GOLDEN RATIO IN UNIVERSITI MALAYSIA SABAH MOSQUE ARCHITECTURE

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THIS DISSERTATION IS SUBMITTED AS A FULFILLMENT OF THE REQUIREMENTFOR THE DEGREE OF BACHELOR OF SCIENCE WITH HONOURS

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DECLARATION

I declare that this thesis contains my original research work. Sources of findings reviewed herein have been duly acknowledged.

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ABSTRACT

This study is about, finding the golden ratio in UMS mosque architecture. Data has been obtained from the Department of Development and Maintenance, Universiti Malaysia Sabah. Two methods have been used in this research to find the golden ratio in the UMS mosque which is the geometric construction and numerical analysis. Two techniques have been used in geometric constructions which are partition of line and generating golden rectangle. The geometrical and numerical analysis reveals very clearly that the golden ratio is not been applied in the UMS mosque. The golden ratio did not appear repeatedly in some part of the building measurements. It is not found in the roof plan, the minaret and portal of the mosque. The nonexistence of the golden ratio in some part of UMS mosque indicates that the mosque designed and its structure does not follows the golden ratio proportion. Thus, the mosque is still beautiful physically without the existence of golden ratio. Numerical analysis gives out an accurate result compare to geometric construction.

NOMBOR NISBAH EMAS PADA SENIBINA MASJID UNIVERSITI MALAYSIA SABAH

ABSTRAK

Kajian yang dijalankan bertujuan untuk mencari nombor bukan nisbah pada senibina masjid UMS. Data telah di perolehi daripada Jabatan Pembangunan Universiti Malaysia Sabah.Dua kaedah telah digunakan dalam kajian untuk mencari nombor nisbah emas di masjid UMS. Kaedah tersebut adalah, pembinaan geometrik dan analysis berangka. Dua teknik telah diaplikasikan dalam pembinaan geometrik, iaitu pembahagian garis dan pembentukan segiempat sama emas. Analisis geometrik dan analisis berangka yang telah dikendalikan menunjukkan dengan jelas bahawa nombor nisbah emas tidak diaplikasikan di dalam masjid UMS. Nombor nisbah emas tidak kelihatan berulang di sesetengah bahagian ukuran bangunan. Ia tidak kelihatan di pelan atap, menbar dan *portal* masjid. Ketidakhadiran nombor nisbah emas di sesetengah bahagian masjid UMS menunjukkan bahawa rekabentuk masjid dan strukturnya tidak menggunakan pembahagian nombor nisbah emas. Namun, boleh dikatakan bahawa masjid UMS masih cantik dari segi binaan. tanpa kewujudan nombor bukan nisbah. Analisis berangka menunjukkan hasil yang lebih tepat dan jitu berbanding dengan pembinaan geometrik.

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LIST OF SYMBOLS

Φ	Phi
τ	Tau
μ	Mean
ε	Epsilon

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CHAPTER 1

INTRODUCTION

1.1 A Glance at Golden Ratio

Golden ratio is a number or ratio that is often encountered in mathematical, science and architecture field. It is a ratio given by an irrational number, 1.618025751. Golden ratio is denoted by Greek letter, Φ (phi) where it can be written in its numerical quantity given by Eq. (1.1)

$$\Phi = \frac{1+\sqrt{5}}{2} \tag{1.1}$$

Golden ratio has a linked with the Fibonacci sequence and also called as the Golden Mean, Golden Proportion, Divine Ratio, Divine Proportion, sacred cut, or simply Φ (ratio) (Mehrdad, 2005).

Golden ratio is one of the significance terms in geometry and in Fibonacci sequence. Fibonacci sequence named after Leonardo of Pisa, better known as Fibonacci. The Fibonacci Sequence is a set of numbers that starts with 0, 1, 1, 2, 3, 5, 8, 11, 43, 55 and it go continuously (Wikipedia, 2006). In other words, the sequence is a set of numbers that begins with 1 and 1 and each term thereafter is the sum of the prior two terms (Mehrdad, 2005). Golden ratio can be obtained through the Fibonacci sequence when any number in the sequence is taken been divided with a number before it and will get approximately 1.618.

