Dissertation

On Techniques of Historic Timber Architecture in Lan Na: an Investigation on Existing Evidences

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Kurzfassung

Meine Untersuchung erforscht die Bautechnik der historischen Holzarchitektur der Region Lan Na (gegenwärtig Nordthailand). Dieses Thema wurde bislang vernachlässigt, was auf akademischem Gebiet eine große Lücke darstellt. Zum Beginn steht ein Überblick über die zum Thema verfügbare Literatur, ihre kritische Bewertung und die Vorstellung meiner Forschungsmethode. (=> Kapitel 1) Meine Forschung hinterfragt primär wie der Zimmermann im alten Lan Na Holzbauten tatsächlich gebaut hat. Wie ist er mit Beschränkungen und Schwierigkeiten umgegangen, die im Zuge der Errichtung einer Konstruktion auftreten? In meiner Untersuchung werden zwei Arten von Quellen studiert: 1. schriftliche Quellen (1.a. Inschriften auf Steinplatten und 1.b. Abhandlungen zum Bauen); 2. Untersuchungen an existierenden Bauten. Informationen auf Steinplatteninschriften eröffnen grundlegende Überlegungen für den Grund, warum ein Bauwerk errichtet wurde, und den Prozess des Bauablaufs selbst. Abhandlungen zum Bauen klären und erläutern spezifische Terminologien, die Zurichtung der Bauteile und den Prozess der Errichtung. Gründliche Analysen der Abhandlungen haben Schwerpunktsetzungen der Zimmermänner und ihre detaillierten Überlegungen erhellt. (=> Kapitel 2)

Meine Untersuchung der Abhandlungen zum Bauen und meine Feldforschung an ausgewählten Bauten mündet im Vorschlag die Dachkonstruktionen in Lan Na in die Systeme *Tang Mai* und *Tang Yo* zu klassifizieren. Das *Tang Mai* System ist durch eine Übereinanderschichtung von Querbalken charakterisiert, die jeweils von paarweisen Säulen getragen werden. Mit zunehmender Höhe der geschichteten Balken wird ihre Länge reduziert. Das *Tang Yo* System beruht auf der Ausbildung winkelstabiler Dreiecke. Paarweise schräggestellte Komponenten werden mit einem Querbalken verbunden um den Rahmen auszusteifen. Meine Untersuchung beleuchtet die verschiedenen Überlegungen und Schwierigkeiten, die im *Tang Mai* bzw. *Tang Yo* System auftreten und zu verschiedenen Entwicklungsrichtungen führen. Das kann an Konstruktionen und Holzverbindungen abgelesen werden. (=> Kapitel 3 und 4)

Um die spezifischen Charakteristika der Lan Na Bautechnik zu umreißen, stelle ich in meiner Untersuchung Forschungsergebnisse aus den Kapiteln 3 und 4 Informationen über Bautechniken in den Nachbarregionen von Lan Na: Luang Phrabang und Chiang Tung gegenüber. Das Ergebnis lässt vermuten, dass sich die historischen Holzkonstruktionen keineswegs geradlinig entwickelt haben. Lan Na scheint mit Chiang Tung und Sipsong Panna das Prinzip konstruktiver Orientierung in Querrichtung geteilt zu haben, das durch die Verwendung der "flankierenden Säule" gekennzeichnet ist. Andererseits unterscheiden sie sich in der Baumethode. Ganz abgesehen vom konstruktiven Aufbau in Querrichtung zeigt die Lan Na Verbindungstechnologie größere Übereinstimmung mit der Baukultur von Luang Phrabang und Sukhotai. (=> Kapitel 5)

Das letzte Kapitel ist ausschließlich der Auseinandersetzung mit dem Aufkommen der "flankierenden Säule" gewidmet, einem Bauteil, das Thai Wissenschaftler als spezifische konstruktive Eigenschaft Lan Na's ansahen. Ganz im Gegensatz dazu schlägt meine Untersuchung zwei Hypothesen vor, wie die "flankierende Säule" entstanden sein könnte. Die erste Hypothese behauptet, dass die

