The Role of Geometry in Architectural Design: Exploring Form, Space, and Structural Integrity

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1. Abstract

Geometry is the language of man, and it is developed by man and used in various ways. According to Francis D.K. Ching's "A Visual Dictionary of Architecture," geometry is "a branch of mathematics that deals with the properties, measurement and connection of points, lines and angles, end solids, deduced from the describing conditions by means of certain assumed properties of space." However, varied applications of geometry give rise to a number of other definitions. It gives the building a sense of continuity and structural integrity. The way that humans perceive the outside world and articulate the world inside of them is through geometry. Geometry is the "common language" of the planet. Life is based on geometry, which is also the material foundation upon which we construct the symbols that stand for our divine and flawless selves.

Keywords – geometry in architecture, architectural order, form and space, structural integrity, proportions and ratios, spatial organization, design elements, visual perception, architectural composition, geometric principles

2. OVERVIEW

Geometry is a summary of the fundamental components, structures, and sequences that make up an architectural work. It is possible to perceive and experience each of these components. While some may be easily noticeable, others may be more hidden from our senses and mind. In a building's structure, some may be dominant while others have a supporting role. While some may function as qualifiers or modifiers of these signals, others may communicate meaning and pictures.

However, these components and systems must always be connected to one another in order to create a cohesive whole with a unifying or coherent structure. When the arrangement of components clearly demonstrates how they relate to one another and the framework as a whole, architectural order is established. There is a conceptual order that may be more permanent than fleeting perceptual perceptions when these links are seen as complementing one another and contributing to the unique nature of the whole.

Since geometry is the foundation of my study, I have attempted to identify connections between it in a number of areas, so geometry serves as the basis for all of the criteria. Geometry appears in the form and shape of many architects' creations. In both the plan and the details, geometry is clearly seen as the space sequence. The entire structure is represented by geometry, to which philosophies are

affixed. A later section of this dissertation report discusses each of these requirements.

3. GEOMETRY ESSENTIALS

3.1 POINT

A point is the essential component of the basic design process. The foundation of all geometry is the point. The most fundamental and fundamental geometrical element is the point; it is infinitely small but not dimensionless. One could argue that its diminutive size is always contingent upon the frame in question. A point has no length, width, or depth; it just represents position. It doesn't occupy any space because it is simply there, making it stagnant, centralised, and aimless. In many geometric elements, it is the start and finish of a line and the point where two lines converge or cross to form a centre.

A location in space is indicated by a point. It is conceptually stagnant, centralised, and aimless since it lacks length, width, and depth. A point serves as an organisational element in architecture and is the only one that provides "consistency" in the interaction between the point and other peripheral elements. In the lexicon of form, a point can be used as the primary element to indicate:

- The line's two ends
- Where two lines meet
- The intersection of lines at a plane or volume's corner
- The field's centre

3.2 LINE

A point's route becomes a line as it progresses. Since the dawn of civilisation, lines have been one of the most basic components of design. Lines have always captivated people. From the infinite horizon to the fragile venis in a leaf, from the rising to the vertical sketch or painting, lines are present in every aspect of one's existence. There are lines of many kinds in the natural world. Numerous natural configurations can be found if one examines the environment around them.

The line is also occasionally referred to as the axis, or distance, between two locations. In contrast to a point, which is by definition static, a "line" is a vector scale that has length but neither breadth nor depth. A line can visually convey direction, movement, and growth when it describes the trajectory of a moving point. It creates a plane's edge. Other graphic elements can be joined, linked, supported, surrounded, or intersected with it. Give planes shape and describe their edges.

Two factors determine whether a form is arranged as a line: (a) its width is very small, and (b) its length is noticeable.

3.3 PLANE

The trace of a line's route describes a plane if it moves in a direction different from the intrinsic direction. Any flat shape that isn't typically thought of as a point or a line on a two-dimensional surface is a plane. The plane's third dimension is its length and breadth, but not its depth. Conceptual

lines that make up the form's edges enclose a planar form. The shape of planar form is determined by the properties of these conceptual lines and how they relate to one another.

The two most fundamental planes of a spatial unit are vertical and horizontal. These are the main architectural topics of interest. A plane defines the boundaries or limits of a volume in the composition of a visual construction. The plane ought to be considered a crucial component in the lexicon of architectural design if architecture as a visual art is particularly concerned with the creation of three-dimensional volumes of mass and space. In essence, human movement and activity take place on the horizontal plane. Each space's limit, and consequently the limit for horizontal movement, is the vertical plane.