The Golden Ratio is foremost a proportion, not a number, as a numerical quantity it is $\Phi = \frac{1+\sqrt{5}}{2}$ about 1.618 (Mehrdad, 2005). The Golden Ratio is the unique ratio of two terms when the ratio of the larger term to the smaller term is in the way as the smaller plus larger to the larger. Golden Ratio is always been related with an aesthetical value, because of its proportion. Golden ratio has also been widely used in the fields of music, architecture art and physical nature.

A lot of studies have been done to find about the usage of golden ratio in architectures all over the world. Researches have found the ratio in enormous buildings. It had been found in pyramids, mosques and in some modern architecture (www.goldennumber.net). Studies by psychologists have been devised to test the idea that the golden ratio plays a role in human perception of beauty. The aesthetics of the golden ratio has developed by a large corpus of beliefs (Wikipedia, 2006). Golden ratio in architecture has also been linked with an aesthetical value. It is said that, the architecture looks beautiful mathematically with the existence of this proportion. Recently, there is a huge interest of modern architects in the application of Golden ratio in architecture particularly the mosque.

stairs. *Qadi* or respondents of the mosque repeat the imam ritual so that it can be heard to large worshippers. Qur'an is placed on *kursi* where it's positioned next to *dikka*, from which the *qadi* reads and recites (Frishman and Hason, 2002). Dome are the hallmark of mosques and Islamic architecture. It is one of the greatest contributions made by Islam to architecture (Frishman and Hason, 2002). It is often placed directly above the main prayer hall.

Onion-shaped domes are common in South Asia and Persia. Minaret is a tall and slender tower which is built near or into the mosque structure (Wikipedia, 2006). It is built to make sure the voice of the muezzin making the *adhan* will be heard by the worshippers from a very far distance. It is also served as the local landmark. Another significant part of the mosque is the portal. It is the concealment of the interior of a building from outside view.

1.3 Objectives of Research

The objectives of this research are :

a) To find whether there is Golden Ratio in Universiti Malaysia Sabah's Mosque by using two methods
    (i) Geometric construction
    (ii) Numerical analysis
b) To compare the two methods mentioned above in the accuracy of golden ratio measurements in the architecture

1.4 Scope of Research

This research will be fully focused on the application of mathematics in architecture which is the Golden Ratio. This research will be done on the Mosque of Universiti Malaysia Sabah.

CHAPTER 2

LITERATURE REVIEW

2.1 Fibonacci Sequence

The Fibonacci sequence is named after Leonardo Pisano known as Fibonacci. Fibonacci (1170-1250) is an Italian mathematician. Fibonacci made an outstanding contribution to the development of mathematics. Fibonacci formed a numerical sequence called Fibonacci numbers : 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, and so on. This series generated by $f_n = f_{n-2} + f_{n-1}$, for $n = 3,4,5,...$ with $f_1 = f_2 = 1$ (MathWorld: Fibonacci Number, 2005). Each of the term is the sum of the two previous terms. Fibonacci obtained this numerical sequence as the solution for the famous problems of rabbits reproduction (Stakhov, 2005).

In this mathematical problem, Fibonacci assume that all the rabbits never die and the female always and only produces one pair every month. By realizing this, he was able to produce a sequence for the number of rabbits born in a year. At the end of the first month, a new pair of rabbit is produced, so now there are two pairs of rabbits. For the third month, the original female rabbit produces a second pair and the total of rabbit in the field become three pairs. The sequence keeps repeating and the result is illustrated in Figure 2.1.

