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ABSTRACT

Through a comparison with the traditional Chinese manual Yingzao Fashi (Technical Treatise on Architecture and Craftsmanship), this paper analyzes the composition and design methods of Zen-style bracket sets described in the Kamakura Zoei Myomoku, a technical document inherited by the Kawachi family of carpenters at the Kenchoji Temple in Kamakura, Japan from the 13th to 19th century. As a result, the paper suggests that there were some similarities between Chinese and Japanese modular designs, which both used the cross-section of Gong as the basic unit, while other techniques like the use of a baseline for equal spacing and the rafter size as the basic unit, are considered to be Japanese innovations.

Keywords: Zen-style, bracket set, woodworking manuals, Kamakura Zoei Myomoku, Yingzao Fashi, Gongcheng Zuofa Zeli


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1. INTRODUCTION

Zen architecture was introduced from China to Japan in the 13th century. What influence did Zen architectural culture bring to Japan in the medieval period (13th–16th centuries)? From the introduction of ironware in prehistory, the introduction of Buddhist architecture in the 7th century, to the acceptance of Western architecture in the Meiji period at the end of the shogunate period, as well as a series of historical phenomena that followed the world trend and set off the modernist architectural movement in modern era, the history of Japanese architecture is a developmental process of continuously accepting foreign cultures and digesting and transforming them into Japanese culture.

In terms of the Zen-style architecture, the trailblazing research of the pioneers such as Hirotaro Ota and Sugashi Iida encountered a huge difficulty of lacking physical evidence to support. Although Japan has more ancient relics like the Horyuji Temple in Nara (7th century) and the Phoenix Hall of Byodo-in Temple in Kyoto (11th century), very few buildings remain in the heyday when Zen architecture was introduced (13th–14th century). The relics of Kanto Zen-style architecture are represented by the Jizo Hall of Shofuku-ji Temple in Tokyo (1407, national treasure) and the Shariden Hall of Engakuji Temple in Kamakura (the first half of the 15th century, national treasure), both of which are three-bay with the surrounding porch, are already the largest of the extant relics. From the scale of the relics, it is difficult to imagine the magnificent five-bay temple depicted in the Ancient Drawings of the Kenchoji Temple (1331), which is 9 jo 丈 wide. Scholars in the past had to speculate on the historical development of Kamakura Zen-style architecture from the rare documents, drawing information and small-scale architecture left in various places.

The newly discovered historical materials group Kamakura Zozi Myomoku in the 1980s enriched the historical data of Zen-style architecture. Particularly, the recorder of Kamakura Zozi Myomoku is the hereditary carpenter family of Kenchoji Temple, and the historical position of Kenchoji Temple in the history of Japanese architecture determines the importance of this technical manual.

Kenchoji Temple ranks first among the five-mountain temples in the Kamakura period. It was founded in the 5th year of Kencho (1253), so it is named. Although Zen Master Eisai founded the Shofukuji Temple in Fukuoka and the Kenninji Temple in Kyoto before the Kenchoji Temple, they are both temples of Zen Buddhism and other Buddhist sects, not pure Zen temples. The Kenchoji Temple in Kamakura is the first Buddhist temple in Japan to specialize in Zen Buddhism, and it is the originator of authentic Zen temples. From an architectural point of view, this temple was a pioneering work that fully introduced the design methods and rules of Zen architecture in the Song dynasty (960–1279). Although the temple, which took 5 years to build, has not survived, it was very different from the wayo 和样 style that has been formed after a long period of Japanization since the acceptance of Buddhist architectural techniques from mainland China in the 7th century. The Kenchoji Temple is considered to be an authentic Song-dynasty...
style building \[^{3,4}\]. In the 5th year of Koan (1282), the Engakuji Temple in Kamakura was built, and the prototype of Zen architecture was born out of these temples. At the same time, with the implementation of the five-mountain system of Zen Buddhism, these temples had a huge impact on the construction of lower-level Zen temples within the system.

It is a pity that the halls of the Kenchoji Temple and the Engakuji Temple were repeatedly destroyed by fire and rebuilt many times. Zen monasteries flourished in Japan during the Northern and Southern dynasties (1333–1392), but in the 15th century, the power of the Kamakura nobles declined, their territories were sold, and a large number of monasteries were abandoned. During the Edo period in the 17th century, the temple of Zen was restored with the help of the Tokugawa family. The new group of artisans who worked for the shogunate and the local feudal lords began to shoulder the responsibility of the era, while carpenters in the Kamakura area had been marginalized and lost their former vitality. Because of this, Kamakura carpenters did not merge with the carpenter group of the new era, and the records of the craftsmen still retained the local technical characteristics until the 19th century in Kamakura Zoei Myomoku. It can be seen that Kamakura Zoei Myomoku is an important historical material for the study of Japanese Zen-style architecture. The first author of this article, Tadanori Sakamoto, took Kamakura Zoei Myomoku as the research subject of his doctoral dissertation \[^{5}\]. This article is based on the Japanese paper, titled “The influence of Chinese architecture in the carpenter’s technical book Kamakura Zoei Myomoku: About the composition and design method of the bracket sets” by Tadanori Sakamoto in 2015 \[^{6}\]. On this basis, the framework and content of the thesis have been adjusted for Chinese readers, and descriptions of related terms such as Kiwari 木割 manual, ayita, and shiware 枝割 have been added. In order to facilitate the understanding of Chinese readers, Tadanori Sakamoto has drawn a large number of schematic diagrams to explain technical terms in this paper, and published for the first time the decomposition model of bracket sets in the Shariden Hall of the Engakuji Temple \[^{4}\].