"flankierende Säule" als Ergebnis des Prozesses konstruktiver Vereinfachung des komplizierten Wechsels der vielen verschieden hohen und/oder breiten Dächer über einer Halle auftrat. Die zweite Hypothese betrachtet die Erfindung der "flankierenden Säule" als Resultat einer Überlegung den Prozess des Abbindens konstruktiver Bestandteile zu vereinfachen. In meiner Forschung werden diese zwei Hypothesen anhand von Argumenten und vermuteten Gegenargumenten einander hypothetisch gegenüber gestellt. Das Hauptziel dieses Kapitels ist die In-Gang-Setzung einer Diskussion über die Entwicklung historischer Holzkonstruktionen in Lan Na. (=> Kapitel 6)

Abstract

My study explored the building technique of historic timber architecture in Lan Na region, (currently Northern Thailand). This topic has been neglected hitherto creating a vast deficiency in academic field. At the beginning an overview discusses the available literature about the topic and its critical evaluation. This is followed by an outline of my research methodology. (→Chapter 1) Primary question of my research is how the carpenter in old Lan Na erected a timber building practically? How did he overcome constraints and difficulties arising in assembling a structural system? Two kinds of sources are studied in my investigation: 1. written sources (1.a stone slab inscriptions and 1.b building treatises) and 2. evidences from actual buildings. Information on stone slab inscriptions reveal general ideas related to the purpose of construction and the process of establishing a building. The building treatises clarify and explain specific terminology, the preparation of building components, and the erection process. In depth analysis on building treatises has revealed carpenter's priorities and their detailed concerns. (→Chapter 2)

As a consequence of the study of building treatise and field investigation on selected building, my study suggests a classification of the roof structure system in Lan Na into: *tang mai* and *tang yo* system. The *tang mai* system is characterized by stacking of crosswise beams that are carried by pairs of standing pillars. In each level of stacking in upward direction, the length of crosswise beam decreases. The *tang yo* system is based on the formation of an angle-stable triangle. Pairwise inclined components are connected with a crosswise beam to rigidify the frame. My study illustrates the different considerations and constraints connected to *tang mai* and *tang yo* system resulting in different developing directions as seen on structural arrangement and wooden joinery. (→Chapter 3 and 4)

In order to outline the specific characteristic of Lan Na's building technique, my study juxtaposes research results from chapter 3 and 4 against the information of building techniques obtained from the neighbor regions of Lan Na: Luang Phrabang and Chiang Tung. The result suggests that historic timber structure in this region most likely did not develop in straightforward way. Lan Na tended to share with Chiang Tung and Sipsong Panna the principle of structural arrangement in transverse direction characterized by the usage of "flanking pillar." On the other hand disagree concerning assembling method. Lan Na joinery technique presents more coherence with the building culture of Luang Phrabang and Sukhothai regardless of their deviating structural arrangement along transverse axis. (→Chapter 5)

The final chapter is solely devoted for discussing the emergence of "flanking pillar," the component that Thai scholars considered as a specific structural trait of Lan Na. In opposition my study provides two hypotheses suggesting how the "flanking pillar" has come into being. First hypothesis states that the "flanking pillar" occurred as a result from the process of structural simplification of the complicated change of so many differently high and/ or differently wide roofs above one hall. The second hypothesis considers the invention of "flanking pillar" resulting from an intention to facilitate the assembling process of structural components. My research treates these two proposed possibilities at

hypothetical level providing argument and counter argument. The main aim of this chapter is to promote the discussion on the development of historic timber structure in Lan Na. (→Chapter 6)

