Chinese wood frame buildings and the changing dimensions of their structural components in different time periods

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The Features of the Chinese wood frame buildings are same in character from dynasty to dynasty. The study concentrates on 9 Chinese wood frame buildings from Tang to Yuan dynasty and tries to relate these buildings with the text described in a building manual book published in Song dynasty *Yingzao fashi.* The features of some buildings match with the text described in the book some do not. But on the other hand Liang Sicheng, scholar of Chinese architecture in his book claimed that Chinese wood frame architecture has a unique system of characteristics (Liang, 1984). The system of wood frame Chinese architecture did not change but the proportion of the features has changed in different dynasty. The aim of the paper is to compare the features of the buildings those have been studied according to *Yingzao fashi* with Liang's observation on the change of building style in different periods.

Key words: *Chinese wood frame building, Yingzao fashi, Dynasties of Chinese history, Chinese architecture*

1. INTRODUCTION

Chinese wood-frame architecture has a history of more than a thousand years; the earliest surviving building can be traced back to the Tang dynasty. There are little sources of information to study them, especially for those built in the Tang-Yuan period. Other than the surviving buildings themselves, can be relied on *Yingzao fashi*, a building manual published in Song. The study concentrate on 9 Chinese wood frame buildings from Tang dynasty (9^{th} century) to Yuan dynasty (13^{th} century) in a different group and the focus of the study is to relate these buildings with the text prescribed in the book *Yingzao fashi*, a building manual published in Song dynasty (10^{th} century). The features like the size of the *cai* and the disposition of the column, the roof section, the bracket sets, bay width, column height have been compared with the book. The features of some buildings match with the text described in the book some do not.

On the other hand Liang Sicheng, scholar of Chinese architecture, in his book, *A Pictorial History of Chinese Architecture: a study of the development of its structural system and the evolution of its types* he claimed that Chinese wood frame architecture has a unique system of characteristics (Liang, 1984). The system of wood frame Chinese architecture did not change but the proportion of the features has changed in different dynasty. According to the evidence (buildings, books of the buildings, artifacts and models of the buildings) and his thorough surveyed on 16 extant buildings from Tang Dynasty (9^{th} century) to Ching Dynasty (19^{th} century) he divided the Chinese Wood frame Architecture into 3 periods, which are: the Period of Vigor (from mid 9^{th} to mid 11^{th} century), the Period of Elegance (from mid of 11^{th} century to the end of 14^{th} century), the Period of Rigidity (from 15^{th} to 19^{th} century).

The major changes were observed through out these periods into the major feature groups of the buildings. The noticeable change among these feature groups is the gradual reduction of the *tou-kung.*, the structural element, from one-half to one-third in Song to one-fifth in Ming Dynasty(14^{th} century) compare to the column height. Another feature is the change in the number of intermediate bracket sets of *tou-kung*, which are gradually increased. Third change is the disposition of the columns which became so regular in the later period. The last one is in the appearance of the roofs, which are straighter, then the previous (Liang, 1984).

The aim of the paper is to compare the features of the buildings those have been studied according to *Yingzao fashi* with Liang's observation on the changes of

building styles in different periods to understand the Chinese wood frame buildings.

2. CHARACTERISTIC OF CHINESE WOOD FRAME BUILDING

The basic characteristics of Chinese wood frame buildings consists the following components: a) raised platform, b) column or wall c) *tou-kung* (Bracketing Unit) and the curved roof. It was illustrated in the following elevation and section (fig1, 2).

a) Raised platform: The basic component of Chinese wood frame buildings. This is basically a raised base for the timber post and lintel structure and this structure helps to support the overhang eaves (fig1).

b) Column or wall: Another important feature in Chinese wood frame building. The diameter of the columns actually varied from time to time. The columns are either straight or slightly inclined. In earlier period (Tong and Sung dynasties) the outer columns are taller compare to the columns of central bay. But during the Ch'ing period the columns are of equal height. The columns are slightly conical. The dispositions of the columns are also regular and rigid from the earlier period. As a result the buildings of Ch'ing are much more rigid in appearance than the earlier period.

c) *Tou-kung* (Bracketing Unit) and the curved roof:

- Bracket sets (*tou-kung*): The bracket sets are very important
  feature in Chinese wood frame architecture. The Chinese bracket sets are very complex member. Their base is a simple square block (*lu tou*) set on the top of the column. The bracket sets are the combination of blocks (*tou*) and arms (*kung*). The main functions of the bracket sets are to transfer the load from the above structure (fig2). This bracket sets can be placed not only on the top of the column but also in between two columns and on the top of corner columns. So they called as 'column set', 'intermediate set' and 'corner set'. The bracket set has three main parts: *tou, kung* and *ang* (tail). In earlier period the bracket sets are too heavy compare to the later period (fig3).The placements in the intermediate sets are increased in later period. During Sung dynasty the numbers of intermediate sets never exceed two but in Ch'ing or Ming period the number of sets sometime increased to seven or eight (Liang,1984).

- The curved roof: The curved roof with overhang eaves has 5 types of its categories (fig 4). The curved roof of Chinese architecture is determined by the raising of the edge purlin and the depression of the rafter line. The curvature of the roof depends on the depression of the purlin below the rafter line at the earlier period but conversely the later period's roofs are steeper.