This paper tries to trace the developmental process of Japanese construction technology through the analysis of Kamakura Zoei Myomoku, and then conducts a comparative study of Chinese and Japanese architecture. After studying the composition and design methods of Zen-style bracket sets in Kamakura Zoei Myomoku, it compares with the traditional Chinese manual Yingzao Fashi (Technical Treatise on Architecture and Craftsmanship) from the Song dynasty, and analyzes which design methods of Japanese Zen-style architecture have been influenced by Chinese architecture.


The Kawachi family in Kamakura during the Edo period was responsible for the construction of the Kenchoji Temple, the originator of authentic Japanese Zen monasteries. Kamakura Zoei Myomoku [Figure 1] is the hereditary collection of handwritten records inherited by the Kawachi family. In the late 1980s, these documents about construction were found among the old files collected by the Kawachi family. In 1987, the Zen architecture historian Kinya Sekiguchi \[^{7}\] introduced the existence of

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3 Kinya Sekiguchi believes that the source of Japanese Zen-style architecture is not from North China, but originated from the architectural style of the late Southern Song dynasty in the Jiangnan region between the south of Jiangsu Province and Zhejiang Province of China. However, there are many views on whether the Kenchoji Temple in the founding period is an authentic architectural style of the Southern Song dynasty. For details, please refer to Ancient Buildings of Sung and Yuan Periods Seen in Southern Kiangsu and Chekiang Provinces (i): Ancient Pagoda and Detail of Wooden Structure in the Sung Period and Ancient Buildings of Sung and Yuan Periods Seen in Southern Kiangsu and Chekiang Provinces (ii): Style of Wooden Structures of Sung and Yuan Dynasties and Zen-style Architectures around the Kamakura Period by Kinya Sekiguchi.

4 The drawings and photos cited have obtained the publishing permission from the copyright owner.
Kamakura Zoei Myomoku. There are a total of 660 records in this batch of documents, including construction technology, account books of contracted projects, land contract, and so on. The earliest document was written in 1633 and the record continued to the second half of the 19th century. Among them, architectural documents include shrines, Buddhist halls, pagodas, gates, residences, interior furniture, decoration, and many other contents. The Buddhist Hall documents include the precious Zen-style three-bay Buddha Hall, Zen-style five-bay Buddha Hall and five-bay mountain gates, which reflect the architectural tradition of Kamakura five-mountain temples. They are the first-hand historical materials recording the construction technology of Kamakura carpenters with high historical value. These records are tentatively named as Kamakura Zoei Myomoku and are rated as “tangible cultural property” (material relics) in Kamakura city. It is known as the double jewels of architectural historical materials, together with The Construction Drawing of Engakuji Temple (Sectional Elevation) 5 (1573) [Figure 2], which is inherited by the carpenter family—Takashina family—of the Engakuji Temple that ranks second in the Kamakura five-mountain temples.

The ancestor of the Kawachi carpenter family, named Zenshin, died in 1280. His descendants are divided into the main (or stem) family and the branch family. The main family is called Kyuemon Kawachi, and the branch is called Chosaemon Kawachi and Denbee Kawachi. The main family took the position of takumi-no-suke 6 and inherited the position of carpenter for the Kenchoji Temple. The historical materials, Kamakura Zoei Myomoku, that had been passed down so far are the relics of the Chosaemon Kawachi family. This family inherited the position of carpenter of the Jufukuji Temple and the Eishoji Temple in Kamakura, and has the qualification of Daikushi that can assist the main family to build the Kenchoji Temple.

The main writers of Kamakura Zoei Myomoku are Denkichi Kawachi and Kichizaemon Kawachi from the branch family. Denkichi Kawachi (?–1662) wrote five volumes between 1633 and 1638, and Kichizaemon Kawachi (?–1670) wrote 10 volumes between 1649 and 1652. Judging from the age of the craftsman's death, the transcripts may be the notes the craftsman made while studying with the old craftsman, which are not very proficient yet and may be recorded while listening and transcribing.

Figure 1. Records of Three-Gate Pavilion in Kamakura zoemiyomoku Source: Collected by Kamakura National Treasure Museum; photo by the author

5 The original document is collected in Kamakura National Treasure Museum. It is about 3.5 m long and 2.2 m wide. It is a rare Zen-style architectural drawing of Azuchi-Momoyama period. It was designated as a national important cultural property in 2011.

6 The official office in charge of construction in the government or palace is called takumi. suke means second in command.
The old craftsmen who served as teachers were mainly Sakanaka-takumi, Chikugo Kakuonji, and Soemon Kakuonji. Sakanaka-takumi was from the main Kawachi family and also a carpenter of the Kenchoji Temple. The other two were craftsmen from the Shibuya family, a hereditary carpenter family for the Kakuonji Temple. In addition, there were also sporadic teachings from carpenters in other parts of Kamakura. It can be seen that the carpenters in the Kamakura area had a certain degree of communication when educating their apprentices.

