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Structure, Form and Architecture- An Analysis

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Abstract: It has long been recognised that an appreciation of the role of structure is essential to the understanding of architecture. It was Vitruvius, writing at the time of the founding of the Roman Empire, who identified the three basic components of architecture as firmitas, utilitas and venustas and Sir Henry Wooton, in the seventeenth century, who translated these as 'firmness', 'commodity' and 'delight'. Subsequent theorists have proposed different systems by which buildings may be analysed, their qualities discussed and their meanings understood but the Vitruvian breakdown nevertheless still provides a valid basis for the examination and criticism of a building. This paper aims to understand the relationship between structure form and architecture through various examples of man made and natural structures.

Index Terms **- Structure, Form, Architecture, Structural Stability, Architectural Timeline, Structural Materials.**

I. INTRODUCTION

The two major components in the formation of buildings are the architectural structure and the form. The interaction and conflict between these two components and their balanced growth in the process of manufacturing and development of building techniques led to the creation of a new generation of buildings with an advanced technological structure in which the structure is a generator for the form. The shape stems from its structure and the aesthetic expressions (tectonic) are united or may be harmonious (acting as a whole).

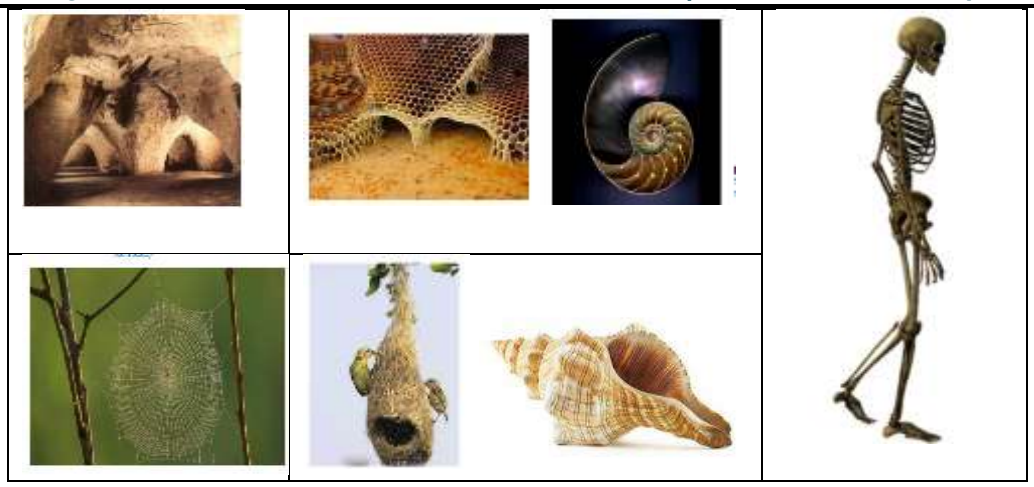
Structure can be defined as "Construction or framework of identifiable elements (components, entities, factors, members, parts, steps, etc.) which gives form and stability, and resists stresses and strains". Form is "the visible shape or configuration of something" and Architecture is "the art or practice of designing and constructing buildings``

Statue of Unity, Gujarat, India

Eiffel Tower, Paris, France

Taj Mahal, Agra, India

Apart from man- made structures Various structural forms can also be seen in nature like the caves, nest of a bird, Ant Hills, human skeleton, shells, Honeycomb etc.



Man made structures follow a process

2. **NECESSITY OF THE PRESENT STUDY**

In the past, building structure is only to keep the stability and ensure the function of the building. With continuously high technology and new materials applied in the area of building now, structure has been the new and important factor of architecture spacial form.

3. **OBJECTIVE OF THE PRESENT STUDY**

The objective of this paper is to learn the relationship between Structure, Form and Architecture to make a synergy between them and create the Architecture structurally strong & stable, functionally optimized and aesthetically pleasant. To achieve this objective we must know the fundamentals and behaviour of structural forms and this can be achieved through case studies along with study model experiments.