The two most fundamental planes are horizontal and vertical.

3.4 VOLUME

A volume is created when a plane is stretched in a direction different from its inherent direction. The three dimensions of a volume are conceptually length, breadth, and depth.

Every volume may be examined and is thought to be composed of:

1. Points or vertices where many planes converge

2. Lines or edges where the planes converge

Surfaces or planes that delineate two borders or limitations of a volume

3.5 FORM

Form is a broad concept with multiple definitions. It could be used to describe a recognisable exterior look, as that of a chair or the human being seated on it. As in the case of water in the form of ice or steam, it may also refer to a certain state in which something acts or manifests itself. The phrase is frequently used in art and design to refer to a piece's formal structure, or how the components and aspects of a composition are arranged and coordinated to create a cohesive image.

Form in the context of this research refers to the external contour, internal structure, and the concept that unifies the whole. Shape is more precisely defined as the fundamental component of form that determines its appearance—the arrangement or relative placement of the lines or contours that define a figure or form—even if form frequently incorporates a sense of three-dimensional mass or volume.

4. THE FORM'S PRIME GENERATORS:

4.1 AMOUNT

A proportion is an organised relationship, whether visible or invisible, between two similar items. Geometry, arithmetic ratios, and visual perception can all be used to manipulate and experience it. It has been discovered that a specific ratio generally satisfies human senses.

Geometrical concepts are the foundation of the proportional system. This system establishes

relationships between components to create a harmonious whole. It facilitates the creation of an organised relationship in the design. It is a system for connecting the many elements of a composition. This technique creates an integrated whole by breaking up larger sections into smaller ones. Within a single composition, it creates a system of proportions between linked parts of various sizes and shapes. Within a single composition, it creates order and harmonises parts of various sizes and shapes. It harmonises components of various scales and creates order. Achieving unity, balance, rhythm, and other aspects in the composition of elements is accomplished through the use of proportion.

4.2 SETUP

The methodical placement, joining, and coordinating of components to create a cohesive whole that is both conceivable and perceptible and that fulfils a desired role for essential operations and activities is known as organisation. Organisation leads units of aim to the entire composition and creates a harmonised composition that relates to the different sections. By arranging and regulating the relationships between solids and voids, solids and solids, and voids and voids, it creates sequence.

An order of linking between the many components that coordinate each other for essential functions and form a cohesive whole is called organisation.

4.3 CIRCULATING

"Route of Movement" is the phrase used to describe the route used to travel from one place to another. Since it is difficult to travel a route without a destination, the path that connects an observer to his destination is of utmost importance.

The perceptual thread that connects a building's areas or any collection of interior or external spaces can be thought of as the path of our travel.

We experience a space in connection to where we have been and where we hope to go because we travel through a sequence of spaces in time.

4.4 FORM AND SPACE

"Geometry" has to do with space and form. Thus, an attempt has been made to investigate the level of geometry in various shapes and areas, such as buildings. A recognisable outward look may be referred to by the encompassing term "form," which has multiple connotations. The foundation of an architectural approach is a person's perception of an architect. When starting a new project, the concept of space and form is always the starting point and focal point.

Form alludes to the idea that provides a whole its wholeness as well as its internal and outward structure. However, the majority of efforts focused on the form's exterior configuration. Shape more precisely refers to the fundamental elements of form that determine its appearance (characteristic contour), even if form frequently include a sense of volume. Forms and spaces (shape) also have visual attributes like texture, colour, and size. The pattern and arrangement of elements, as well as their location, orientation, and visual inertia, are all governed by the relational qualities of forms.

5. SPACE QUALITIES, CONSTRUCTED AND DECONSTRUCTED

Let us think about what a vista means, which is not present in one kind of garden but is there everywhere in the other. In addition to being highly manufactured, a French garden is also highly artificial. Instead than appealing to one's emotions towards nature, its trees and flowers serve as material that subordinates the entire scheme. There is an obvious separation between form and material, with the former obviously dominating the latter. Trees are classified as conical or cubic in shape, despite the fact that they are constantly evolving and being generated, and the effects of this activity are not recognised. Only rectangles and circles are placed and organised on the large, flat, gravel-paved plot, forming a symmetrical, geometrical pattern. All other plants have been exiled from the garden. The only surface that will never change is a perfectly motionless one. The full dominion of the intellect is demonstrated by the ability of materials, such as water or trees, to produce a single, cohesive garden without regard for diversity or generative alterations. The end effect is a well designed area.

