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Influent of Overall Architectural Arrangement on Structural Elements Design

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ABSTRACT

In designing a civil structure, difference professionals are involved from the conceptual stages through the constructions up to the final project stages. Because of this, there are difference links which exist between difference professionals which need to be addressed properly to obtain the best environmentally friend structure with adequate cost as well as strength and durability.

In particular, when we look at the cooperation of architects and engineers, we may observed that they have some difficulty in working together harmony. This is due to the complexity of intangibility and tangibility as well as actual and abstract notion of the Architecture. Structural engineers focus more on tangible and actual notion on structures and detail aspects. On the other hand, Architects put great prominence on global and general aspects, such as spatial forms and atmosphere generated. This contradictory ways of thinking sometimes result in difficulty in communication [10].

Moreover, in the design processes the general arrangement or structural form chosen for a building at initial stage will normally determine the type of structure which will have to be adopted to support it and will perhaps also dictate the selection of structural material [4].

In fact the structural dimensioning of previously defined morphological system results in it being a less trustworthy system, leading to a structure that is greatly susceptible to seismic damage This is because of the delinquency of relating the already defined architectural form and that of the structural design [11].

Furthermore, "reference [7]"quoting different architects ideas and stating: "All professionals need to learn the art of Architecture because it concerned altogether - John Ruskin. Le Corbusier said that "Architecture is the accurate, proficient, and outstanding play of masses brought together in light". For these reason, Architects and structural engineers need to have a better understanding on the joint works and carry out the activities in close proximity to produce a sound architectures.

Keywords: *Structural form, Architecture, Architects, Structural Engineers.*

1. INTRODUCTION

Throughout the antiquity, buildings has usually been designed and built by only one person, hence called Master Builder. It was an architect, engineer as well as constructor, all professionals in one. During the time when the industrialization has begun, the complexity of the constructions became more and more, and the demands of the buildings by the society became greater than before. Material of the construction and tools developed with the technical development. This became the challenging factors for one person to know everything plus to think about every aspects in the constructing/ designing of a building or a bridge structures. These result in the division of works between Architects, builder and difference Engineers [5]. Besides, the separation of work lead to the cause of other problems. The utmost problem among these was probably the communication between the different professions in the processes. In a building project both good communication and efficient collaboration is required between different professionals. What was in the past as one man works became now a collaborations between different professions and at the same time they works apart from each other rather than closer. In the previous decade, this issue has got more and more attention, both out on the field as well as in the Institutions. It is clear that in the near future the advancement of both construction technologist and method of construction will be unrealistic. Because of these, it is necessary for architects and engineers to work together much closer, both in the school plus out on the field [3]. In addition to these, the chosen structural form has a great influence on optimization techniques in structural design which is the need to find the best way to gain the maximum output from the resources in hands. In these paper

we will look closely on the correlation of architect works with that of Structural engineers in particular throughout the Design processes and their influent.

A. Objective

1).To gain a knowledge on how structural forms influent structural element design and Vic versa

2).To create awareness on the connection between both structural engineers as well as Architects.

3).To elaborate how to design a safe, durable, aesthetic and economical structure by regarding the importance of the connection of overall architectural arrangement and structural elements throughout the design processes.

2. LITERATURE REVIEW

The process of structural design may be subdivided into two parts: the first one is preliminary design stage, when the form and general arrangement of the structure is developed, and the second is the analysis and the determination of various structural elements dimension. The general arrangement or structural form chosen for a building at initial stage will normally determine the type of structure which will have to be adopted to support it and will perhaps also dictate the selection of structural material [4].