Acknowledgements

My PhD research wouldn't have made possible without supports from several individuals .First and foremost, I would like to pay gratitude to my PhD supervisor, Ao.Univ. Prof. Klaus Zwerger, his professionalism and dedication to the student are unprecedented and that I cannot thank him enough. He spent his own time and his personal expenses in order to review my research objects on site. It was more than once that he took a trip with me to Northern Thailand; Shan state, Burma; and Laos. On site investigation with Prof. Zwerger was inspiring; his great expertise has enabled me to improve sensibility in research, or to be precise, to form a "sensible eye." In addition, we had to deal with old Lan Na terminology which presented in different linguistic senses of expression. Conveying this and put together into the readable English was not an easy task at all since English is not my native language. I felt so fortunate and so appreciative that my supervisor was willing to spend hundreds of hours reading and correcting my dissertation draft. Eventually, arrived my final dissertation.

My first course work at TU WIEN in 2013 had equipped me with a strong foundation in systematically analyzing a historic roof construction, despite the contents about the European system of design. I also had a chance to participate in a research project "Die Dachwerke der Wiener Hofburg," under Dr. Gerold Eßer; I found his personality as a project leader quite inspiring. He was the one who grounded the fundamental knowledge of "Bauforschung" (Building Research) to me.

In 2013 I started working as an architect with HOLODECK architects, and it was architect Marlies Breuss who has given me this wonderful opportunity to work with the designing team, planning and building Austrian Embassy in Bangkok. Later on, I became a project manager. It's unforgettable experience, thank you very much, I've learnt a lot from you!

Before coming to Austria to attend TU WIEN (in December 2012), there was a trial-and-error phase in developing my research framework. Early of that year (May 2012) my wife and I in accompany with Monsinee Attavanich (PhD) and Kridsada Pollasap, travelled to Northern Thailand for carrying out my first documentation of Lan Na historic timber structures. We did not know anything back then. It liked walking in to a jungle shaping by the complexity of historical stratum. Nevertheless, I started to conceive some spirit from this trip.

Basically, my interest in Lan Na architecture was stemmed from the teaching of Prof. Vivat Temiyabandha during my Bachelor study at KMITL (1996-2002).I admit that having learned from his lucid perspective was a true inspiration to further my study, as a result I've been driven to the greater extent. Thus with my heartfelt gratitude, I would like to dedicate my PhD. Dissertation to my beloved professor. Another important person to be mentioned here is Asst. Prof. Phongsakorn Yimsawat, who tirelessly explained the detail concepts of Lan Na art and crafts during the revision period of my Master Thesis. His advices that I've taken then are still valuable until now.

Family is always our great supporter. It was really time consuming during the course of my writing and preparing my dissertation, I couldn't take care my family that much. I feel sorry for that; fortunately, they all understood what I was going through. Last but not least, I have to thank my

dearest wife, Orawan Tungteekha-ayu , including her family for their supports. I owed a lot to my wife who had accompanied me to Northern Thailand many times, one time we went up as far as in Chiang Tung. It's an advantage that she is a native Northern Thai, she has been able to correct my cultural misunderstandings. After all, I would like to thank to her patience, her unconditional love, compassion and understanding. Thank you for being there!

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Chapter 1

Introduction

1.1 Geography of Lan Na Region

Topographical region of old Lan Na is characterized by mountains stretching in north-south direction dividing the region into scattering river valley-plains. Lan Na mountain ranges are part of the larger network connecting to the neighbor Shan Hill in Myanmar and Laos PDR. Four main rivers: Ping, Wang, Yom, Nan and their tributaries run across the valley plains and provided resources for ancient states formation. The Lan Na region corresponds roughly to the modern Thai administration organized politically into 8 provinces: Chiang Mai, Chiang Rai, Lampang, Lamphun, Mae Hong Son, Nan, Phrae, and Phayao. The cultural sphere of old Lan Na expanded beyond the current territory of Northern Thailand including additional two adjacent provinces: Tak and Uttaradit and the Chiang Tung in Shan state, Burma.