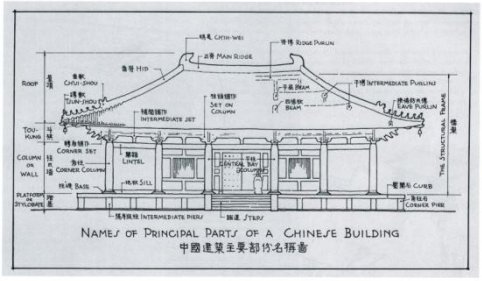


***Figure 1**: Principal Parts of Chinese Building (Liang, 1984).*

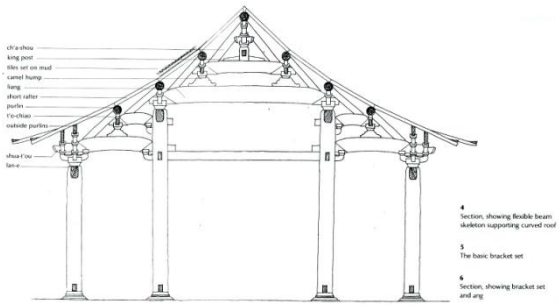


***Figure 2**: Section of a wood-framed building (Liang, 1984).*

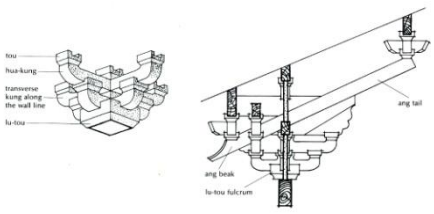


***Figure 3**: Different parts of Bracket set (Liang, 1984).*

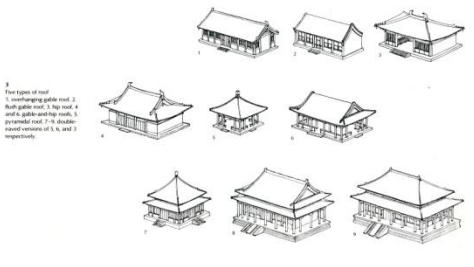


Figure 4: *Different types of curved roofs (Liang, 1984).*

But the study concentrates on the 3 features groups and has to find out the relation of the studied buildings according to Liang's observation that how these features are changed into their dimension or style. Liang has divided the Chinese wood frame Architecture into 3 periods and major changes were observed through out these periods into major feature groups of the buildings. The three features are:

a) The size of the cai and the disposition of columns.
b) The roof section.
c) *Shengqi*, and the ratio of bracket height to column height.

a. The size of the *cai* and the disposition of columns:

According to *Yingzao fashi* the term *'cai'* has two meanings. First one is that *cai* is a standard sized timber which has used to make the arms (*Kung*) of a bracket sets. Eight sizes or grades of *cai* are established to measure the Chinese wood frame buildings. And the other meaning of *cai* is a module for measurements. The depth and the width of the *cai* has divided into 15 and 10 equal parts which called *fen*. Every measurement of the buildings has to be measured by the *fen* value of the any grade of *cai* (fig 5).

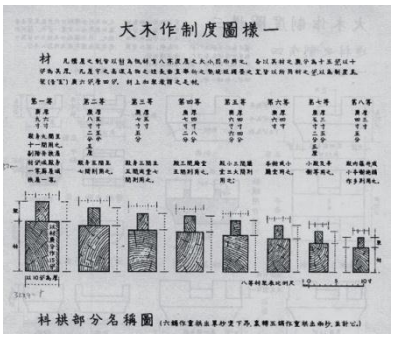


Figure 5*: Dimension of cai. (Yingzao fashi)*

The size of the *cai* has changed in different period and also the disposition of the columns are more rigid and regular at the later period.

The Period of Vigor (850-1050): This period includes the time period from Tang dynasty to early Sung dynasty. During this period the size of the brackets are huge so that the size of the *cai* is also huge. The brackets are fin shaped in ridge and bud shaped in hip. The *hua-kung* or the arms are big to support the overhang of the eave.

Another characteristic of this period is the position of the columns which are not regular and not in the same alignment because to keep the space cleans for the Buddhas statues placed inside the buildings (fig 6 and 7).

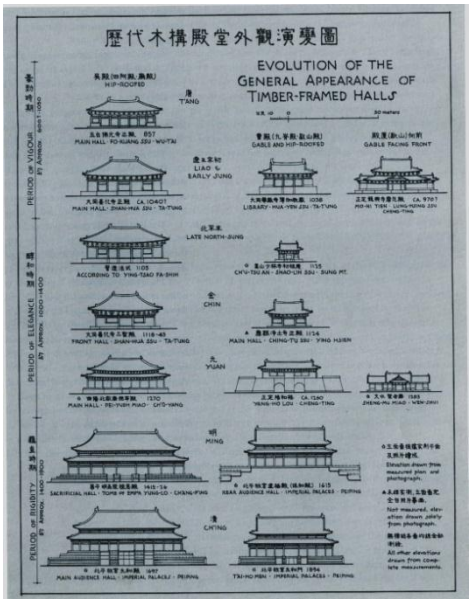


Figure 6*: Liang's evolution in the appearance of the Chinese wood framed building (Liang,1984).*

Period of Elegance (1000-1400): This period start from the early Sung dynasty and end at the Ming dynasty. In this period details in the structural component had done and the style of this period described by elegance and refinement. In this period the size of the bracket sets were gradually reduced. The intermediate bracket sets are larger than the previous period and more complicated in their size. Diagonal *kung* had introduced for the first time in this period (fig 8). The positions of the columns are adjusted to provide the space for the Buddhist worshippers. Omitting the hypostyle columns often affected the roof structure. To control this irregularity in the position

of the columns, the hypostyle columns are increased in the height to support the beams above. And at the transition bracket sets are employed (fig 9).