In fact the outcome of dimensioning of already defined structural form can result in a less truth worthy structural system which is greatly susceptible to seismic damage. This is because of the delinquency of relating the already defined architectural form and that of the structural design [11]).Engineers use Optimization techniques in structural design as a tool. The purpose of these Technique is to select the best option by the Decision makers or Designers from the available resources in order to gain the maximum benefit [16]. However, structural optimization process and methodology adopted for a given problem is also influenced by Model of Structure, dimensionality, choice of design variable and the type of structure [12]. According to [15], based on the structural form classifications, four types of structure are distinguishable such as: Truss, Shell, Solids, and Composite materials. The Truss structural form can be perceived in all areas of engineering sciences that involve structural mechanics. The properties of In-plane and out-of-plane of Shell structures deformations are commonly used in optimization and aerospace structural analysis. In geo-technical and mechanical engineering, solids structures play an important role [13].In aerospace and other engineering discipline usually civil engineering the application of the composite structural types can be seen. All these factors affect the way by which the optimization technique is carried out. Furthermore, the model in which the structure is idealized for optimization also affect the processes. The engineers model the structure in such a way that it represent the real structural form. This approximate model for mathematical sense must accurately represent the original structures for optimizations prototypical [14].

The influence of structural form can be observed from the “Willis, Faber and Dumas building (Fig.2)”case. Where there was a requirement of external glass wall as well as large wall free interior spaces, there was no alternate to the adoption of a frame-type structure. The reinforced concrete was selected as a structural material rather than steel due to the need for a curvilinear plan-form as well as columns which were set back from the perimeter. The result in this case was a building in which both architectural and structural requirements were satisfied in equal measure. The building was in such a way that it is free from both technical as well as architectural criticism. Due to the complexity of roof top arrangement of The office in Viena by” Coop Himmelblau group” (Fig. 2.1),the selection of skeleton frame type of structure and steel as a construction material to ensure that the element are slender enough was a mandatory option rather other type[4].

Fig.2.0: Willis, Faber and Dumas office, Ipswich, England 197

Anthony Hunt, structural engineer and Foster Associates, architects. The architectural expression was provided by the translucent walls of this building, the curvilinear plan and cantilevered floor slabs on the structural properties of reinforced concrete (Photo: Alastair Hunter).

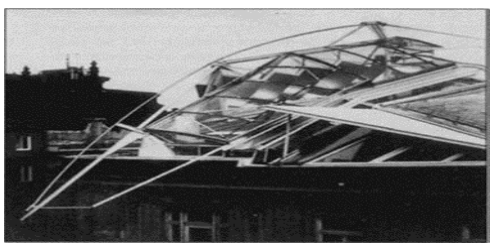

Fig.2.1: Rooftop Remodeling in Vienna, Austria, 1988

Coop Himmelblau, architects. [Photo: Gerald Zugmann).

A. Defining Architecture

Before we look at what the Architect and Structural Engineers ways of working is with corresponding definitions, we need to understand the basic concept behind the Architecture. Most architects and architectural critics have tried, at least once during their professional lives, to define architecture. Even in architecture schools, one popular exercise in theory classes has been to ask students to define architecture. A list of such definitions for architecture is compiled by Francis Ching (1996, p.S [7] quoting different architects ideas and stating: "All professionals need to learn the art of Architecture because it concerned altogether - John Ruskin. Le Corbusier said that "Architecture is the accurate, proficient, and outstanding play of masses brought together in light". The only way you can build, the only way you can get the building into being, is through the measurable. You must follow the laws of nature and use quantities of brick, methods of construction, and engineering. Architecture also exists without necessary assistance from an architect and architects sometimes create buildings which are not architecture. - Norval White." If architecture is seen solely as the province of architects, whether heroic or not, then it is likely that people may not only misunderstand their role in creating the built environment, but also become suspicious of their activities and blame them if they do not like the results [8]).Architecture is a course about interior and exterior arrangements of structure so as to achieve operational functions. The arrangement does not only have to meet the requirements of spatial combination but also have to provide an artistic configuration as well as a sense of harmony with the surrounding environment [10].

1) Elements Of Good Architecture:

Architecture can be evaluated based on different perspective, but for Good Architecture the following elements under the major two categories should be fulfilled [9].