Chiang Mai and Lamphun provinces are situated on the valley plain along Ping River. To the West, they are surrounded by Thongchai Range and to the East by Khun Tan Mountain chain. Lampang is situated along Wang River beyond the mountain of Khun Tan. The mountain range Phi Pan Nam (literally translated as “spirit that divided the water”) divided Phayao and Chiang Rai from Nan. Ing and Kok are the tributary rivers of Mekhong running across valley plains of Phayao and Chiang Rai. Nan province derived its name from Nan River. Nan is enclosed by Luang Phrabang Mountain Range defining the Northeastern border between Thailand and Laos PDR. The highest ridge of mountain range in Northern Thailand is Doi Intanon (Mountain Intanon) of Thongchai Range. Its peak reaches 2535 m. Historically, Lan Na people called it “Doi Luang” meaning “Great Mountain.” Karen people called it “Doi Ang Kar.” Both names convey the same meaning.

The botanist, Edward F Anderson separated the vegetation zone in northern Thailand into deciduous and evergreen forest. The deciduous forest can be found up to a height of 1000 m comprising two subdivision groups: mixed deciduous forest and deciduous dipterocarp forest. The first mixed deciduous forest is characterized by the presence of teak wood (tectona gradis), the latter deciduous dipterocarp forest refers to the open or discontinuous canopy at about 15 m height (Anderson 1993, p. 39). The second vegetation zone, hill evergreen forest can be found above the elevation higher than 1000 m. The forest type consists of dense and extremely rich stands of evergreen trees presenting a solid canopy up to 50 m. (Ibid., p. 41). Most timber used for construction purpose had been taken from mixed deciduous forest (Graham 1996).