Making a thing insubstantial gives it transparency and gives eyesight a special quality. Visual transparency is the ability to see through an object's entire surface. The source of light and vision power within the self appears to be God-like, placed at the vertices of a cone-shaped world, allowing the self to see into the furthest reaches of the cone. This conical issue is undoubtedly approached by transparency in accordance with the law of perspective.

Every time new leaves grow on plants and threaten to distort conical forms or other geometrical patterns, a gardener must use his shears with extreme caution to correct even the smallest aberration. Deformity or distortion must be found and removed as soon as it occurs for any reason. An enclosure created by a conical or cubic plant keeps meaning contained and stops it from fading or straying. Therefore, a French garden can be said to consist of only one landscape when the spatial order converges on a single point. It entirely ignores the polysyllabic richness of landscape and vision. That's the fundamental idea of a built garden.

But what happens if the garden is outcropped, as opposed to French, and the landscape is allowed to sway and agitate as it pleases? What if vision moved from one distorted fragment to another in response to changes in the buyer's perception or actions, rather than heightening perception, expanding the cone of vision, and ultimately achieving integrating the landscape through openness at a larger scale? A Japanese garden might be the outcome.

A Japanese garden is characterised by the lack of a perspective, as was previously mentioned. The multi-layered nature of the terrain, which is seen in the trees, rock formation, and planting, is the reason for this lack of view.

There is always fragmentation in the landscape, and rock blocks rock. Additionally, seeing is prohibited throughout this entire garden. Similar to Tenryuji or Nanzenji's garden, the landscape is composed of overlapping, connected landscapes with minor deviations. Different landscapes coexist. There are always concealed areas because of overlap. Changing one's point of view can reveal a hidden component, making what was before evident latent. Because of this technique, it is challenging to capture the entire garden. Although the spectator can clearly see the scene in front of

his eyes at all times, it can be challenging to organise the overall plan. He finds it hard to gauge how big his design is in relation to the garden as a whole or how far away a particular plant or rock is, and without a defined hierarchy, different landscapes are created as one's perspective changes. When a Japanese garden lacks a transcendent centre or vision that can provide order to space, it loses perspective and becomes unconstructed space.

But after all, the Japanese garden is a purposefully man-made entity, so derogatory adjectives like "without order" or "unconstructed" are undoubtedly insufficient. The seeming lack of order must be rooted in a Deconstructionist concept that deliberately encourages irregularity. Parts of the continuous, multilayered landscapes do not merely and voluntarily connect themselves. In that case, perhaps there is something to learn about the connections between the parts.

6. Development of geometry from antiquity to the present

The cornerstone is geometry, which also carries the noble joy of mathematics. Geometry is what creates machinery. The era we live in is fundamentally geometrical. Each and every concept is focused on geometry. Following one hundred years of investigation, modern art and ideas are now looking beyond the purely coincidental. They develop mathematical forms and a more geometrical mindset as a result of geometry. One type of organisational tool that is utilised is geometry. A variety of mythological theories are connected to geometry.

Man constructed geometry by affixing different theories to geometrical shapes. Hindu philosophy holds that many symbols have distinct meanings. For example, the "square" is symbolic of the "earth" in accordance with the cardinal points. It is also believed to be the home of a deity. It is an element of basic geometry that is mysterious and absolute. Because it has a religious foundation, it does not allow for any alterations during the transition process. The primary regulating element is the "triangle," which represents the Indian "Trinity." Basic geometric forms were established by humans based on natural forms.

The 'circular' is depicted in Islamic architecture as a form that has neither beginning or end, representing eternity. It embodies fairness and is the most ideal. The most fundamental and parent figure of all geometric polygons is the circle. Islamic architecture is increasingly characterised by the "Dome," a very geometric aspect. People consider it to be a "image of heaven." The "square" is considered to be the most externalised form of creation and a representation of the "earth." These fundamental geometric shapes are employed in a variety of ways in public and religious structures. The square-shaped courtyards are found in the tombs of the king and queen. Both tombs have domes constructed according to Islamic custom. Likewise, "square" is used for courtyards in the majority of mosques, and "dome" is used for tombs. The mosque was developed using a combination of squares and circles.