The nature of Kamakura Zoei Myomoku belongs to the modern (16th–19th century) Kiwari 木割 manual. Kiwari is a Japanese architectural term that means a design technique that determines the dimension of each building component, the distance between each component, and the proportional relationship between them. The ancients determined the size of each part when divided (called wari in Japanese) woods, so the technique of determining the size and proportion of wood is called Kiwari. Wari in Japanese means one tenth. Therefore, the “wari” in Kiwari has the double meaning of cut-off and proportion.

The basic method to determine Kiwari is to first set the standard distance between two columns, that is, the standard column distance L, then determine the proportional factor α according to the scale of the architecture, and multiply those two to obtain the column diameter C, that is, C=αL. Then the column diameter is multiplied by another factor β to get the rafter diameter (the side length for the square rafter) T, that is, T=βC. After the column diameter is obtained, it is used as the datum dimension, and multiplied by the proportional factor of each component to determine the dimensions of beams, purlins (stringers), and various bracket sets. The

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7 In ancient times, it was also called Kikudaki.
rafter diameter at the eaves can be used as an auxiliary datum dimension.

The proportional factor varies according to the scale and type of buildings, as well as the sects of craftsmen, regions, and times. Therefore, once seeing the size of the building’s bay or column diameter, the craftsmen can immediately judge whether the Kiwari of the architecture is thick or thin.

There might have been a proportional relationship between the bay size and the column diameter, or between the column diameter and the size of the main components in ancient Japanese architecture before the 12th century. However, there is no historical materials at present, and a clear conclusion cannot be drawn yet. The proportional relationship itself may only be a general rule, and the quality of design depends more on the personal feeling of the carpenter in charge.

In Japan, the books that clearly stipulate the dimension and proportion relationship between wooden building components appeared in the 15th century. At that time, craftsmen were all run by families. In order to ensure the leading position of the family in technology, obtain the right to monopolize construction projects and achieve the hereditary function of craftsmen, Kiwari system, the technical core of the family, must be inherited. Therefore, the Kiwari manual that secretly handed down by the family was born. The early Kiwari manuals include Sandaikan (Three-generation Scroll, 1489) and Kikudaki-no-Chumon (The Annotation of Kiwari, 1563 or 1574). This systematic design technology is called Kiwari technology.

In recent years, it has been confirmed that the ancestral secrets of craftsmen began to circulate in the market in the second half of the 16th century. In the mid-17th century, the inheritance of Kiwari technology was no longer limited to families, but allowed to be passed on to disciples from everywhere. Therefore, the sects of the carpenter were gradually formed. In 1655, the published Kiwari manual finally appeared in public, that is, Shinpen-hinagata (The Newly Edited Prototype)⁹.

It is unknown whether the Edo shogunate had the intention to promote the standardization of architectural design, so as to promote the publication of Kiwari manuals. However, the widespread popularity of Kiwari manuals in the middle of Edo (18th century) is a clear historical fact, which even gradually led to the unification of the design of Japanese temples and shrines. During the Meiji period (1868–1912), some people criticized that the design of Japanese temples and shrines only followed the Kiwari manual, which made them all look the same.

The most famous Kiwari manual in the Edo era are Shomei (written in 1605–1608) by the Tokugawa Shogunate craftsman family, Heinouchi family, and Kenninjiha-kadensho (The Family Book of Kenninji Temple School, written in the early 18th century) of another Shogunate craftsman family - Kora family. Kamakura Zoei Myomoku is about 30 years older than Shomei. Compared to Shomei and Kenninjiha-kadensho, Kamakura Zoei Myomoku has no attached drawings but only regulations on the sizes, and it is more like a memorandum. Nevertheless, it uses the common language of the early Kiwari manual, which is similar to The Construction Drawings of Kamakura Engakuji Temple. Therefore, it can be considered that Kamakura Zoei Myomoku is an early Kiwari manual of early modern period (16th–19th century) that keeps the characters of the medieval period (13th–16th century). Its content is very different from the mainstream.

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⁸ At the end of the scroll, there are words like Shungen and Shochin in 1489, Yoshihida Fujiwara and written by Jokichi Fujiwara. They didn’t exist originally, but were copied after 4 times and included in Goshikenki written in 1682.

⁹ Written in the first year of the Ming dynasty (1655) by Segawa Masashige of Kofu, Toshima County, Musashi (one of the urban areas of today’s Tokyo), one volume, 30 cm long. The original meaning of “prototype” was sample and model. This book includes design principles and drawings. Segawa Masashige is the Chief master carpenter who could design according to rules and standards (called Toryo in Japanese). According to the preface, this book was co-authored by Segawa Masashige and his son. The earliest original edition is collected in the National Diet Library, Japan.
west Japan technology centered in Kyoto, and it belongs to the Kanto region’s unique technology system centered in Kamakura. In other words, Kamakura Zoei Myomoku remains in the clique tradition of Kamakura five-mountain temples, which was very popular in the medieval (13th–16th century) Japanese architecture, and retains the strong influence of Song-dynasty Chinese design techniques that introduced to Japan from the Kamakura era. Since none of the five-mountain temples in Kamakura remains today, the architectural image and technology of the time cannot be seen in the relics, so this batch of historical materials is particularly important.