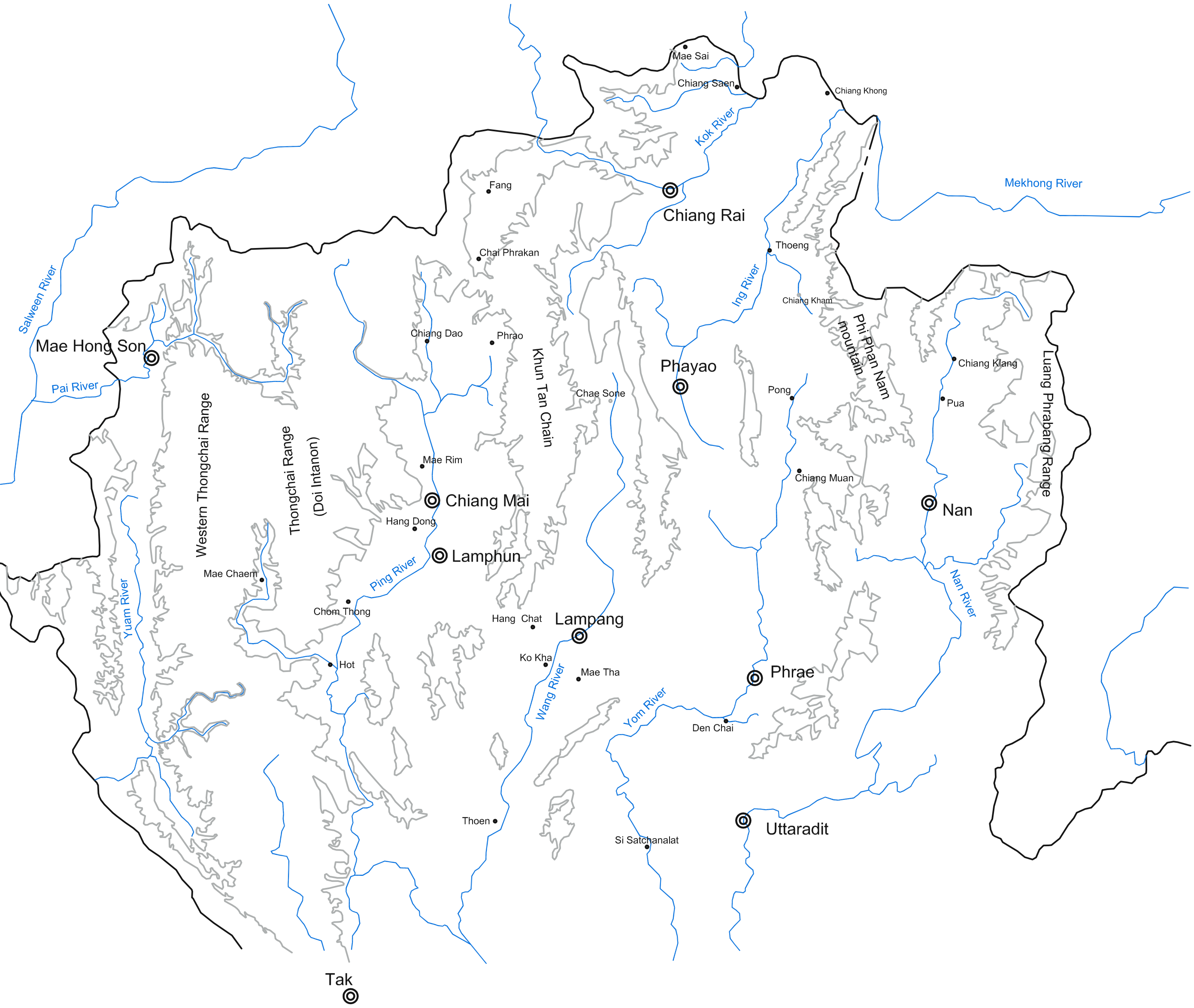


Fig. 1.1 Topographic Map of Lan Na

1.2 Critical Overview: Lan Na Historic Building Research

Fundamental issues in Lan Na historic art and architectural study probably derived from Thai nationalistic ideology that attempt to integrate Lan Na objects into the main chronology of the country. Department of Fine Arts, a government department of Thailand responsible for heritage and conservation has classified and labeled Lan Na objects belonging to "Chiang Saen" style, the 4th period of stylistic evolution of art in Thailand. The characteristic of religious edifices according to Chiang Saen style is described: "wooden building, most pillars were made of timber. The building is open-sided presenting a multi-tiered roof. The roof tiles were made from clay or wooden shingle. Very often carpenter did not install a ceiling enabling us to see the roof structure (Nindet 1976, p. 8). In the book *Architecture in Thailand*, the author Nard Photiphrasat described "Chiang Saen" style building as follow: "…timber structure without any enclosed ceiling, see through all roof structural components" and "exposed timber frame pediment in combination of Naga sculptural form at the porch space" (Photiphrasat 1944, no page number). As a matter of fact, Chiang Saen is a historic town in old Lan Na situated along the Mekong River in Chiang Rai province, dated around 18-24 Buddhist Century. The stylistic term was criticized as too narrow to cover the variety of art and architecture in the Lan Na region (Griswold 1961 and 1966). Implying the term Chiang Saen to point at this region is too "superficial" and cannot lead to the deeper understanding of history (Valliphotama 1982, pp.22-23).

Some authors tried to avoid nationalistic narratives, thus seeking to emphasize the significance of individual and understanding Lan Na through local artistic expression. Fua Hariphitak, a Thai artist and art historian interpreted Lan Na architecture and described the mentality of Lan Na craftsmen as "dwelling amidst the beautiful natural environment, craftsmen in Lan Na loved nature and the <u>real</u> [underline by the author] rather than the idealistic representation. They did not fall into the establishment of strict architectural order as in Rattanakosin [Siamese] style." (Hariphitak 1965, reprinted 2010, p. 277). For Hariphitak, the comparison between the architectural order of Siam and of Lan Na was important as he sought to find a distinction of sense between capitals and countryside.

An early essay of Vivat Temiyabandha who originated from Chiang Mai, later became a prominent figure in Lan Na has presented the structural expression of religious building in Lan Na (viharn of Pong Yang Kok monastery) and elaborated the harmonization between the structural components in a transverse frame and its decoration as "…the decorative elements are in geometric form and arranged on each structural component, they represent the direction of transferring load without distorting the concept of structural form." Therefore he summarized the aesthetic sense of craftsmen in old Lan Na by coining the definition "simplicity, sincere (naïve) and never pretentious" (Temiyabandha 1975, reprinted 2014, p. 81).