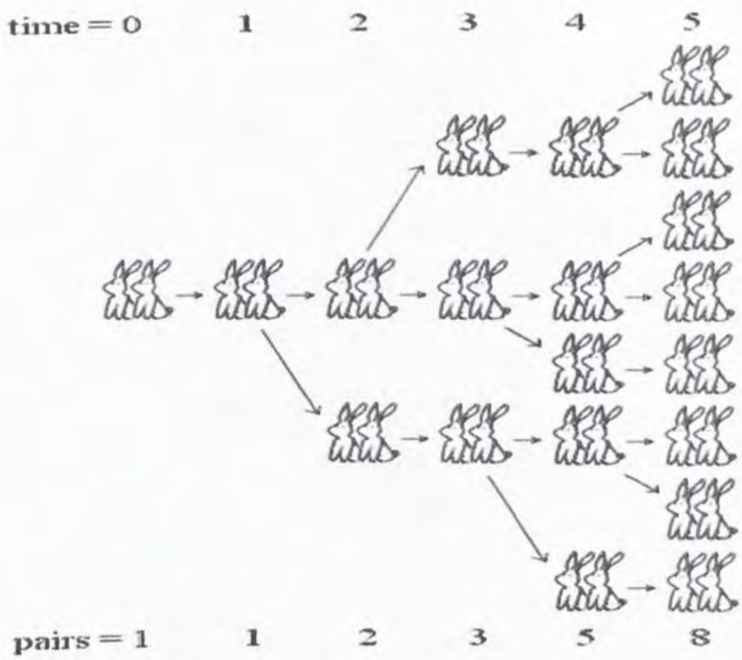

Figure 2.1 The chronology of rabbit populations which gives the Fibonacci sequence

(Source:http://www.fibonaccinumber.com)

2.1.1 Fibonacci in Nature

Fibonacci is spread widely in nature. Fibonacci sequence can be found throughout nature: in the bones of the fingers, hand, and forearm, the location of the navel and where the fingertips touch the thigh in relation to the height of the adult human body. Many plants show this series in the arrangement of the leaves around the stem, their trunks; the number of scales that make a spiral seed patterns in a sunflower or daisy and in the curvature of certain seashells (Reynolds, 1999).

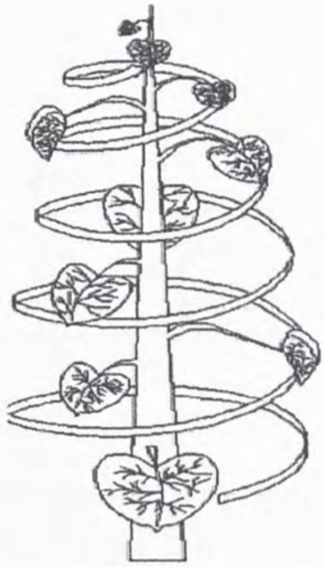

Figure 2.2 The distribution of leaves around a central stem

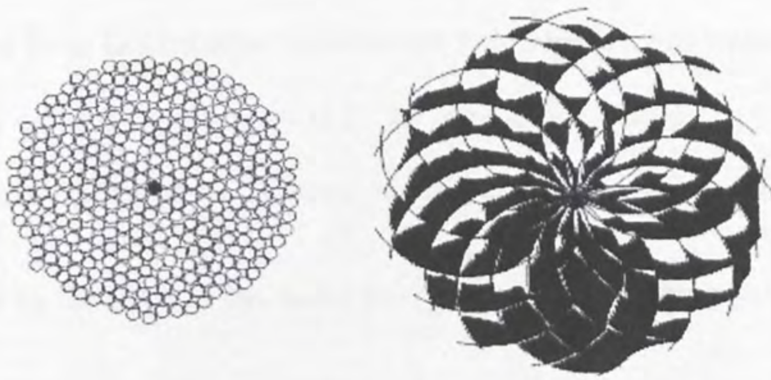

Figure 2.3 Seed in sunflower and pinecone shows the existence of Golden spiral

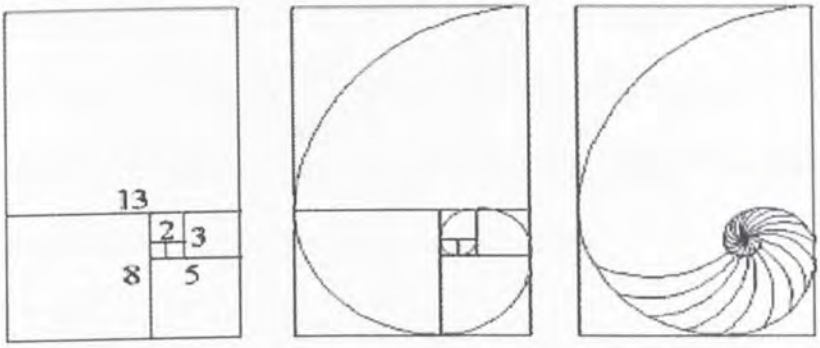

Figure 2.4 The Golden Mean spiral in seashell: *Nautilus pompilius*

(All of the figures above are taken from the same source; Geometry in nature and Persian Architecture, http://www.sciencedirect.com)