3. THE ZEN-STYLE BRACKET SETS AND ITS DESIGN METHOD IN KAMAKURA ZOEI MYOMOKU

There are three documents in Kamakura Zoei Myomoku that clearly record the Kiwari sizes of the bracket sets, which are Three-Bay Buddha Hall (1663), Five-Bay Buddha Hall (1635), and Three-Gate Pavilion (1634). The author sorted out the dimension records of the three-extension bracket complex in the body of the hall (called Moya in Japanese), and drew Figure 3 referred to the image data of the bracket sets in the same period and the architectural relics.

Kinya Sekiguchi pointed out that the contents of Kamakura Zoei Myomoku are very similar to The Ancient Drawing of the Engakuji Temple that was drawn in the 4th year of Genki (1573) [7]. Because there is no image data in Kamakura Zoei Myomoku, the following morphology analysis of bracket sets refers to the Tatejiwari [8] in The Ancient Drawing of the Engakuji Temple.

All kinds of components of bracket set in Kamakura Zoei Myomoku can be classified into four categories: To (bearing block, Dou 斗), Hijiki [9] (bracket arm, Gong 橋), Odaruki [10] (tail rafter, Ang 昂) and Keta (Purlin, 柱). Bearing block can also be divided into Daito bearing block, Makito bearing block [San-dou, Figure 4], Kaketo bearing block [Jiaohu-dou, Figure 3], and Houto bearing block. Among them, Kaketo is the most characteristic bearing block in Kamakura Zoei Myomoku. It is the bearing block holding the Odaruki tail rafter or the Hijiki bracket arm that extended from the vertical wall. Its length and width are 10 percent bigger than that of the Makito [11]. The Houto [(6) in Figure 3] is not supporting the crossing bracket arm, but is under the tail of the lower strut [Sasu; ⑤ in Figure 3] to support the upper tail rafter of the third extension of the outer eaves.

In Japan, bracket arm is called Hijiki, and bracket sets that parallel to the outer wall and

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10 Jiwari is the map showing the state of land division. In urban planning, land zoning and plot division design are called Jiwari plan. While Tatejiwari refers to the drawing that draws half of the elevation and section of a single building on one drawing. Tate here means vertical. The Tatejiwari in the ancient drawing of The Engakuji Temple in the text is the sectional elevation.

11 In order to facilitate the comparison with the Yingzao Fashi, this paper takes the use of Japanese Chinese characters as the basic principle for the architectural terms in Japanese, such as Chinese Hua-gong, and the corresponding Japanese components still use Hijiki. Architectural terms without Chinese characters are expressed by Roman letters pronounced in Japanese or the transliteration of Chinese characters.

12 Generally speaking, Ang is called Odaruki in Japanese, and Ohitaruki is a unique term in Kamakura Zoei Myomoku.

13 Kake has no Chinese characters in Japanese. It is literally translated as hanging, which is similar to the meaning of Jiaohu (interaction) in Chinese. However, because of its special size, it is different from the Jiaohu-dou in China, so here directly uses Kaketo.

14 The professional term “Kaketo” is also recorded in other early kiwari manuals, such as Magoshichi-Oboegaki, Kobayashi family book, a carpenter family of Shonai county (today’s Yamagata prefecture), and Shomei in the early days of Edo. However, none of these books stipulates that the length and width of the “Kaketo” bearing block should be increased by 10%. Kinya Sekiguchi pointed out in The Bracket of the Zen style (1), that generally, the length of the Makito bearing block (San-dou) is the same as that of the Houto bearing block. The phenomenon of enlarging Kaketo bearing block is only confirmed in Sagami (today’s Kanagawa prefecture), Musashi (today’s Tokyo prefecture), Shimousa (today’s Chiba prefecture), Kai (today’s Yamanashi prefecture), Shinano (today’s Nagano prefecture) and other Eastern countries (today’s Kanto region).
Design method of Zen-style bracket sets: Part 1

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on the vertical wall all have their own names, but there is no unified name like Heng-gong or Hua-gong.

The characteristic of Zen-style bracket sets is that the height, width and length of Heng-gong and Hua-gong are all different. Specifically, the bracket arm of the first extension that parallel to wall is called Waku-Hijiki in Japan, and Waku means frame. The length and height of Waku-Hijiki are all standard sizes. The length of Hijiki from the second extension upper is one Makito bearing block longer than the standard size, so the component is called Naga-Hijiki (Long bracket arm) in Japan [⑧ in Figure 3]. Meanwhile, the section height of bracket arm in vertical wall direction increases, so that it aligns the top of the lower bracket arm to the bottom of the upper bracket arm, and the section width increases 10 percent than that of Waku-Hijiki. Since the surfaces of these two components are overlapped, they are called Kasane-Hijiki in Japanese [① in Figure 3] that emphasizes the overlapping and integrated state of the upper and lower components. In fact, this integrated state strengthens the overall structure of bracket sets.