By embracing a single religion, a single set of rules, and a single civilisation, the Romans aimed to establish a symbolic representation of a new kind of organised global order. This organisational spirit is demonstrated by the way they group buildings, as in the Forums, how they organise business activities in common areas, how they combine three orders on the building's exterior, as in the Colloseum (Tuscan Doric on the first, Ionic on the second, and Corinthian on the third and fourth);

how they combine Ionic and Corinthian to form the composite order; how they develop multifamily apartment houses; how they provide different types of recreation in baths; and, lastly, The immense halls of the Baths, Basilicas, and the Partheon exhibit an arrangement of the growth of internal space (as reported by Fleming in 1974). The Romans are credited as being the primary creators of geometry in ancient civilisation.

Its shape is derived from the union of a hemisphere (dome) and a cylinder (rotunda) over a circular floor plan. The Pantheon's design demonstrates the harmonic arrangement of a rectangle and a circle. Two squares make up the rectangle, and each square's diagonal equals the circle's diameter. Therefore, it is evident that the 'latent geometry' establishes a relationship between the Pantheon's rotunda and portico thickness. Through the opening zenith, it creates a meaningful whole by uniting a celestial dome and a longitudinal axis, with the vertical rising freely to the heavens. The floor's centre, not the sphere's centre, was the point that needed to be emphasised. With its complete simplicity, the Pantheon served as the model for the centralised building. Various times saw the form's revitalisation, each in a unique way. In the succeeding ages, even the illumination of a dome acquired a mystical quality. Form as a geometrical organisational tool was exemplified by the Romans through the creation of the Pantheon.

Some applications of geometrical forms were discovered by the Greeks. Greek was the first to conceptualise autonomous forms that were not dependent on any one unified word perspective.

Rectangular planes with a conical dome roof over them made up the fundamental shape of Gothic and mediaeval architecture. The buildings were primarily central in shape. Examples of the extension of the centric from into rich and complicated spatial compositions, such as a high centric space encircled by a ring of lower space, were found in addition to the single space building. In 359 A.D., the principle was applied in S. Constantina, Rome, where a barrel vaulted ambulatory surrounding the modestly sized dome.

Three axial chapels and an ambulatory in S. Lorenzo, Milan, disrupted the pure circular design. The sixteen-sided water shell was created in Ravenna's octagonal core area of S. Vitale. Richness and complexity were gradually being added to the form.

The external and interior shapes of Gothic and Renaissance cathedrals, as well as Turkish mosques, were formed during the Middle Ages by combining the development of central and linear forms and juxtaposing them. A centric space is traversed by a linear path, which shows how the two basic concepts intersect. When the cross is superimposed on the circle, it forms a potent symbolic design, a kind of mandala, in which the goal and the journey are combined to tell a stirring tale of faith and release.

In early Christian architecture, inherited spatial shape served as a manifestation of a few basic geometrical concepts. From here, Byzantine architecture differs from Early Christian building in the "Third Dimension" feature. From this point on, the fundamental ideas did not change as the third dimension developed. Romanesque architecture is characterised by its skeletal framework and an extra tower. Gothic architecture was distinguished from Byzantine architecture by its use of pointed arches and its logical vaulting and buttressing system.

A major component of Renaissance architecture was geometry. Using functions, the spatial geometry was established. By incorporating various geometric elements that maintained their identities while reacting to the full configuration, larger organisations were accomplished. His study makes clear that functions were presupposed by perfection shape, with the circle being the most divine and ideal form.

The structure in the Vatican that symbolises the renaissance's development is St. Peter's. The sixteenth-century talents Bramante, Vinci, Michelangelo, and Raphael were all active in Rome during the papal era. In 1503, Bramante was the first to sketch two church layouts. The "pentrigion," according to his interpretation, is the core layout with four towers at each corner. In the first option, the Greek cross was widened, creating a domical centre from the dome. The inner arms formed a square ambulatory around the middle of this fully centralised church. In the second effort, four semi-circular north axes were added around the four apses of the main area, and the load-bearing piers were generally strengthened. A semi-spherical dome overshadowed the core area, emphasising the center's significance to both Rome and all Christians.

The objectives and techniques of human creativity were altered by industrialisation in the 18th century. Certain shapes used in the Roman Byzantine, Romanesque, Gothic, Renaissance, and baroque periods have taken on new dimensions, personalities, and styles, and have come to represent this era.

