Gothic Architecture: Evolution Of Proportion And Geometry Through The Ages

The objective of this essay is to critically analyse and show how, since ancient times proportion and geometry have always been the fellow companions of architecture on its journey of evolution through the ages. Throughout history, appreciated architecture has always emanated from an adequate knowledge and understanding of some form of geometric principles. To understand this interconnected bond between proportion, geometry and architecture we must first understand their origins and definitions. We understand that architecture is defined as the art or practice of designing and constructing buildings. However, we will be gazing at it through a much wider scope which will also encompass all its forms including design, planning, environmental design and structural engineering. Origins of the word can be traced back to mid-16th century from Latin architectura, from architectus (architect). In a similar fashion geometry is defined as the branch of mathematics concerned with the properties and relations of points, lines, surfaces, solids, and higher dimensional analogues. Initial traces of the word come from Middle English via Old French geometria, acquired from Greek g? ‘earth’ + metria. Likewise, proportion comes from Old French, proportionate ‘in respect of a share and is now defined as the relationship of one thing to another in terms of size, quantity, or parts of a whole. The Golden ratio is the fundamental display of harmony between proportion and mathematics applied by nature in the universe and by man in art. Early man demonstrated his grasp of geometric patterns in the decoration of objects and dwellings through weaving is a testament to the further influence of geometry in the progression and development of architecture. Federov (1981) established only seventeen symmetry group patterns of a plane exist. Yet, mankind is not exhausted by the countless imitations of these patterns as combined with architecture the possibilities are seemingly infinite. All seventeen patterns appear together on one building, The Alhambra, Granada to showcase how artistic creativity is not held back by mathematics instead, it imbues aesthetic purpose and meaning to the design. Here, the focus will be on the correlation of proportion, geometry, mathematics and architecture. The presence of ample historical evidence is conclusive of long architectural periods of a large region being influenced by a single geometric aspect. The world of architecture has also been honoured by architectural masterpieces designed by scholars of mathematics and geometry like Vitruvius, Kepler, Brunelleschi, Alberti, Leonardo da Vince and Christopher Wren to name a few.

Recent developments in archaeology and historical research techniques have uncovered that the earliest pithily designed structures were built in the early Mesolithic era, around 9000 BC. Prior to which rock formations and caves provided man with a more rudimentary form of shelter. In the Introduction, it was established how primitive man displayed a simple mathematical understanding. At the time, the options for materials was limited and thus, lack of resources restricted man to fulfil his needs in the construction of his dwelling. This was a period of overwhelming domination of the vernacular format of architecture. Around 5000 BC, all over the world various early communities began developing masonry and from it, simple structures (Hofmann and Smyth 2013). Buildings were now being constructed with crude walls consisting of stacked dried mud bricks. For example, during the copper age in Turkey, people began arranging orthogonal masonry walls to form a cellular structure capped with a timber shingled roof. At the same time timber structures with thatched roofs began appearing in and around Europe. Around 4000 BC the Sumerians erected structurally sound reed houses. These were

constructed by bundling and bending reeds into an arch, matting mud and using reed as filler. Astonishingly, they are comprised of all the structural elements found in Gothic and Romanesque cathedrals (Sandstrom, 1970). As mankind developed. Mathematics too saw its advancements. Need to keep time for sowing, harvest and trade gave birth to the development of calendars, simple weights and measurements. However, the first leaps of advancements in the fields of mathematics and architecture were taken by the Egyptians with the introduction of a variation of the decimal system, the Egyptian civilisation was progressing further developing astronomy and further polished mathematics and architecture (Rossi 2004). From 3000 BC to 500 AD Egyptian civilisation witnessed rapid developments in various fields of science. This in turn led to the creation of many fascinating structures accomplishing feats considered impossible around most of the world. The Egyptians felt a deep connection between religion and astronomy. This connection was harmonised by Geometry and thus used to reflect upon the ‘cosmic order’. Man’s deep interest in the cosmic orders of the universe was facilitated by astronomy, geometry and mathematics. Tons Brunes in his works ‘The Secrets of Ancient Geometry’ suggested that an ancient form of an occult system of geometry was the basis of the design and structure of ancient architecture. He argued that this system consisted of certain geometric proportions and numerical dimensions which were held on to a sacred pedestal and a source to a higher power. His claims are granted by the construction of the great pyramids. The Largest manmade structure of its time, to grace the earth was built by arranging massive stones with hairline precision to form the great pyramids in an exact symmetrical proportion of the previously mentioned golden ratio to the accuracy of three significant figures of the decimal place. It is also theorised that the pyramids are aligned with the Orion constellation and were purposely built in this way with deliberation. This sense of concern for accuracy reflects on mans desire to look up at the cosmos for inspiration and guidance. Whether Brunes theories are irrefutable is yet to be seen, but he manages to show the existence of basic geometric patterns and proportions in the construction and design of ancient structures.