During 1970-1980, field studies won interest in archeological and anthropological research. An enthusiastic entrepreneur, Lek Viriyaphant had personally patronized a group of promising young scholars for carrying out field works throughout the region in Thailand. It is noteworthy to mention that this movement led to the establishment of the first open-air museum in Thailand. The academic works of scholars in the group presented new evidences attempting to break with the pure stylistic approach of the Department of Fine Arts. Their approach shall be seen in the light of regionalism integrating the micro history, cultural practices, and ritual belief altogether. A journal and publication house called *Muang Boran*, translated literally as Ancient City was founded in 1975. It opened a new arena and requested contribution from professional, local historians as well as amatures.

Having emphasized the practice of individual as opposed to Department of Fine Arts' general stylistic approach, the "value" embedded in the cultural object started to be recognized as well as the significance of those people producing it –the craftsmen and the carpenters. According to *Muang Boran*'s writings, the term value can be extensively applied in several contexts and meanings. It ranged from aesthetic, spatial quality, social, cultural, and traditional value, as well as wisdom. For *Muang Boran* circle, the "values" are the specific characteristic of regions; it was conceived and expressed in special means.

In 1978, Temiyabandha collaborated with Anuvit Charernsupkul, an architectural historian who was one of the important persons in *Muang Boran* circle. They published the first research on Lan Na dwelling together. Charernsupkul adopted the formal analytic approach of modern architecture to read Lan Na house. The research attempted to understand Lan Na building in the perspective of modern spatial theory. Charernsupkul interpreted the culture of sitting on the floor as practiced by Lan Na people to influence a horizontal expansion of the house (the connection of bedroom through open-covered terrace). This constituted the specific "spatial quality of solid mass" (Charernsupkul 1978, reprinted 1996, p. 14). In addition, the house in each region of Lan Na is attributed to different regional characteristics. The expression of house in Chiang Mai is the most delicate; the representation of solid and void is in balance, while the house in Lampang presented a massive volume and slanting roof (Ibid., p. 15). Behind such a spatial-functional approach, he attempted to situate the "value" of old dwelling into modernity scene.

Temiyabandha contributed to the section *Rituals in House-Building*. The chapter is a revision from his article firstly published in *Muang Boran* journal, January 1978*, Ritual Behavior Associated with House-Building*. He adopted a quasi anthropological approach in an attempt to rationalize ritual practices during the process of house erection. For example, in order to erect a pillar, people needed not only technical knowhow but also courage; they sought them from ritual and spiritual belief (Temiyabandha 1978, reprinted 1996 p. 54). According to his writing, "Lan Na architecture is not only the fruit from the technological development, but also the mirror reflected to the world's will –a spiritual persuasion to fulfill human desire, to eliminate fear and to prosper the hope" (Ibid., p. 32). Thus according to Temiyabandha's intrpretation, the carpenter must obtain ritual knowledge in order to play the leading role in ceremony during an erection process of the house. His study referred to some carpentry techniques that were described in ritual text. The compilation of ritual in house building is very useful benefiting the academic in Thailand and inspired the researcher in next generation.

Charernsupkul continued exploring old settlements in Northern Thailand in accompanied with an archeologist, Srisak Vallibhodhama (currently the director of the board of *Muang Boran* journal). He published several articles. The article *Wieng Phra That Lampang Luang* (1979) presented how

Charernsupkul read the viharn of Lan Na (an important typology of Lan Na religious edifice) and developed his methodology of historic architecture research in general “viharn Luang [grand viharn] is situated on the central axis of the monastery compound characterizing as an open-sided building. The principal Buddha image is enshrined in the center. Approaching to the viharn along the axis of building, our vision is framed towards the arch [located in front of the building] controlling our vision to focus to the glided brick housing floating in the central space (see Fig. 3.22); viharn of Nam Tame characterizes by the open form presenting the space similarly to the grand viharn. It demonstrates the most beautiful spatial expression (see Fig.3.15). The building has exposed ceiling seeing through to roof components and roof tiles […] viharn of Phra Putt presents the closed form [wall] and massive volume” (the statement is quoted in Vallibhodhama 1979, before Charernsupkul republished it by himself in 1982).