Table I: Elements of Good Architecture

"**PRIMARY CATEGORIES**				
Greek categories	**Architectural elements**			
1 Quantity'	Form	Pattern	Structure	Geometry, etc
2 Activity'	Function	Needs	Effects	Exchange etc
3 Quality	Meaning	Association	Resemblance	Style, etc.
SECONDARYCATEGORIES				
1Substance	Construction	Materials	Design, etc	
2 Relation	Context	Community	Nature	Feeling, etc.
3 Will	Spirit	Power	Politics	Attitudes, etc.

B. Structural Engineer's Way of Working

"Engineers for many people, especially to the public, are mysterious figures. The most frequent remark is: 'What do they do? They just make things stand up,' as though this were not a noble thing to do [2]. What do engineers learn? Most engineers agree upon solving problems. Engineers are "problem solvers". Engineer select the best solution of the project in hand from the different alternative which has the least total cost and simple to be carryout. The projects are often a part of a bigger connection and often there are discussions about which solution is the best. For winning this argument, the engineer has to have proof in calculations of costs and productions. "Engineer: 'this is so, because Newton said so', 'we should take this course of action because calculations indicate it will be the cheapest'" [1]. In the design processes, the major responsibility of Structural engineers are as follow. First, the synthetization of the overall structural system that is select the geometry and the type of structural members that make up the structure. Second, the dimensioning of the structural element to support the apply loads comfortably. Creating a structural concept requires a deep knowledge of structural behavior. Sizing the members requires information about the internal forces resulting from the loading. The internal response of the structures can be acquired using mainly computer based approach for structural analysis [6]. Besides these, Engineers do often work in teams, in large project teams where they each have a small part in the whole project. Engineers' carryout the detailed analysis of the structure which have a great important to the overall system. Even though the details seem small for others, there are a lot of calculations that have to be done to know that it will hold for all the load cases that could be possible. However engineers can also dig themselves too deep into details and they are not always too keen on coming back up again [1].

C. Architect Areas of Work

Architect is more concerning about the spatial compositions, aesthetic values of the Structures, the schematization design process and management of the internal and external configuration, and decoration and coordination with surrounding environment [10]. Architects put more emphasis on general and global aspects, such as spatial forms and atmosphere created.

1) Inspirational Source Of Form Finding By Tyas And Popovic Larsen:

As explained at [5] the most important source of motivation for form finding processes was given by Tyas and Popovic Larsen for structures. Form finding's sources of motivations are divided into a few large sections as follow.

The first one is the nature. Many architects use the beauty in nature to find different forms for a particular structure, but what they might not think about is the knowledge of mechanics. As an example: trees can be very beautiful with their colors and their strange combination of their branches. Many architects find this as a very interesting and try to imitate them. Trees have aesthetic attribute and they also show a classical physical law. The size of the branches is in such a way that it goes decreasing from the intersection point of the support to the far ends. This can be compared to a normal cantilever case. The best way of forming a cantilever is to do it as trees branches.

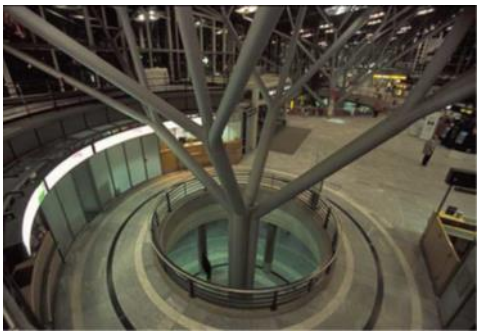

Fig 2.2: Stuttgart Airport

Fig2.3: The Millennium Dome

The second is intuition or common sense. This ability is what everybody has; even those who are not engineers know that you cannot use a cable as a column in a building because it can fall if it tries to stand on its own. These are the conditions on the grounds on how the tents where developed. Our ancestors quickly understood that in order for the fabric/skin to span over the distance, it needs to be tensioned and they do learn these by trial and error. They also observed that if it is not anchored in poles it will fall to the ground. This basic idea can be seen in many of the modern tensed membrane structures today; as an example: the Millennium Dome (fig2.3).