The head of the Ohtaruki (Odaruki; Xia-ang/tail rafter) in Kamakura Zoei Myomoku is of the angular type unique to the Kanto region, and the third extension, which is the top one, is called Hashiru-15 Ohtaruki [④ in Figure 3]. The second extension, the lower tail rafter, is called Kasane-Ohtaruki [Overlapping tail rafter; ③ in Figure 3]. Here “overlapping” also means the integrated state of upper and lower components. Although the Kasane-Ohtaruki is also the tail rafter looked from the outside, in fact it is a decorative one. It is made of one piece of wood to make two kinds of heads. The inner side is bracket arm, and the outer side is the horned head. Figure 5 shows the decomposition model of the bracket sets under the eaves of the Shariden Hall of the Engakuji Temple in Kamakura.

The component with one head of bracket arm and one head of horn is the Kasane-Ohtaruki. It is a fake support component, and the inclined timber playing the role of structure is a diagonal brace, called Sasu [⑤ in Figure 3] extending from the center of the column to the inner side of the roof.

These bracket sets are connected horizontally through bracket arm (Fang 枋) or purlin (Heng). The round purlin on the outermost side of the eaves [eave purlin, Liaoyan-fang, ⑩ in Figure 3] is the most special component of all. Its sectional height

Figure 3. Composition of Zen-style three-extension bracket sets in Kamakura Zoei myomoku. Source: Drawings by Tadanori Sakamoto according to the record

15 In Japanese, Hashiru has no Chinese character. It means “run.”
16 Splicing will weaken the structural strength. After the Kanto earthquake in 1923, when repairing the Sarira Hall of Engakuji Temple in Kamakura, this component was spliced with two timbers.
The bracket sets above are restored by the author according to the Kamakura Zuei Myomoku. They are basically the same as the bracket sets of the existing Kanto Zen-style Buddhist Temple\[8\]. Especially, the record about techniques of Kasane-Hijiki and Kaketo should be noted. There are no similar records in other modern (16th–19th century) Kiwari manuals, except Kamakura Zuei Myomoku, which shows that these two techniques are the unique and important characteristics of Kanto Zen-style bracket sets\[9\].

The first step of the bracket sets design method in Kamakura Zuei Myomoku is to determine the datum dimension, and then multiply it by the proportional factor to obtain the size of the other components. However, the datum dimension and the proportional factor of various components vary with different Kiwari manuals. After analyzing the regulations of Kamakura Zuei Myomoku, we can know that it sets the column diameter as the most basic datum dimension, and the bracket arm as the second. The carpenters will set the bracket arms’ sectional height, width \[h\] in Figure 3 and extension length \[H\] in Figure 3 as auxiliary datum dimensions\[10\].

When calculating the vertical direction (facade direction) of bracket sets, the proportional factor needs to be simplified and easy to operate. In Kamakura Zuei Myomoku, the vertical upper and lower ends of each bracket sets component coincide with the horizontal line of 1/2 the height of bracket arm, that is, \(u = 0.6h = \text{Bracket arm length (height)} \times 1/2\), as shown by the horizontal dotted line in Figure 3. These equidistant horizontal baselines have an integer multiple alignment relationship with the upper and lower ends of bearing block and bracket arm.

It should be noted that 1/2 the height of bracket arm = the height of shikimen\[18\] (Ping + Qi) in Kamakura Zuei Myomoku, which is different from the height ratio of 2:1:2 for the Er, Ping, Qi in Yingzao Fashi. This

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17 About the composition of bracket sets in the existing Kanto Zen style Buddhist temples, please refer to The Bracket of the Zen Style (1) by Kinya Sekiguchi
18 That is, the depth of the Dou’s mouth (height of Er) and the height from bottom to the bottom line of Dou’s mouth (Ping + Qi) account for half of the overall height of Dou. The height of Ping + Qi is called Shikimen in Japanese, Figure 4.
equidistant horizontal baseline is not only used in the scale design of the vertical (facade) direction of bracket sets outside, but also the rainbow beams and bracket sets inside and Naijin inner sanctum (daguang/neizheng) bracket sets. The author believes that it is not a coincidence, but proves that the method of using equidistant horizontal baselines to control the height of the components exists at the beginning of the design. Only then can the upper and lower ends of each component highly coincide with the horizontal baseline.

Similarly, the horizontal size of bracket sets is also based on the extension length [H in Figure 3] as the datum dimension. The design method of the bracket arm that is vertical to the wall (Hua-gong) is to first draw the axes of the equidistant extension length of bracket arm, H; then the extension length of the Ohtaruki tail rafter (Xia-ang), the depth of eave; and then the horizontal extension distance of wooden platform (Wooden base), and so on, are all based on the extension length of bracket arm as the basic unit size to calculate. However, there is no multiple relationship between the horizontal extension length of bracket arm (hen-gong) and its cross-sectional height, so there is still some ambiguity. At present, it is speculated that Japan uses the principle of To-chigai to determine the extension size of bracket arm [11]. To-chigai can be literally translated into bearing block staggering, which means not shielding each other. The principle of To-chigai is shown in Figure 6, that is, the left contour of the Daito large bearing block is aligned with the right contour of each extension’s Makito small bearing block, and contours of Makito small bearing block on the same side are aligned, as well as the right. It decides the extension size of bracket arm based on the principle of aligning contours of the upper and lower bearing block. Wayo style does not use the principle of To-chigai, which is the unique design method for hen-gong of Zen style.