4. **STRUCTURAL TRANSFORMATION THROUGH ARCHITECTURAL TIMELINE**

11,600 B.C. to 3,500 B.C. — Prehistoric Period

Bee hive hut, Dolmen, Stonehenge are some of the examples of structures during the Prehistoric period. Bee hive hut was a pyramidal shape dry stone compressive structure which was built using mud and stone. Dolmen is a megalithic structure typically formed from a large horizontal stone slab resting on two or more upright slabs. The structural system of Stonehenge was post lintel or post slab

Bee hive hut

Dolmen

Stonehenge

3,050 B.C. to 900 B.C. — Ancient Egypt

Few famous structures during this period were the Egyptian pyramids and Temple of Edfu. These structures are of monumental scale. The pyramidical form ensures stability and symmetry and stone was used as the building material. Temple of Edfu is also a monumental scale structure and the structural system was post and lintel system.

Egyptian pyramids

Temple of Edfu

850 B.C. to A.D. 476 — Classical Period

This includes the Greek and the Roman period. To understand the structural systems prevalent during this period the Parthenon- Acropolis of the Greek period and Pantheon and The Coliseum of the roman period.

Parthenon-Acropolis Athens, Greece

Pantheon Rome

The Coliseum Rome

Stone was used as the major building material. In Parthenon the Trabeated system of construction was used and Columns act as vertical support element of the main structure. The structural system of Pantheon Rome was Post slab and Post Lintel system. The column was arranged in circular and rectangular was. The ornamentation of both the structures was done using the styles of Doric, Ionic and Corinthian. The Coliseium Rome is a free standing elliptical structure made of stone and Mortar.

527 to 565 — Byzantine, 800 to 1200 — Romanesque and 1100 to 1450 - Gothic

The remarkable structures during these periods are the Hagia Eirene, Turkey of Byzantine period ,the Basicilica of Saint Sernin of the Romanesque Period and Notre Dame De Chartres, France of the Gothic period.

Hagia Eirene, Turkey

Basicilica of Saint Sernin

Notre Dame De Chartres, France

The characteristics of Hagia Eirene was that brick, limestone and sand mortar was used instead of stone and domed roofs and elaborate mosaics and classical forms were used. Basicilica of Saint Sernin was a transitional Architecture with a Byzantine-domed Apse and an added Gothic like steeple. It was constructed of stone and brick. Notre Dame De Chartres, France used the post and lintel structural system and Pointed Arches, Flying Buttresses and Ribbed Vaulting. Stained glasses were used as ornamentation element.

1400 to 1600 — Renaissance, 1600 to 1830 — Baroque, 1650 to 1790 — Rococo and 1730 to 1925 — Neoclassicism

The structure and Architecture during these periods can be understood through examples like Villa Rotunda, Italy of the Renaissance period, Palace of Versailles, France of Boroque period, The Helblinghaus, Austria of Rococo period and United States Capitol USA of the Neoclassicism period.

Villa Rotunda, Italy

Palace of Versailles, France

Helblinghaus, Austria

United States Capitol USA

Villa Rotunda, Italy is characterised by symmetry , use of Dome and Arch and post and lintel structural system. Palace of Versailles had complex shapes, extravagant ornaments, opulent paintings and bold contrasts with the use of Vaults, Arches and Buttresses. The Helblinghaus, Austria is characterised by decorative designs with scrolls, vines and shell shapes and delicate geometric patterns. United States Capitol is symmetrical with dramatic use of columns, domes and Arches with the use of Post and lintel structural system.

1890 to 1914 — Art Nouveau, 1895 to 1925 — Beaux Arts, 1905 to 1930 — Neo-Gothic and 1925 to 1937 — Art Deco

The examples to understand the structure, form and Architecture during these periods are the Hotel Lutetia, Paris of Art Nouveau period, Palais Garnier Opera House, Paris of Beaux Arts, Woolworth Building, New York of Neo-Gothic period and Chrysler Building, New York of Art Deco Period.

Hotel Lutetia, Paris

Palais Garnier Opera House, Paris

Woolworth Building, New York

Chrysler Building, New York

Hotel Lutetia, Paris of Art Nouveau period is characterised for Ornamentation , Asymmetrical shapes, Arches and Decorative surfaces and Palais Garnier Opera House, Paris of Beaux Arts is also characterised for Ornamentation , Arches and Decorative surfaces but Order, symmetry, Formal Design and Grandiosity was used. Woolworth Building, New York of Neo-Gothic period was a framed high rise structure with strong vertical lines and a sense of great height. It had Arched and pointed windows with decorative tracery. Chrysler Building, New York of Art Deco Period used Steel and concrete as building materials and was a Ziggurat shaped high-rise structure with terraced pyramid shapes with each storey smaller than the one below.

