely has aesthetic and spatial contribution to the pedestrian and the city. Footbridge, the direct logical solution for road crossing, changes the human experience from originally subtle movement to point-to-point direct connection. There is a human desire of reclaiming space and walking experience.

Kai Tak

Kai Tak is chosen as the site of the design experiment because it is a typical fragmented district by highways. Kai Tak area, being the previous international airport of Hong Kong, was a restricted area. Accessibility to Kai Tak was highly controlled and the whole Kai Tak area was isolated by six - ten lanes highways and flyovers, including Prince Edward Road East, Eastern Road and Kai Fuk Road. As Kai Tak is subjected to redevelopment, this isolated situation need to be resolved.
Several urban problems exist in the neighboring districts. These problems include urban decay, obsolete housing estates, poor accessibilities, transport problem, lack of open space and unpleasant living environment. There are currently transformation programmes of Kowloon Tong, Kowloon Bay, Kowloon City and San Po Kong areas into business area. The redevelopment project of Kai Tak area is an excellent opportunity to improve the interface between the new Kai Tak and the surrounding old districts. It also gives an opportunity to trigger the improvement of the poor urban conditions of the neighboring old districts.

The moving out of the airport from Kai Tak to Chek Lap Kok leaves a great flat land of near 300 hectares for redevelopment. The first Outline Zoning Plan of this area was issued in 1998. After several revisions, the latest OZP was issued in 2006 base on the principle of no reclamation. Key items in the redevelopment scheme includes cruise terminal, metropark, water-front promenade & multi-purpose stadium. With the increase in residents and human activities after redevelopment of Kai Tak, a number of strategic highway networks are planned, like the Central Kowloon Route & Trunk Road (T2). Also, the new area would be equipped with a new railway - Shatin to Central Link. 2 stations are planned within or near the Kai Tak area, they are Kai Tak Station & To Kwa Wan Station. In the planning of Kai Tak area, pedestrian walkway is the major connector to the neighboring districts. The accessibility of human across the Kai Tak boundary is achieved by landscape decks, retail footbridges and elevated connections.

A new typology would be explored to replace the existing pure functional footbridge system along the Kai Tak district. In the sense of integration between structure and architecture, this new type of architecture reclaims land and open space for pedestrians, re-establish the connection between old neighboring districts and the new Kai Tak district.
SECOND LAND

As to reclaim the land area and human experience, a SECOND LAND is proposed to provide a new, elevated ground level for human activities, leaving the ground level high-traffic highways undisturbed.
URBAN STRATEGY

WHOLE SITE IS DIVIDED INTO 4 ZONES ACCORDING TO THE DISTRICT NATURE:

WATERFRONT - HUMAN ACTIVITIES RELATED TO THE PIER AREA.

LEISURE - FOR THE CHANGING COMMERCIAL DISTRICT IN KOWLOON BAY

COMMUNITY - EXISTING AND FUTURE PLANNED RESIDENTIAL DISTRICT

HERITAGE - FUTURE HERITAGE PATH AND PAST AIRPORT TERMINUS REMAINS
DIAMOND FRAME STRUCTURE

A DIAMOND ATOM BONDING STRUCTURE IS ADOPTED INTO FRAME STRUCTURE TO PROVIDE THE BASIC SUPPORT OF THE SECOND LAND PLATFORMS.
Frame work provide support for surfaces. Combination of surfaces provides different functional space with various spatial qualities.
WITH THE SAME DIAMOND STRUCTURE PRINCIPLE, FRAME STRUCTURE CAN VARY IN SIZE AND DIMENSIONS TO SUIT DIFFERENT EXISTING HIGHWAYS CONDITIONS.
FRAMEWORK PROVIDES 3 LEVELS OF PLATFORM ACTIVITIES: GROUND LEVEL, INTERMEDIATE LEVEL AND ROOF LEVEL. 3 LEVELS ARE CONNECTED TOGETHER THROUGH ONE MAIN ROUTE FOR PEDESTRIAN MOVEMENT. DIFFERENT PROGRAMMES ARE ATTACHED TO THE MAIN ROUTES. CIRCULATION IS NOT LIMITED TO THE MAIN ROUTE, IT PROVIDES VARIOUS OPTIONS FOR PEOPLE WITH DIFFERENT INTENTIONS. THERE ARE CHOICES OF MOVEMENT AND EXPERIENCE.
BIRD BONE STRUCTURE

The slab structure is inspired from the rigid but lightweight bird bone structure. It's parametric with the decking materials and functions of the space. Depth of the slab can be varied to suit different purposes like tree-planting, grass planting and skylight. It also allows different possible decking materials to achieve different light permeability and spatial qualities.
K-10000

TOWER CRANES OF AMERICA, INC.

HOOK RADIUS CRANE CAPACITY
STD. 269 FT 132 T
     82 M 120 T
LONG 330 FT 104 T
     100 M  94 T
END
ARCHITECTURE LIBRARY

Overdue Fines on Thesis
HK$1.00 per hour

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