In Kamakura Zoei Myomoku, there is a special term for the distance between the axes of two bracket sets, that is ayita. Its pronunciation can be transliterated as aita, anta, or ayita. Terms of other components in Kamakura Zoei Myomoku are mostly expressed in Chinese characters, but katakana is specially used here. This pronunciation itself can correspond to the Chinese character Jia, but deliberately not using Chinese. The author speculates that there are two reasons for the above use of pronunciation mark. The first may be to pass down the pronunciation introduced by Chinese craftsmen, just as katakana is also used to mark foreign words in modern times. The second may be to avoid confusion between the column distance and the bracket sets’ axial distance.

Kamakura Zoei Myomoku stipulates that the size of the larger bay (central bay) is three ayita, and the rib bay (secondary bay) is two ayita. It can be seen that in Zen-style architecture, the column distance is specified by ayita, the bracket sets’ axial distance. However, ayita is a unique concept of Zen style. Earlier wayo-style architecture used shiwarì instead of ayita to determine the distance of the columns.

Since the 7th century, the design method of wooden architecture introduced from China and Korea was to determine the distance of the columns first, and set it as the datum size. The rafters were unevenly distributed because the column distance was the full scale. From the end of the Heian period to the Kamakura period, the accuracy of wayo-style architecture was improved, and one of the purposes was the pursuit of an even

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19 The author did not find the word with the same pronunciation and meaning in Yingzao Fashi.
20 The Japanese pronunciation is Shi-Wari, shi is the quantifier of rafters, 1 shi = side length of rafters + distance between adjacent rafters, wari still means “proportion and scale.” Shiwari refers to the method of taking 1 shi between rafters as the basic unit size to determine the plane size, so it has a corresponding proportional relationship with the spacing of column and bracket sets.
distribution of rafters. At this time, the Hanegi cantilever [Figure 7] had been used to support the loads of eaves, so the rafters including the corner could be made into parallel, and the section had been changed from the round shape in ancient times (7th–12th century) to square. In the 13th century, the shiwarı principle that determined the plane size of wayo-style architecture was established \[12,13\]. The so-called shiwarı, as shown in Figure 8, means the size of 1 shi was the side length of a square rafter + the distance between adjacent rafters. Shiwarı principle was determining the size of 1 shi of the equally spaced rafters first, and then the distance of the columns as several shi, which means that the size between columns was an integral multiple of the equal spacing of rafters \[14\]. Therefore, shiwarı was a wayo-style architecture scale principle that determined the relevant dimensions of the plan based on the rafters. Before the formation of Zen style, the shiwarı system had appeared in wayo-style architecture. According to the Japanese architectural relics, the Rokushigake \[6 rafter arrangement, Figure 9, right\] had been widely popularized from the 13th to 14th centuries, that is, the horizontal length of one bracket set exactly corresponds to 6 rafters + 5 spacing.

For the establishment of the shiwarı system, please refer to About the Development of shiwarı, especially the Occurrence of Rokushigake-tokyo by Kenji O and On the Determinable Method of the Measurement of a Span between Rafters in Buddhist Main Halls in the First Half of the Medieval Period by Akinori M.
Wayo-style architecture had the shiwari system, but there was no concept of ayita, which means there was no bracket sets’ axial distance. So, what was the relationship between the unique ayita of Zen style and the shiwari of Wayo? The author analyzed the size of the Three-Bay Buddhist Monastery in the Kamakura Zoei Myomoku, calculated the result that, 1 ayita = 8 shi. And combined with the form of bracket sets from the sectional elevation of the The Construction Drawing of Engakuji Temple, the author restored the multiple size relationship between ayita and shiwari of Sanken-butsuden (the Three-Bay Buddhist Monastery), as shown in Figure 10.

Although there was no direct relationship between ayita and the size of the bracket arm, the equidistant baseline obtained after eight equal divisions of ayita basically aligned with left and right end contours of the Makito bearing block, so it can be assumed that ayita was about eight times the length of the Makito baering block [11].

4. THE COMPARISON WITH THE DESIGN METHOD OF BRACKET SETS IN THE SONG-DYNASTY YINGZAO FASHI

It can be said that the architectural technology recorded in the Yingzao Fashi was the source of Japanese Zen-style architecture. Bracket sets were the most characteristic components of Zen-style architecture, thus the comparison between Kamakura Zoei Myomoku and Yingzao Fashi was limited to bracket sets. In Japan, Takuichi Takeshima was the first architectural historian who studied Yingzao Fashi.