1900 to Present — Modernist Styles, 1972 to Present — Postmodernism and 1997 to Present — Neo-Modernism and Parametricism

The examples to understand the structure, form and Architecture during these periods are United Nations Secretariat Building Manhattan, New York City of Modernist Styles, Sydney Opera House Australia of Postmodernism period and Heydar Aliyev, Baku of Neo Modernism and Parametricism.

United Nations Secretariat Building Manhattan, New York City

Sydney Opera House Australia

Heydar Aliyev, Baku

Nations Secretariat Building Manhattan is an example of framed structure using reinforced concrete and steel as building materials. Sydney Opera House Australia of Postmodernism period Heydar Aliyev, Baku of Neo Modernism and Parametricism are examples of large span RCC Shell structures.

5. STRUCTURAL REQUIREMENTS

To perform its function of supporting a building in response to whatever loads may be applied to it, a structure must possess four properties: it must be capable of achieving a state of equilibrium, it must be stable, it must have adequate strength and it must have adequate rigidity. Structures must be capable of achieving a state of equilibrium under the action of applied load. The requirement for adequate strength is satisfied by ensuring that the levels of stress which occur in the various elements of a structure, when the peak loads are applied, are within acceptable limits. This is chiefly a matter of providing elements with crosssections of adequate size, given the strength of the constituent material. The determination of the sizes required is carried out by structural calculations. The provision of adequate rigidity is similarly dealt with Architectural structures must, therefore, be capable of achieving equilibrium under all directions of load. This requires that the internal configuration of the structure together with the means by which it is connected to its foundations must be such that all applied loads are balanced exactly by reactions generated at its foundations. Geometric stability is the property which preserves the geometry of a structure and allows its elements to act together to resist load. The application of load to a structure generates internal forces in the elements and external reacting forces at the foundations and the elements and foundations must have sufficient strength and rigidity to resist these. They

must not rupture when the peak load is applied; neither must the deflection which results from the peak load be excessive.

6. STRUCTURAL MATERIALS

The shapes which are adopted for structural elements are affected, to a large extent, by the nature of the materials from which they are made. The physical properties of materials determine the types of internal force which they can carry and, therefore, the types of element for which they are suitable. Unreinforced masonry, for example, may only be used in situations where compressive stress is present. Reinforced concrete performs well when loaded in compression or bending, but not particularly well in axial tension. The processes by which materials are manufactured and then fashioned into structural elements also play a role in determining the shapes of elements for which they are suitable. These aspects of the influence of material properties on structural geometry are now discussed in relation to the four principal structural materials of masonry, timber, steel and reinforced concrete.

7. RELATIONSHIP BETWEEN STRUCTURAL FORM AND STRUCTURAL EFFICIENCY

The shapes of structural elements, especially the shapes of their longitudinal axes in relation to the pattern of applied load, determine the types of internal force which occur within them and influence the magnitudes of these forces. These two factors – the type and the magnitude of the internal force created by a given application of load – have a marked effect on the level of structural efficiency which can be achieved because they determine the amount of material which must be provided to give the elements adequate strength and rigidity. Elements in architectural structures are subjected principally either to axial internal force or to bending-type internal force. They may also be subjected to a combination of these. The distinction between axial and bending is an important one, so far as efficiency is concerned, because axial internal force can be resisted more efficiently than bending-type internal force.

8. CONCLUSION

Through all these studies it can be concluded that the relationship between form and structure has been subjected to several i.e. more than one point of view during the historical stages of architecture. The first point of view is that the shape is the determinant for the structure. Previously, structural considerations were not of utmost importance during the initial design stage when determining the architectural form. The other point of view is that the structure is the giver of the form, and the exterior view of a good building should be nothing but a visual expression of an effective structural reality and not the primary basis of the structure.

Due to the impact of technological development and the emergence of digital programs and following the Parametric design, the concept of design of the architectural form had changed and the shape has not been designed randomly but follows a set of rules for formal generation. The most important of them is the influential forces, where the concept of form follows the forces has been emerged, expressing the impact of forces through dealing with the structural behaviour of building and materials, and thus, the form became subordinate to

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