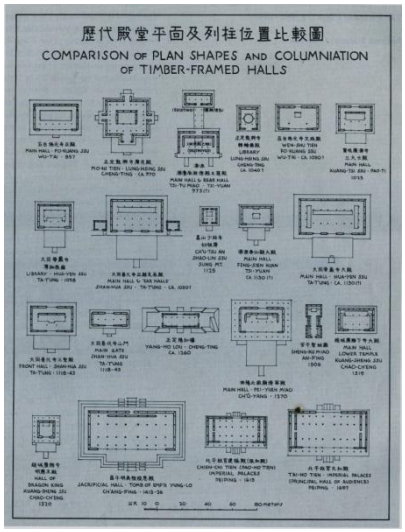


Figure 7*: Columniation of the Chinese wood framed building (Liang, 1984).*

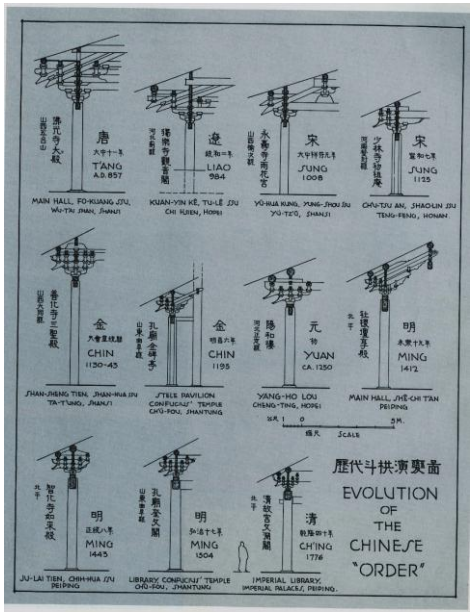


Figure 8*: Decreasing size of the bracket sets from Tang to Ch'ing dynasty (Liang, 1984).*

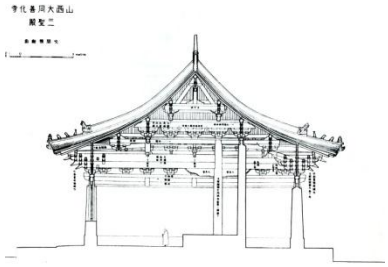


Figure 9*: The increasing height of the hypostyle column (Liang, 1984).*

Period of Rigidity (1400-1912): This period start from the Ming dynasty through the Ch'ing dynasty to the republic. In this period the size of the all horizontal member has increased and the size of the bracket sets are decreased. The number of intermediate bracket sets are never exceed 2 during Sung dynasty but in the Ming period the number increased from 4 to 6 and at later the number increased from 7 to 8 (fig 8). The positions of the columns become regular in this period (fig 7).

b. The roof sections

The Period of Vigor (850-1050): In this period according to *Yingzao fashi* the roof is determined by the raising of the ridge purlin and the depression of the rafter line. The height of the ridge purlin is determined before and the curvature of the roof is attained by the depression of the successive purlin. When the height of the ridge purlin has been determined, the curvature of the rafter line is obtained by lowering the first one after the ridge purlin by 1/10 R of the height (R is the raise of the ridge purlin). The next one is depressed by 1/20 R. In the repetition the depression is reduced by half in each time. Then the points are joined together to form the roof line (fig 10).

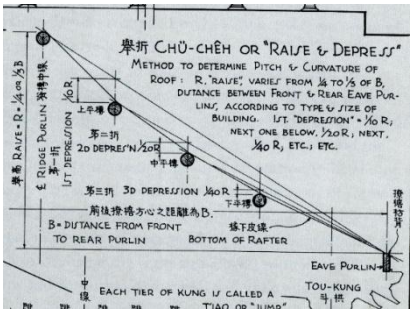


Figure 10*: The roof section of Sung dynasty (Liang, 1984).*

Period of Elegance (1000-1400): During this period the roof line start to becomes straighter than the earlier period.

Period of Rigidity (1400-1912): During this time the roofs become steeper than the earlier period. The roof line become straight than Tang and Sung dynasty (fig 6). In this period the roof is determined by raising the frame. In this time according to Ch'ing regulation the slopping for the pitch has been started from the bottom purlin. At the bottom the first is the distance between the two purlin 5/10x, second step 7/10x, third is 8/10x and up to 9/10x. The last step is to

position of the ridge purlin. Thus the pitch of this period's roof is steeper than the earlier period (fig11). The slope of the roof has 45ºangle.