In Yingzao Fashi, the number of bracket sets is counted by duo. It is stipulated that two

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22 Takuichi Takeshima (1901–1992), Japanese architect graduated from Imperial University of Tokyo (now the University of Tokyo) in 1927. He has followed Mr. Tadashi Sekino to visit China for many times. He once talked with Qiqian Zhu and Xiang Tao about the lithographic version of Yingzao Fashi and the collation of the imitation song version. From 1939 to 1942, Takeshima basically completed the first draft of the interpretation and research of Yingzao Fashi, but it was burned down by the air raid in 1945. The rewritten manuscript was submitted to the University of Tokyo as a doctoral thesis in 1949. In 1970, he published A Study on Yingzao Fashi and reprinted it many times.
The technique of making the end of Hua-gong bracket arm into the horned head in Yingzao Fashi is similar to the Kasane-Hijiki bracket arm in Kamakura Zoei Myomoku. However, this technique in Yingzao Fashi is only limited to four-layer bracket sets 四铺作, which is different from Kamakura Zoei Myomoku. The Shang-ang strut is equivalent to the component called Sasu strut in Kamakura zoei myomoku.

Qixin-dou bearing block in Yingzao Fashi is still called Makito bearing block in Japan, and Jiaohu-dou bearing block is equivalent to Kaketo bearing block. The width of the Jiaohu-dou bearing block is 18 fen°, which is slightly larger than that of the Qixindou bearing block with a width of 16 fen°. It is the same as the relationship between Kaketo bearing block and Makito bearing block in Kamakura Zoei Myomoku. The width and length of all the Ludou bearing block are all 32 fen°. The width of Daito bearing block in Kamakura Zoei Myomoku is three times that of bracket arm. Assuming that the width of Gong is 10 fen°, the width of Ludou bearing block is 30 fen°. It can be seen that the size of Ludou bearing block in Yingzao Fashi is slightly larger than that in Kamakura Zoei Myomoku. Yingzao Fashi stipulates that San-dou’s short side (width) should be taken as the front, which is also different from the way of using the long side of the Makito bearing block as the front side in the Kamakura Zoei Myomoku.

In Yingzao Fashi, the Er of the Ludou bearing block is equivalent to the gan of Japanese, Ping is equivalent to the Shikimen of Japan, and Qi is equivalent to the Toguri of Japan. The height ratio of Er, Ping, Qi is 2:1:2, which is the same as the proportion and size specified in the Gomawari (five-bay arrangement) in the Shomei and the Kiwari in Kamakura Zoei Myomoku. It is worth noting that the calculation method of

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23 However, when the size of each bay is different, the distance between bracket sets is allowed to change within one shaku. It can be seen that there is also a design method that gives priority to determining the size of the bay.
the bottom size of bearing block is the same as that in *Kamakura Zōei Myomoku* and *Yingzao Fashi*, but different from that in *Shomei*. In *Yingzao Fashi*, the bottom width of bearing block is obtained by cutting 2 fen° inward from the upper end dimension, and *Kamakura Zōei Myomoku* also calculates how much Toguri needs to be cut inward from the lower end dimension of the Makito bearing block [Figure 4]. While *Shomei* directly specifies the lower end width of bearing block.

Next, let us discuss whether there is a vertical alignment of the gong on facade [Figure 12] in *Yingzao Fashi*, that is, whether there is a To-chigai principle.

The distance between the axes of the two San-dou bearing block on Nidao-gong bracket arm is 52 fen°, and the width of Ludou bearing block is 32 fen°. The short side of San-dou bearing block is 14 fen° long, so the width of Ludou bearing block + width of San-dou bearing block = 46 fen°, which is 6 fen° less than the distance between the axes of two San-dou bearing block. Similarly, the distance between the axes of the two San-dou bearing block on Man-gong bracket arm is 82 °, and

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**Figure 11.** The composition of six-puzuo bracket sets in *Yingzao Fashi* (referred to Figure 240 in *The Annotation of Yinzao Fashi* written by Liang Sicheng [15]. Source: Drawing by Tadanori Sakamoto

**Figure 12.** The types of Gong in *Yingzao Fashi* (referred to Figure 241 in *The Annotation of Yinzao Fashi* written by Liang Sicheng [15]. Source: Drawing by Tadanori Sakamoto
the distance + the width of San-dou bearing block × 2 = 80 fen°, with a gap of 2 fen°. It can be seen that there is no counterpoint relationship between the left and right outer contours of the Ludou bearing block and the inner contour of the San-dou bearing block on Nidao-gong bracket arm, as well as between the outer contour of the San-dou bearing block on Nidao-gong bracket arm and the inner contour of the San-dou bearing block on the Man-gong bracket arm [right side of Figure 11, Heng-gong], that is, there is no Japanese To-chigai principle as in Yingzao Fashi.

5. HISTORICAL SIGNIFICANCE OF KAMAKURA ZOEI MYOMOKU
To conclude, the comparison results between Yingzao Fashi and Kamakura zoei myomoku are summarized as follows.

(i) Yingzao Fashi not only distinguishes between Hua-gong bracket arm and Heng-gong bracket arm, but also the name and size of Heng-gong vary due to different locations. For example, Guazi-gong bracket arm and Ling-gong bracket arm are called Hakari-Hijiki bracket arm in Japan. Ling-gong bracket arm is longer than Guazi-gong bracket arm, while the Hakari-Hijiki bracket arm in Japan has no length change. It can be seen that Kamakura Zoei Myomoku only distinguishes bracket arm that is vertical or parallel to the walls, and which are not subdivided in the same direction. There is no change in the length, which simplifies the classification of bracket arm in Yingzao Fashi.