The third source would be inspiration from precedent engineers and architects, or Master Builders. Today we study how to construct a building by applying scientific principles. We learn how to calculate, analyze, and use computers to find the best solutions from difference options. It has not always been in this ways. Before the industrialization concepts, people learned by apprenticeship. You watched older, more experienced Master Builders, during construction processes and if you were a good apprentice you could take over after your teacher. This process is still used today, though not as specific. You acquire knowledge from others mistakes or successes and develop it. The example of this could be the Egyptian pyramids; they were the precedents of I.M. Pei's Louvre Pyramid.

Fig 2.4: The Egyptian Pyramid

Fig 2.5: The Louvre Pyramid

The fourth is the one people are using nowadays in institutions which are known as scientific knowledge. Due to the concept of industrialization, it leads to the needs for faster, adequate and low cost of constructions of, especially factories. And because of the fact that new materials for construction were being used, the knowledge of its properties, how it works and how it reacted on the application of difference loading became very important for the builders to know in order to use it efficiently than ever. The development of scientific knowledge had already begun, as an example: Galileo and Leonard Euler. The bending stresses in the beam were studied by Galileo and Later the buckling of Beam was studied by Leonard Euler respectively. This is the way how the new builders used and further developed to understand how different structural elements and materials worked. The development of theoretical analysis made it possible to understand the structural behavior of new Structural forms before building it. Due to this, the today's designers do not have to depend on only experience and intuition, to form new architecture. Furthermore, the development of science also made it difficult for one person to know everything being carryout during design processes. This lead to the subdivision of master builder into different professions, as the Architects and Engineers. However, to construct a building, both professions were still needed in the processes. What became the most Challenging problem now is the collaboration between the different people needed in the process. For a good collaboration to happen, there has to be a respect and understanding for each other, which is not always there.

3. STUDY AND DISCUSSIONS

When we think about structures, we usually consider bridge, tank, and towers. Even though these structures are appealing, the reality is the objects which surround us in our daily lives are a structure. As an example: A bread being made by mixing different ingredients is also a structure. If you pay attention carefully to a wide variety of structures, you will notice that many of them have resemblances. Different structures might serve the same function example: Bridge, no matter how complicated the form maybe, its function is to span the gap in a location where there is an obstruction safely. People most often, classify the structure based on the function it is made for. Some structures are made to contain something, some structures support something on top, and some span space. Structures which serves the same function may have difference structural form which may lead to complicated design. Based on the structural form classification we have a shell, solid and framed types of Structures, which have difference design characteristic [15].

Despite the fact that, from the conceptual stages through the constructions up to the final project stages, the involvement of difference professionals in the processes, the importance of the link between architect and structural engineer inspired the me to study it started from when I was in my region Gambella. This is due to the fact that the influence of structural form in the later stage of the design is indispensable. In consideration to these, to obtain the best environmentally friend structure with adequate cost as well as strength and durability, architect and Structural Engineer needs to works in close proximity.

A. The concept of Architectural Development.

Before the architecture development by the concerning professionals, people (owners) may grasp the idea of the functional characteristics of it. The activities that are going to be carryout creates difference types of functions for which experts develop them by creating difference architectural part. Architecture concentrates more on the spatial functionality and aesthetic attribute of the works in hand and is more concerning with the artistic views, feel and functionality of the design. In consideration of these, space will be turned into architecture. In harmony with the owner requirements, the schematic design of the architecture of the whole structural arrangement will be visualized prior to the preliminary and detailed design stage. Now if one begins with the analytical views of the space, the dimensions of architectural elements are at the ends of the chain's relationship, which will be influenced by the overall form of the structural arrangements.