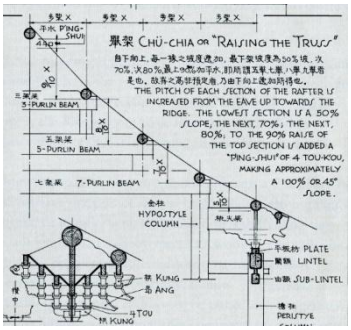


Figure 11*: The roof section of Ch'ing dynasty (Liang, 1984)*

c. The corner column height and the ratio of bracket height to column height:

The diameter of the column and the height of the columns are varying from Sung to Ch'ing dynasty. According to the *Yingzao fashi* during the Sung dynasty the height of the corner column should be slightly taller than the central and they are slightly inclined towards inside. But the Ch'ing building's columns are of equal height and straighter than the building of Sung. Simultaneously the numbers of intermediate bracket sets are also increased.

The ratio of bracket height should be 1:2 of the column height during Tang dynasty but through the years to the Ch'ing the height of bracket set become $1/5^{th}$ of the column height.

The Period of Vigor (850-1050): During this period diameter of the corner columns according to *Yinzao fashi* never exceed three *cai* and the height of the corner column should be slightly taller than the central bay's column (Liang, 1984). The height of the bracket is ½ of the column height. The intermediate bracket sets are identical with the column sets.

Period of Elegance (1000-1400): The height of the corner columns start to decrease and become equal to the central columns. But the hypostyle columns are sometimes taller than the corner column to hold the structure.

The height of the bracket becomes one- third to one- fourth. The intermediate sets become larger in size and does not rest on columns. During this time 2 intermediate sets are used in the central bay.

Period of Rigidity (1400-1912): The heights of the columns are equal in every bay. According to Ch'ing regulation the height of the columns should not exceed 60 *tou-k'ou* or ten diameters and the diameter of the column is six *tou-k'ou* or 4 *cai.*

The height of bracket becomes one-fifth of the column height and the numbers of bracket sets are increased to 4 to 6 and later 7 or 8.

3. THE DETAILS OF THE SELECTED BUILDING

Nine Chinese wood framed buildings from Tang to Yuan period are selected and studied according to *Yingzao fashi* and the buildings are divided into two groups according to its period of time.

Group 1: The Period of Vigor

i. Nanchan si da dian
Location: Mount Wutai, Shangxi Province. Built year: 782 Structural type: 4-rafter building, clear span, with 2 columns.
ii. Fo Guang Si Da Dian
Location: Wu Tai County, Shanxi Province. Built year: 857 Structural type: 8 - rafter building, a 2 - rafter beam in front and in back, with 4 columns.
iii. Dule si Shanmen
Location: Hopei Built year: 984 Structural type: 4-rafter building, centrally divided with 3 columns.

Group 2: Period of Elegance

iv. Fengguo Temple
Location: Northeast corner of Yixian in Liaoning Province. Built year: 1020 Structural type: 10-rafter building, with a 4-rafter beam in the front and a 2-rafter beam in the back, supported on 4 columns.
v. Jinci Shengmu Dian
Location: Taiyuan of Shanxi province. Built year: 1031 Structural type: 8-rafter buiilding, a 2-rafter beam abutting a 6 rafter beam, with 3 columns

vi. Longxing si moni dian
Location: Zhengding, Hebei province Built year: 1052 Structural type: 8-rafter building, a 2-rafter beam in front and in back, with 4 columns
vii. Shanhua Si Sansheng Dian
Location: Datong, Shanxi provience Built year:1128 Structural type: 8-rafter building, a 2-rafter beam abutting a 6-rafter beam, with 3 columns.
viii. Shanhua si da dian
Location: Datong, Shanxi provience Built year: 1150 Structural type: 10-rafter building, a 4-rafter beam in the front, a 2-rafter beam at the back, with 4 columns.
ix. Yongle gong
Location: Shanxi Built year: 1262 Structural type: 6-rafter building, a 5-rafter beam abutting a 1 rafter beam, with 3 columns.

a. The measurements of dimensions and the analysis of the Group1buildings:

i. Nanchan si da dian:

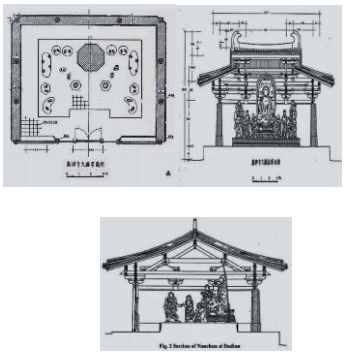


Figure 12*: Plan, long section and the section of Nanchan si da dian (Hand drawn by the author & Liang, 1984).*

The size of *cai* is 24X16cm and the *fen* value is1.6cm and the grade of the building is 3. Although this is a small *ting tang* building but still it consists a larger *fen* value than the later dynasty.
The disposition of the columns: The position of the column has been omitted to make a clear space for the statues. This is one of the characteristic of the period of Vigor. The roof section: The slope of the roof is about 18 degree. Compare to figure 10 it seems less steep than the later period buildings.