Futurism originated in Italy as a response to the country's need for cultural revitalisation. When the comparable forms were combined, a unity was produced. The new paintings reject the cube in favour of dynamic arabesques like the spiral, elliptical, sphere, and any other dynamic shapes that artists might come up with.

Based on the remnants of the Arts and Crafts Movement in Germany, the Bauhaus was established in 1919 and had an unparalleled success in influencing architectural education globally. Without considering the ultimate strength of materials or the purposes of buildings, the Bauhaus pioneered the study of architecture through the manipulation of abstract shapes. In terms of a wonderful form, it was done only to achieve ornamental appeal. Large-scale abstract sculpture became a form of architectural art. Utilising the lexicon of contemporary cultural forms to meet the structural and functional needs of a particular architectural scheme is an art form. One can clearly see how severe geometrical planes were used as adornment. Hans Mayer, the director of the Bauhaus from 1928 to 1929, made the following observation: In spite of Gropies' claims that architecture has developed sociology, theirs was a synthetic universe of shapes that terminated in a cube with yellow, red, and blue sides. People lived in homes like coloured sculptures and sat and rested on furniture like coloured geometry amid a world of white, grey, and black.

1917 saw the development of the "De Stijl" moment in Holland. In order to create a balanced relationship between uneven portions, horizontal and vertical lines were used at right angles. In the De Stijl movement, architects were tasked with creating symbolic pictures that hinted at the collapse of art into the New Harmony concept; the form was not actually utilised as an organising tool for geometry. In Utrecht, Rietveld's well-known "Schrodler House," constructed in 1924, is a prime

illustration of the De Stijl. It appears to show that the architectural embodiment of De Stijl at the time could actually be turned into a real structure.

The 'Purism' movement was another movement that began in France in 1918. Purification of the use of Cubist shapes in machine iconography was the goal. Charles Edourd Jeanneret (18871985) and Andee Ozenfant (188E1966) both published "Le Cubism" (after Cubism) in the same year. Since cubism has turned into ornate ornamentation, the emphasis was on art in its purest form.

Purist aesthetics became a lexicon that Le Corbusier cultivated. Painting was developed based on his hints. His philosophy of mechanisation and modernity, along with his idealisation of platonic solids, had a significant impact. The hallmark of avant-garde architecture is its ability to regulate surface or to examine the overall rationalisation of building design procedures. Surface regulation was frequently the outcome of the plan and section's overall rationalisation into rectilinear geometry. Most of the time, it went beyond just practical demands. Le Corbusier's designs once again set the standard for form as the fundamental organising principle for geometry.

Many architects created architecture using various geometric standards alongside Le Corbusier and after him. The most intriguing Neo-rationalist was Aldo Rossi. His shapes were derived from geometry and then filtered via historical context. It was an identification attempt, which can only be made by appealing to mental imagery and consciousness. The foundation of Rossi's compositional approach is the unexpected and atonal collection of archetypes that has sprouted from memory and can be reconfigured as shape to interpret new architecture possibilities. He views analogy as more than just a means of introducing visuals with implicit meanings and mnemonic references.

7. FINAL COMMENTS

- The primary focus of this study has been the visual characteristics of the geometrical principles of form and space in architecture throughout this presentation.
- Lines defining planes, planes creating volumes of form and space, and points moving through space and establishing lines.
- These features serve more than just visual purposes; they also convey ideas of domain and location, entry and movement path, hierarchy, and order through their interactions with one another and organisational structure.
- Associative values and symbolic content are also connotative meanings of architectural forms and spaces, and their meanings are influenced by cultural and personal interpretations, which can evolve over time.
- By fusing forms and space into a unified essence, geometry not only makes purpose easier but also conveys that elements can be meaningfully organised through the deliberate application of geometrical organising rules.
- Geometry is based on the concepts of ordering.
- Our existence is made meaningful and evident by geometry.

- I was led astray by case studies of various buildings, such as the Eisenman House projects and the Guggenheim Museum by Frank O. Gehry, to believe that deconstruction does not adhere to any geometrical theories.
- I've concluded from this dissertation that deconstruction's buildings adhere to hidden geometry.
- Because deconstruction is a relatively new idea, I was interested in learning more about it. This dissertation has led me to conclude that deconstruction has improved geometry and elevated it to a new level.
- It can be observed that only constructivist designs adhere to geometric rules when comparing them to deconstructivity designs.

Here's the shuffled list of references:

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