Angus J Macdonald. (1997) state that Thus, although some aspects of the design of structures such as the precise geometry of the beams, column grid or the dimensions of the elements may remain undefined until the lateral stage in the design, many important structural choices will be closed once the overall form of a building has been determined. The early concept of a structure, which determine it over all arrangement of it forms and the proportioning of solid and void with in it, therefore, exerts a high influence on its subsequent structural make-up. These imply that the architect is thus, consciously or unconsciously, a structural designer.

B. Structural Engineers and Architects Ways of Working

Architectural products are totally differenced from each other based on their form together with their constituents at micro-level. Structures are supposed to be a creative product completed by architects and structural engineers together. The capability of architectural design of architects and that of the structural design of structural engineers should be tightly integrated and harmoniously complemented. The architect has a relatively limited role in infrastructure construction than in building projects.

Therefore, architects and structural engineers relay on each other in a corresponding way as for different projects, primary role shifts between them. Furthermore, due to the complexity of intangibility and tangibility as well as actual and abstract notion of the Architecture. Structural engineers focus more on tangible and actual on structures and detail aspects. On the other hand, Architects put great prominence on global and general aspects, such as spatial forms and atmosphere generated. This contradictory ways of thinking sometimes result in difficulty in communication.

This different ways of thinking sometimes result in difficulty in communication. Architects deal with issues in a global and top-to-bottom way. On the basis of experience, they take primal conditions, restraints, and available resources into consideration so as to conceive a spatial arrangement with more concentration on the overall structural form. This will allow for the expression of aesthetic as well as the operational functionality of the architectural system [10].

On the other hand, Structural engineers start their analysis from the bottom to top approach that is from the detailed analysis of difference structural elements as taught by traditional education. Those elements may include a specific beams and columns with certain neglect of an overall performance of structures and requirements of sustainable development. Due to these contradictory ways of working, the creative cooperation as well as effective communication of both structural engineers and architects will be greatly affected and this is one of the constraint in schematic and preliminary design processes [10].

C. Collaborations of Architects and Structural Engineers

As we have seen from the definitions given by difference scholars for an Architectures, we understood that it is the results of the collaboration works of structural engineers, architects, and others professionals. Prior to the detailed design stages which mainly focus on the design of substructures and all structural components including the selections of specific materials, determination of construction technology and detailed design for construction, architect and structural Engineer need to cooperate from the schematic stages. Shaopei, L, Huang, Z. (2016) state that designing from the perspective of the overall performance of the structural arrangement is very important for both structural engineers and architects. It does not mean that detail design is not important. Actually, inappropriate details analysis led to many structural failures. Generally, the first important thing in the design is the comprehensive understanding of the overall form of the structural arrangement as well as the operational functionality of the structure for both Structural engineers and architects which need to be established in advance. Then this will be followed by the focus on the detailed design of the specific overall system, substructures, and components to achieve an optimized design. It is possible and necessary to introduce concepts of mechanics in the early stage of design. The application of the concept of mechanic can be seen during the incorporation of important facility such as vertical and horizontal transportation services which are embodied on the structure as elevator shaft and others essential services for life such as water, electricity, gas, heating, ventilation, air conditioning, and acoustics, lighting and waste disposal. Since those are incorporated from the perspective of functions within the specific geometry, a coordinate arrangement is necessary.

4. CONCLUSIONS

From the definitions of architecture given by difference great scholars, it shows a multi-disciplinary characteristic of its existence. The three essentials elements of architectural design which need to be given proper concerns to evaluate an existing or to design a new structure are functions, Aesthetic and that of structural integrity of the components. Functional consideration means the structures should possess certain operational purposes to meet the need of human activities. Structural integrity means the economic feasibility, Structural liability, and constructability of the structure. Aesthetic experiences mean the harmony of the structure with its surrounding environment and it should also provide the symbol of social and aesthetic values for the user. From the above three essentials elements, architects are more concerned with the functional and aesthetic performance. Structural engineers on the other hands are more concerned with the structural integrity. The Author recommended that the best architectural product could be the work completed by both architect and structural engineers from the commencement of the project and up to the final stage.

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