It is often argued that the Greek civilisation laid the stones for the western civilisation through their contributions to geometry and art. The Greek were seeking answers to questions people of other cultures would find hard to fathom. Unlike their Egyptian counterparts, the Greek placed great importance to civic life and religious affairs previously restricted to the higher class was now open for debate. They held a belief that the universe expressed itself through geometric patterns in nature. They wanted their buildings to be beautiful and aesthetically appealing, this was most notable for temples. They wanted to attract more pilgrims and attendees to the temples. This resulted in exemplary architecture with the introduction of temple construction. The Greeks developed fine masonry techniques as their familiarity with stone materials increased. This led to new ideals and standards of construction and paved the way for the Greek orders – Doric, Ionic and Corinthian. Each with its own set of shapes, positions, proportions and dimensions. The tapered Doric columns is a perfect example of the Greek attention to proportion. The Greeks considered these orders as representations of human anatomy as the Doric representing the male, while ionic representing the female. With this new style and techniques, they managed to blur the defining edges of their structures, thus altering the perspective. This need for proportionality led to standardisation or modulation of dimensions with lower half of the diameter of a column as the proportional basis for the rest of the structure. The temples were dwellings for the Gods, craftsmen and architects focused on the use of golden ratios, Pythagorean numerals to satisfy them as they felt mortals were servants to the immortal. They designed their towns with large central open public spaces called agora. The agora was the place where debates on all matters and affairs were held. The façade of the Parthenon designed during the Greek period demonstrates yet another application of

proportions kept constant in the design and structure while emitting a sense of aesthetic pleasure for the observer. Greek contributions were mainly to the use of proportion of the human body to create more Aesthetic architectural systems and relied less on advancing structural development.

Roman conquest resulted in the formation of an empire that controlled most of the known world and this resulted in an influx of knowledge, culture, skills and techniques being introduced to the Roman world. At the same time demand for construction drastically increased as new public and official buildings were required for the governance of such a vast empire. The Romans now hired craftsmen from Greece and other conquered lands, thus adopting Etruscan and Greek architectural practices. Although the Romans adopted the Greek orders, they developed two of their own, the Tuscan and the Composite order. The Tuscan was a plain and simplified version of the Doric order, while the composite was an amalgamation of the Ionic and Corinthian orders. Well known for its developments in the arch, vault and dome. Documents from Roman antiquity have very rarely survived, however one piece of work has stood the test of time, treatise De Architectura by Vitruvius Pollo. Vitruvius presented his principles of architecture: structure (firmitas), function (utilitas), beauty (venustas). He proposed that a building must serve its purpose while possessing structural security without compromising on aesthetics. In his works he reflects on mostly the Greek orders influences in roman architecture but points out in detail how architectural perfection can be achieved through careful and meticulous design incorporating his three principles with adequate weightage towards each principle. He describes in detail the scholarly credentials required by a successful architect as he points out that a vast number of fields are required to properly design and execute architecture properly.

By the 12th and 13th Century, England and France were advancing with more pace than ever. During the medieval period the world was viewed as a reflection of religion. Medieval Christianity emerged as a new religion from Judaism. It was then regarded as the only true religion and followers of any other were heretics. From this influence of religion, came the gothic architecture with the construction of the Abbey of St Dennis, Paris (1135 – 1144 AD). In a time of religious symbolism, gothic architecture brought meaning to the medieval world. Buildings previously commissioned only by the kings and ruling class were now being commissioned by wealthy merchants. These merchants commissioned the construction of elaborate chapels to save them from purgatory and protect them in the life after death. Priests were of these chapels were paid heavily as a legal contract, to say mass and pray for the soul of the commissioner. These gothic chapels were adorned with remarkable sculptures, symbols and paintings. All depicting religious saints and holy men who possessed special powers or were differentiated by possession of their sacred artefacts. They were designed to be welcoming and awe-inspiring structures. Cosmology was now an integral part of the complex medieval society as geometry was being used to portray the grand meaning of the cosmos. Complex patterns from geometric shapes began to appear all around Europe and gave birth to Geometric expressionism. The society was a very secretive one and so guilds were formed of artisans and craftsmen who worked together and avoided sharing their craft secrets outside the guild. Focus of man was being pushed to see the real deeper beauty of these religious buildings not through our eyes, but rather the mind’s eye. For one to understand the science and reason of religion, one had to be spiritual enough to seek the hidden meaning of the cosmos. Buildings were now considered as machines to reveal the divine truth of the cosmos. This language of cosmology was making its way everywhere and the use of aesthetic geometry was rapidly gaining popularity. Gothic architecture became the much-desired form of structural design. Gothic cathedrals began using geometry mathematic and proportion more effectively. Artisans and craftsmen following the