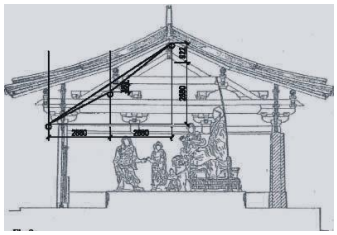


Figure 13*: The roof section of Nanchan si da dian (Hand drawn by the author & Liang, 1984).*

The brackets and the column height ratio: From the figure 12 it is clearly seen that the intermediate bracket sets are identical with corner sets. The height of the bracket is 162cm. Height of peripheral column is 367cm and height of central bay column is 361cm. The ratio of the bracket and column height is 1:2.23

Nanchan si is built in Tang dynasty. According to Liang's observation for the buildings of the period of Vigor, the features of the building are almost match. Although the building was dated before 850 but it consists the same characteristics of the period of Vigor. The gradient of the roof is not steeper and the corner column is taller than the central column and forms a curved roof line. The Brackets are almost ½ of the column height.

ii. Fo Guang Si Da Dian:

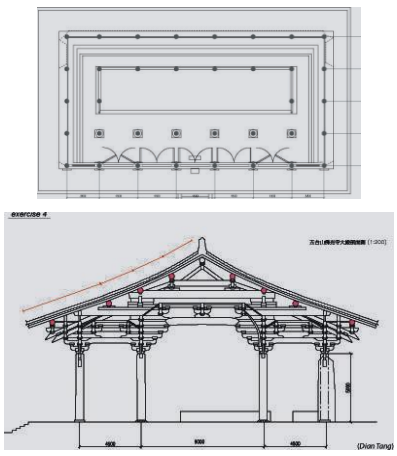


Figure 14*: Plan and section of Fo Guang Si Da Dian (Hand drawn by the author & Liang, 1984).*

The building is built in 857 and belongs to Tang dynasty. This is a 7/4 bay *Dian tang* building. And the internal columns are in equal height. The size of *cai* is 30x 20.5 and

the *fen* value is 1.46cm and the grade of the building is larger than grade 1.

The disposition of the columns: The position of the column has been omitted to make a clear space for the statues.

The roof section: Compare to figure10 the slope of the roof is flatter and matches with the standard of the *Yingzao fashi*.

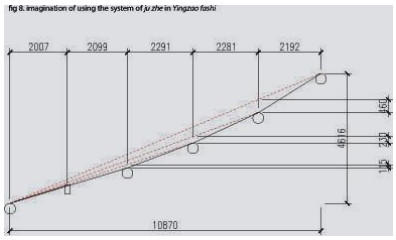


Figure 15*: The roof section of Fo Guang Si Da Dian (Hand drawn by the author).*

The brackets and the column height ratio: From the figure 14 it is clearly seen that the intermediate bracket sets are identical with corner sets. The bracket set height is bigger like building of tang dynasty. And the height of the bracket set is almost ½ of the column height. Height of peripheral column is 508 cm.

The features of the building are similar to the characteristics of the Tang dynasty and much similar with Liang's observation.

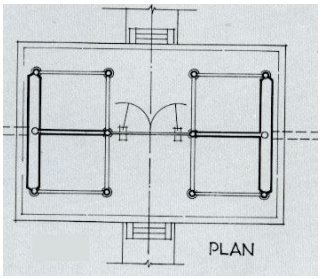
iii. Dule si Shanmen:

The building is built in 984 and belongs to Liao dynasty. This is a small Chinese gate building with simple structure And the internal columns are in equal height. The size of *cai* is 24.5X 16.8 cm and the *fen* value is 1.46cm and the grade of the building is larger than grade 3.

The disposition of the columns: The position of the column has been placed in a longitudinal axis to fix the doors.

The roof section: Compare to figure 10 the slope of the roof is flatter and matches with the standard of the *Yingzao fashi*.

The brackets and the column height ratio: From the figure 16 it is clearly seen that the intermediate bracket sets are identical with



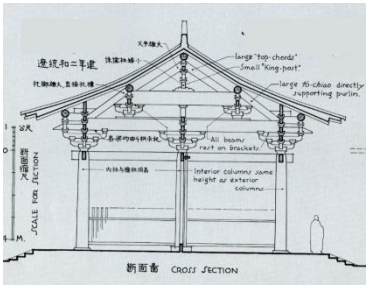


Figure 16*: Plan and section of Dule si Shanmen (Liang, 1984).*

corner sets. The bracket set height is bigger like building of same period. Height of peripheral column is about 500 cm.

The features of the building are similar to the characteristics of the period of vigor as about a dozen of buildings belong to this period (Liang, 1984).

b. The measurements of dimensions and the analysis of the Group2buildings:

iv. Fengguo Temple:

The building is built in 1020 and belongs to Liao dynasty. This is a 9/5 bay *dian tang* building without. And the internal columns are not in equal height. The hypostyle column is taller than the corner column. And this is a one of the features of the period of elegance. The size of *cai* is fit with grade1.

The disposition of the columns: The position of the column has started to be placed in a regular manner but in the front 4 hypostyle columns are omitted to make the big space.

The roof section: The slope of the roof is about 19 degree. Compare to figure 10 the slope of the roof is flatter.

The brackets and the column height ratio: Height of peripheral column is about 980 cm.