(ii) The technique of making the top of Tsu-ts’ai Hua-gong 足材华棋 and the upper extension’s bracket arm integrating and supporting each other in Yingzao Fashi is similar to the technique of Kasane-Hijiki bracket arm in Kamakura Zoei myomoku. However, the width of Kasane-Hijiki bracket arm is 1/10 wider than that of ordinary bracket arm. And there is no similar stipulation in Yingzao Fashi.

(iii) In Yingzao Fashi, Jiaohu-dou bearing block on the head of the Hua-gong bracket arm is slightly larger than San-dou bearing block, which is similar to the technology of Kaketo bearing block. But there is no record that Qixin-dou bearing block is larger than San-dou bearing block, which can be seen that it has been simplified.

(iv) The size of Qi (Toguri in Japanese) reduces with the width of bearing block. This processing method is the same as that of Toguri 24 in Kamakura Zoei Myomoku. Referring to Figure 4, width refers to the width of the Makito (Small bearing block, 巻斗). Then cut inward, the eliminated width is called Toguri width.

(v) When a piece of wood is used to make the inserted Odaruki tail rafter obliquely, the processing method in Yingzao Fashi is the same as that in Kamakura Zoei Myomoku, and Odaruki tail rafter plays a structural role in supporting the eaves. However, there is a big difference between the methods of the two manuals when they are using the double Odaruki tail rafter. In Yingzao Fashi, the two components are all made of a whole inclined wood, both of which stretch out under the eaves, which is consistent with Japan [Figure 3]. The difference is in the second extension. In Japan, its head is in the shape of Odaruki tail rafter, called Kasane-Hijiki overlapping bracket arm which is a fake decoration. Together with the bracket arm of the second extension indoors, they are processed from the same piece of wood [refer to the decomposition component in Figure 5]. Nevertheless, the technique of inserted Odaruki tail rafter in four-layer bracket sets or inserting Odaruki tail rafter inward from the center of bracket sets in the Yingzao Fashi has been confirmed in Kamakura Zoei Myomoku.

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24 Toguri is a nominalization of verb “Kuru”, which means “cutting inward.”
(vi) The cross-sectional height of the eave purlin (Liaoyan-fang) is twice that of bracket arm and directly supported with San-dou bearing block, which is also confirmed in Kamakura Zoei Myomoku.

(vii) There is no detailed description of the size of the column bay in Yingzao Fashi, which can be considered that the size of the column bay is determined by the number of bracket sets, and that in Yingzao Fashi can be understood as similar to the Ayita in Kamakura Zoei Myomoku used as intermediate datum units.

(viii) Using Ts'ai as the basic dimension in the Yingzao Fashi is similar to the method of taking the sectional width and height of the bracket arm as the auxiliary basic dimension in the Kamakura Zoei Myomoku, but the calculation methods of the two are completely different. Yingzao Fashi uses the concept of fen°, while the Kiwari is used in Kamakura Zoei Myomoku to determine the component size. That is the most fundamental difference between them.

(ix) There is no auxiliary dimension similar to Chin in Kamakura zoei myomoku. However, it sets the Shikimen height [Figure 4] as one-half of the section height of bracket arm, and uses it as the basic dimension unit in the design of the facade. The height ratio of Ts'ai to Chin in Yingzao Fashi is 15:6, which obviously has no intention of using equidistant baseline. However, Kamakura Zoei Myomoku takes the Shikimen height that equal to the size of Chin as the datum scale for controlling the size of components, which is similar to Yingzao Fashi. In addition, there is no Japanese facade design principle of To-chigai as in Yingzao Fashi.

Japanese Zen-style architecture was formed after the introduction of late Southern Song-dynasty Chinese architecture. So, the content of Kamakura Zoei Myomoku naturally has a strong connection with Yingzao Fashi. Especially the technique of the Kasane-Hijiki overlapping bracket arm in Kamakura Zoei Myomoku, that is, increasing the sectional height of the bracket arm to extend perpendicular to the wall to fill the gap between the upper and lower bracket arm components and overlap them to strengthen the structure. In Japan, this technique was only used in the Kanto region and its surroundings, and there is no record in other technical books. Therefore, it can be inferred that the bracket sets technique introduced from China to Kamakura in the late Southern Song dynasty was only spread and handed down in some areas. The background may be that the Hanegi cantilever technology which supported the eaves in medieval Japan (13th–16th century) [Figure 7] had been used widely, and the main load of the eaves did not need to be supported by bracket sets. Since there was no need to strengthen the structure in the direction that perpendicular to the wall, so the Kasane-Hijiki overlapping bracket arm technique had not been spread widely.

In addition, there are records of increasing the scale of Kasane-Hijiki overlapping bracket arm and Kaketo bracket arm by one tenth in Kamakura Zoei Myomoku, but no similar record in Yingzao Fashi. Therefore, this technique should appear after the publication of Yingzao Fashi, and whether it appeared in China first, or was created and developed after the introduction of late Southern Song dynasty’s architecture into Kamakura, it remains to be studied.


ACKNOWLEDGMENTS

None.
FUNDING
None.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

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