principle of Greek orders encapsulated cathedrals in detailed and complex geometric patterns and configurations. Buildings were adorned with sculptures of saints and holy figures who were the icons of behaviour considered ideal by medieval society. Easily identifiable by the common man due to each possessing identifiable objects or characteristics. The majority of medieval Europe was illiterate and could not read thus, symbolism was an effective way to convey the ideals, morals and ethics to the populous through religious iconography. Bad behaviour was addressed through the portrayal of devils and demons. This effective use of geometry led to gothic architecture being dubbed ‘The Architecture of Geometry’. The 13th century masons were not adequately knowledgeable in structural engineering and structural integrity and resolved their problems through hard earned experience or a strenuous method of trial and error. This experimentation of geometric designs to securely erect a building resulted in development of new skills and techniques. These new geometric designs were realised after combing knowledge of Greek classical orders with developments of mathematics by the Arabs. At this time approximately 80 cathedrals were constructed or renovated between the period of 1150 and 1280 AD. Arabian influences had crept in through the crusades and the re capture of Spain by the Europeans. Gothic Architecture developed bearing columns and non-bearing walls, flying buttresses, extensive use of glass and tracery for large windows and use of vault supporting ribs among others. Architects and designers relied heavily on the geometry and proportions of the structural members of the building rather than the magnitude of exerting forces on these high ceiling cathedrals. The Artisan used their knowledge of geometry and their familiarity with materials to make up for the lack of structural understanding. Religion was now influencing geometry, as St Augustine, influenced by Plato’s ideas of interpretation of the universe through geometry assigned religious symbolism to numerals, 3 representing the holy trinity. This new concept of numerology influenced the dimensions of a wide range of cathedrals and churches. During this period, a geometric method known as ‘ad quadratum’ was widely popular. Using this system, the proportional dimensions of a gothic cathedral could be worked out through a system of construction lines and a square. As styles and techniques developed attention shifted from size to detail and a more geometrically straight architecture was gaining popularity.

With the advent of the Renaissance in 15th century, new scholarly ideas gave shape to a new movement. In many regards’ renaissance was opposing gothic principles and searched for a new order that put man at the centre of the universe and the creator. Scholars were now governed by humanist ideologies and carried on the Greek principle of using human proportions as a central part of their design. Now architects possessed a vast bank of knowledge stemming from various fields of art and science. This knowledge enabled architects like Filippo Brunelleschi (1377-1446) to lay down the foundations of the Renaissance movement. Brunelleschi was well versed in studies of roman techniques, philosophies and even researched roman ruins. This led to the construction of The Founding Hospital (1419), Florence which is considered to be the first building of the Renaissance movement. His interest in theoretical mathematics and geometry also led him to develop projective geometry, which we now call perspective. This was a mile stone development of architecture and geometry. Art was flourishing in Florence and understanding of geometric principles became essential for any artist or artisan. Vasari also stressed the importance of geometry for quattrocento artists. Leone Battista Alberti (1424-1472) also gifted the architectural world by developing Brunelleschi’s ideas of perspective further.

As Renaissance faded, new movements of architecture rose up over and over again in various forms in a repetitive manner of revivalism and classicism. For example, in Summerson (1971) it

is stated that there is no such thing as pure baroque, just because a word exists does not give evidence to its existence in its purest form. Architectural movements were being mixed together and churned to portray a new sense of architectural development. During this period Architecture started reflecting political ideals. By the 19th century remarkable developments in construction materials and techniques made iron and steel construction possible with the use of reinforced concrete. As a reaction to the apparent stagnation of development of architectural theories and principles as well as a direct reaction of eclecticism, the Modern movement gained momentum. Focus was being sought towards functional principles. Le Corbusier believed that basic geometric shapes endowed the human mind ‘primary sensations’ in humans. He developed a form of modular called ‘Le Modular’ which was a complex system of deriving dimensions and proportions using specific geometric rules. He used this system in “Jeux de panneaux” and “Unité d’Habitation”, he demonstrated his proposed principles in his design by keeping consistent with the structural principles while harmonising divisible shapes and geometric patterns with the golden ratios.

As we analysed the various architectural practices and theories from the ancient world all the way up to the modern world, it was evident how proportion geometry and architecture have always gone hand in hand and gave birth to widely different schools of thought and movements. The underlying proportions of the human body remained fairly constant throughout the ages. As mans ideologies about the world around him and the infinite cosmos beyond his reach developed and changed so did his architectural practices and theories. Although proportion rose and fell in popularity, it still remained a governing aspect of architecture. However, geometry has had a consistent relationship with construction and architecture. From ancient master pieces like the great pyramids and by magnificent displays of architecture by Brunelleschi, da Vinci and le Corbusier are a testament to the interlocked relationship between geometry, proportion and architecture.