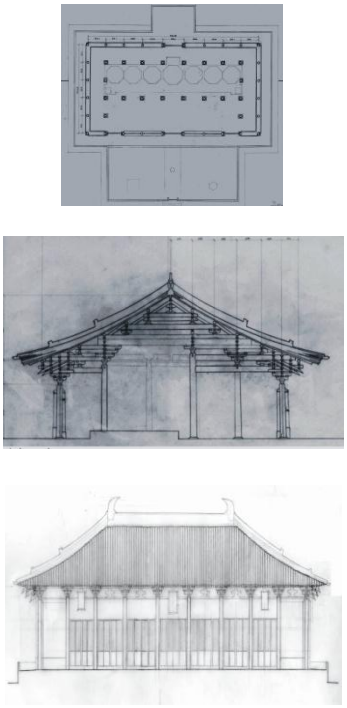


Figure 17*: Plan and section and elevation of Fengguo Temple (Hand drawn by the author).*

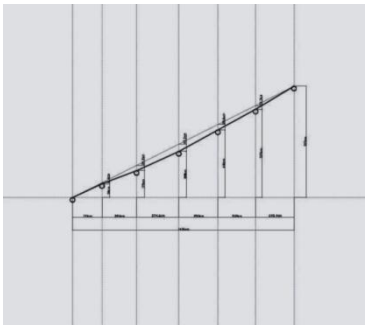


Figure 18*: The roof section of Fengguo Temple (Hand drawn by the author).*

When the building is studied it almost matches with the rules of *Yingzao fashi* and the features of the building are also similar to the characteristics of the period of elegance but in the case of roof it is clearly seen that the roof is matched with the earlier period. And there is no intermediate bracket set. The main reason might be the built period of the building. Causes building of Liao sometimes do not follow the rules (Liang, 1984).

v. Jinci Shengmu Dian:

The building is built in 1031 and belongs to Sung dynasty. This is a 5/3 bay *ting tang*

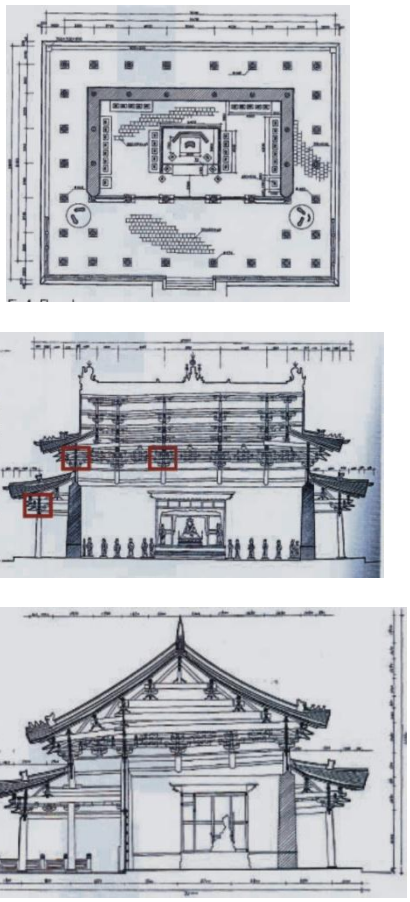


Figure 19*: Plan and section of Jinci Shengmu Dian (Liang, 1984).*

building without suspended ceiling. And the internal columns are not in equal height. The hypostyle column is taller than the corner column. And this is a one of the features of the period of elegance. The size of *cai* is 21.5X 16 cm and the *fen* value is 1.6cm and the grade of the building is grade 3.

The disposition of the columns: The position of the column has started to be placed in a regular manner but in the front 4 columns are omitted to make the big space.

The roof section: Compare to the figure 11 the slope of the roof is started to be steeper than the earlier period (fig 20).

The brackets and the column height ratio: From the figure 19 it is seen that the intermediate bracket sets are not identical with corner sets. The bracket set height is about 400 cm which is about 1/3 of the column height. Height of peripheral column is about 800 cm.

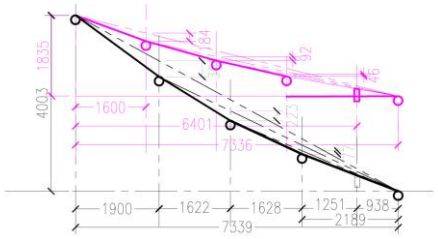


***Figure 20**: The roof section of Jinci Shengmu Dian (Hand drawn by the author).*

When the building is studied it almost matches with the rules of *Yingzao fashi* and the features of the building are also similar to the characteristics of the period of elegance (Liang, 1984).

vi. Longxing si moni dian:

The building is built in 1052 and belongs to Sung dynasty. This is a 7/7 bay with attached porch but with out the porch it is 5/5 *dian tang* building with suspended ceiling. And the internal columns are in equal height.The size of *cai* is 21X16 cm and the *fen* value is 1.6cm and the grade of the building is grade 3.

The disposition of the columns: The position of the column has started to be placed in a regular manner but in the middle columns are omitted to make the big space for the statues. And this is a one of the features of the period of elegance.

The brackets and the column height ratio: From the figure 21 it is seen that one intermediate bracket set is placed and two intermediate bracket sets are placed in the central bay. The bracket set height is about 1/3 of the column height. The column height is also determined by the curvature of the roofline in the elevation. And in the case of a 3 bay dian tang, the corner columns should be taller than the central columns by 2 cun/ 48mm. The corner column height is 865 cm.

The roof section: It is seen that the roof of Moni dian is much steeper and taller than the one following the rules in the book.