2.2 The Golden Ratio

Golden ratio is a famous term that can be heard in mathematics, science and architectural field. Golden ratio is the unique ratio of two terms when the ratio of the larger term and the smaller term is in the way as the smaller plus larger to larger (Mehrdad, 2005). Golden ratio is not a number, but a proportion as numerical quantity represented by the letter Φ, phi, equal to $\frac{1+\sqrt{5}}{2}$, or 1.618025751. Golden ratio can be also defined geometrically as a division of a segment, that is, a division of a line in such a way that the lesser portion is to the greater as the greater is to the total length (Boussora and Mazouz, 2004).

The ratio for length to width of rectangles of 1.61803 39887 49894 84820 has been considered the most pleasing to the eye, throughout history. This ratio was named as Golden ratio by the Greeks. The use of the Greek letter phi to represent the Golden ratio 1.618, is generally said to acknowledge Phidias (Grist, 2001). Phidias, who is a sculptor and mathematician of ancient Greece during 5th century BC, studied phi and created sculptors for the Parthenon and Olympus.

Golden ratio has many terms such as Golden Mean, Golden Proportion, Divine Ratio, Divine Proportion, sacred cut, or simply Φ (ratio) (Mehrdad, 2005). Even though the name varies, but it all gives the same meaning.

Explanation of the Golden Ratio typically commence with a brief description of the Fibonacci sequence. The Fibonacci sequence and the golden ratio have been used to explain the proportions of ancient Egyptian art and architecture (Rossi and Christopher, 2002).

2.2.1 Origin of Golden Ratio

Golden ratio is first studied by the ancient Greek mathematician because of its frequent application in geometry. The ratio is important in the geometry of regular pentagrams and pentagons. The discovery of the ratios by the Greeks usually attributed to Pythagoras or to the Pythagoreans, notably Theodorus or Hippasus. Euclid who is also a famous Greek mathematician wrote Elements gives us the first known written definition of the golden ratio.

> "*A straight line is said to have cut in extreme and mean ratio when, as the whole line is to greater segment, so is the greater to the less*"

Euclid also explains that a construction for cutting a line " in extreme and mean ratio" that is to say the golden ratio. Elements, which consists the work written by Euclid, utilize the golden ratio in several propositions and their proofs.

"Mean and extreme ratio" was the principal term used from the 3^{rd} century BC until about 18^{th} century. Golden ratio is denoted by τ (tau). It is the first letter of the ancient Greek root $\tau(\frac{\varepsilon}{0})\mu$ means cut. Luca Pacioli's Divine proportion of 1509, begins the modern history of the golden ratio. Since the 20^{th} century, the golden ratio represented by Greek letter Φ(phi) after Phidias, a sculptor who is said to have employed it (Wikipedia, 2006).

2.2.2 Obtaining the Golden Ratio

Golden ratio can be obtained from the Fibonacci sequence and from the division of the line segment (Boussora and Mazouz, 2004). Golden ratio can be derived from the sequence when any number in the sequence is taken been divided with a number before it and will get approximately 1.618. The sequence of ratios of consecutive numbers of their sequence converges to Φ: 1.618 (Rossi and Christopher, 2002).

Table 2.1 The sequence of Fibonacci that converges to Φ:1.618.

$\frac{2}{1}$	2
$\frac{3}{2}$	1.5
$\frac{5}{3}$	1.666
$\frac{8}{5}$	1.6
$\frac{13}{8}$	1.625
$\frac{21}{13}$	1.615384
$\frac{34}{21}$	1.619047
$\frac{55}{34}$	1.617647
$\frac{89}{55}$	1.61818
$\frac{144}{89}$	1.61797
$\frac{233}{144}$	1.618055
$\frac{377}{233}$	1.618025

Golden ratio is a proportion, whereby according to Euclid that the division is in such that the lesser is to greater as the greater is to total (Reynolds, 1999). From the division of the line segment, the ratio of whole line to the large segment is the same as

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