When the building is studied it almost matches with the rules of *Yingzao fashi* and the features of the building are also similar to the characteristics of the period of elegance (Liang, 1984).

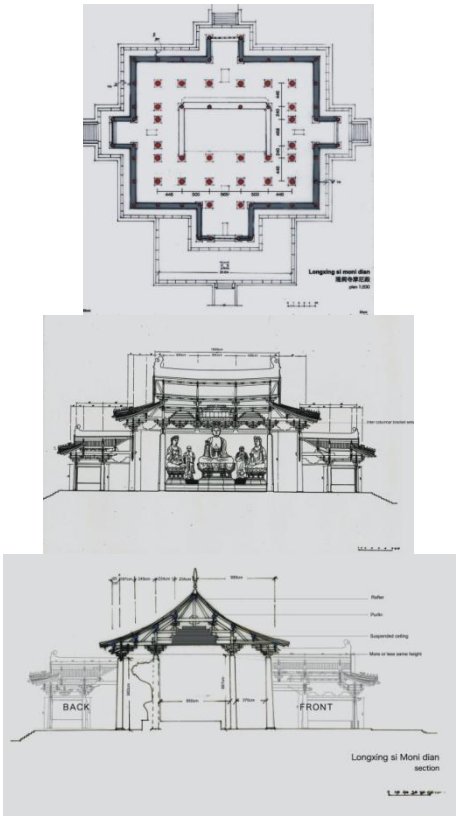


***Figure 21**: Plan and section of Longxing si moni dian (Liang, 1984 & hand drawn by the author).*

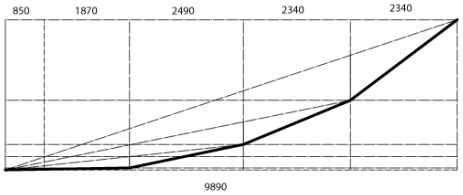


***Figure 22**: Diagram showing a standard roof section using the data of moni dian in mm (Hand drawn by the author)*

vii. Shanhua Si Sansheng Dian

The building is built in 1128 and belongs to Jin dynasty. This is a 4/5 bay *ting tang* building without suspended ceiling. And the internal columns are not in equal height. The hypostyle column is taller than the corner column. And this is one of the features of the period of elegance. The size of *cai* is 26X17 cm and the *fen* value is 1.7cm and the grade of the building is grade 2.

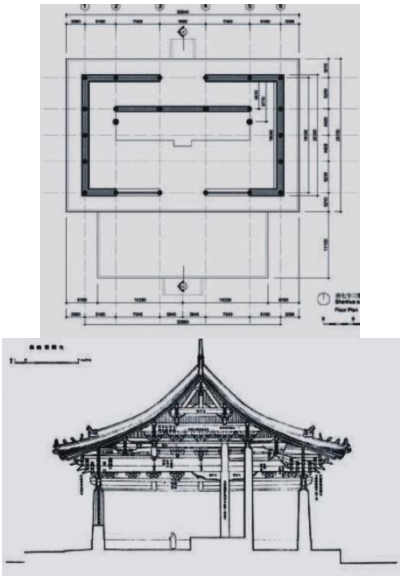


Figure 23*: Plan and section of Shanhua Si Sansheng Dian (Hand drawn by the author, Liang, 1984)*

The disposition of the columns: The position of the column has started to be placed in a regular manner but in the hypostyle columns are omitted to make the big space for the statues (fig 23). And this is also one of the features of the period of elegance.

The roof section: The roof of the building is higher than an ideal 5-bayed *ting tang in Yingzao fashi*.

The brackets and the column height ratio: From the figure 23 it is seen that 2 intermediate bracket set is placed and two intermediate bracket sets are also placed in the central bay. The bracket height is 222cm.The bracket set height is about 1/3 of the column height. The column height is also determined by the curvature of the roofline in the elevation. And in the case of a 5 bay building the height of a corner column should be one-third of the depth of the structure (Liang, 1984).The corner column height is 659 cm.

viii. Shanhua si da dian

The building is built in 1150 and belongs to late Jin dynasty. This is a 7 bay *ting tang* building without suspended ceiling. And the internal columns are not in equal height. The hypostyle column is taller than the corner column. And this is one of the features of the period of elegance. The size of *cai* is 26X17 cm and the *fen* value is 1.7cm and the grade of the building is grade 2.

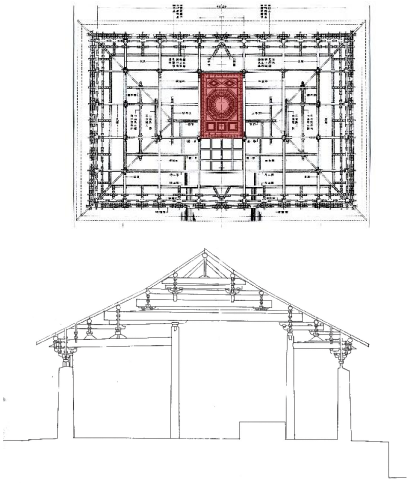


Figure 24*: Plan and section of Shanhua si da dian (Liang, 1984 & hand drawn by the author)*

The disposition of the columns: The position of the column has started to be placed in a regular manner but in the hypostyle columns are omitted to make the big space for the statues (fig 24). And this is also one of the features of the period of elegance.

The roof section: The roof of the building does not match with the description of *Yingzao fashi* (fig 25).

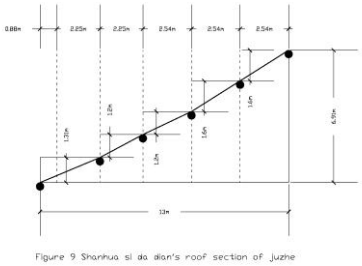


Figure 9 Shanhua si da dian's roof section of Juzhe

Figure: 25*: The roof section of Shanhua si da dian (Hand drawn by the author).*

The brackets and the column height ratio: One intermediate bracket set is placed between two columns. The bracket set height is about 1/3 of the column height. The column height is also determined by the curvature of the roofline in the elevation. The heights of the outermost columns of this building do not exceed the width of the middle bay.

ix. Yongle gong:

The building is built in 1262 and belongs to late Yuan dynasty. This is a 5/4 bay *dian tang* building without suspended ceiling. And the internal columns are not in equal height. The hypostyle column is taller than the corner column. And this is one of the features of the period of elegance. The size of *cai* is 18.5X12.5 cm and the *fen* value is 1.7cm and the grade of the building is grade 2.

The disposition of the columns: The position of the column has started to be placed in a regular manner but in the hypostyle columns are omitted to make the big space for the statues (fig 25). And this is also one of the features of the period of elegance.

The roof section: It is seen the actual size is bigger than the standard and it is flatter than the standard (fig 27). In addition, the rafter length are not evenly distributed and not align with the columns, so it doesn't follow to *Yingzao fashi* and also do not match with the characteristics of the elegance period.

The brackets and the column height ratio: One intermediate bracket set is placed in between two columns. The bracket set height is about 1/3 of the column height. The column height is also determined by the

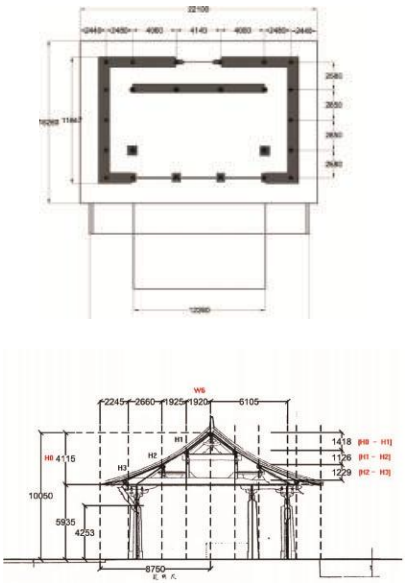


Figure 26*: Plan and section of Yongle gong (Hand drawn by the author).*

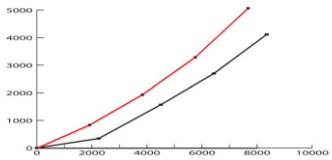


Figure 27*: Roof section of Yongle gong (Hand drawn by the author).*

curvature of the roofline in the elevation. The height of the outermost column is 593.5 cm and the bracket height is 168.2cm.

4. CONCLUSIONS

Nine buildings from *Tang* to *Yuan* dynasty are selected for the analysis. They were divided into 2 groups according to their time periods. It is found that the building of the period of elegance has steeper roof and higher than that of buildings of the period of Vigor. The finding gives another perspective on the study of the size of the *cai* of these buildings by comparing the dimensions of the major structural components of the buildings. It is noticed that the dimension of *cai* has decreased from the period of Vigor (24X16) to the period of Elegance (18.5X12.5). That means the size of the bracket sets are decreased from the earlier. And also the dispositions of the columns are more rigid than the earlier. The roofs become steeper at the later period. So that the studied buildings more or less fit with the Liang's description about the Chinese wood frame buildings. Moreover, many topics such as details of *tou-kung*, the beam size, the grammar of structural system etc. have not been touched and studied. But by the study of the comparison of these buildings by using the dimensional approach to the major structural components help to understand the Chinese wood frame buildings in detail.

REFERENCES

Guo, Q: 1999, *The structure of Chinese timber architecture*. London: Minerva.

Glahn, E:1984, *Unfolding the Chinese building standards: research on the Yingzao fashi.In Chinese traditional architecture*, edited by Nacy Sharzman Steinhardt, 47-57. New York:China Institute in America.

Li, AI: 2001, A shape grammar for teaching the architectural style of the *Yingzao fashi*, Ph.D. dissertation Department of Architecture, Massachusetts Institute of Technology, Cambridge, Mass.

Li, AI: 2003. The *Yingzao fashi* in the information age, paper read at The Beaux-Arts, Paul-Philippe

Cret, and 20th-century architecture in China, at University of Pennsylvania.

Li, AI: 2004. Styles, grammars, authors, and users. Paper presented at Design computing and cognition '04, at Cambridge, Mass.

Liang Sicheng. 1984, *A pictorial history of Chinese architecture: a study of the development of its structural system and the evolution of its types*. Edited by W.Fairbank. Cambridge, Mass.: MIT Press.

Nancy, S: 1984, *Chinese traditional architecture.* New York: China Institute in America.

Turabian, Kate L. 2007. *A manual for writers of term papers, theses, and dissertations*. 7th ed. Chicago: University of Chicago Press.