In the year 1986, Charernsupkul continued to formulate a methodology for historic architecture research and presented it in the article *The Approach in Historic Architecture Research in Thailand* (1986). He suggested that the study shall take design and style as a starting point and analyze the relationship among them. Then it shall trace the influences resulting from history and belief that attribute to specific characteristics of design and style. Finally the analysis should assess the formal and spatial quality of the study objects. In his analysis, Lan Na religious building expressed the “plastic form,” meaning “an expression that is comparable to sculptural form, elastic and cohesive” (Charernsupkul 1982, p.26). Charernsupkul frequently employed the term “school of crafts/ carpentry” thus staying rather ambiguous. The term does not refer directly to a specific group of artisans, but rather indicates the art/ architecture presenting a coherent style. It implies a common principle shared in a circle of craftsmen like carpenters. Different art historians in *Muang Boran* circle defined the meaning of this term as “a style or format of art that [was so] repeatedly and continually used by a majority until [it] represented a distinct characteristic” (Sooksawasdi 1986, reprinted 2005 p.24).

Technical aspects that drove an actual execution of a building seem to be out of scope from his proposed research approach. People interested in historic timber structure in Lan Na might even feel skeptically whether a carpenter in old times did prioritize the aspects of spatial quality and the expression of form similarly to modern architecture. Nevertheless, the lacking in his methodology cannot be simply interpreted that he had no consideration on technical aspects at all. His publication *Analytical Evidence in Archeology and Art into Art History Research* (1984) has suggested a framework for the investigation on the “creative quality” in art objects towards two different phases of art production: 1) the conceiving and design process, and 2) crafting process. The first phase relates to the formulation of pattern in respond to a requirement shaping from different factors: economic, social and political aspects, belief, and available technical aspects. The latter refers to an investigation through realization process according to the skill and technical mean of each individual or of school of crafts/ carpentry. During the early 1980s, he had conducted a research investigating historic stone architecture resulting in a lucid publication *Structure Types and Pattern Bonds of Khmer and Srivijayan Brick Architecture in Thailand* (1984). Different stone joining techniques and brick patterns are illustrated and compared in this volume in greatest depth. But such research method has never been adopted for investigating historic timber structure in Lan Na.

From 1980 onwards, the numbers of exploration research conducted by local architectural historians are increasing. Among others, an important person contributing to this field was Samart Siriwetchaphan. He led a team to conduct series of research and published three relevant reports presenting both progress and fall back in the development of research method. In his study, Lan Na historic timber architecture is categorized according to the regions reflecting to their specific characteristics.

The first volume is an investigation on the oldest type of viharn in Lampang province, *Open-Sided Viharns and its Arches of Lampang School of Carpentry* (1982, reprinted 2003). His application of the term "school of carpentry" presents some progressive aspect beyond Charernsupkul's. He analyzed the coherence of spatial quality between the viharns of Phra That Lampang Luang monastery (Fig.3.22), viharn of Lai Hin (Fig.3.38-39), viharn of Pong Yang Kok (Fig.3.45), and Wieng monastery (Fig.3.29). The grand viharn and viharn of Nam Tame of first monastery are set as the "role model" distributing stylistic development in comparison to the others. The common characteristic of Lampang School of carpentry is described as "the roof complex of all viharns presents three reductions of the gable ridge; two toward the front and one to the rear side. The opened plan of viharn created the rhythmic volume and provides the circulated space as well as comfort" (Ibid., p. 80). The aspect that presents an improvement in his study is the inclusion of local history. Beside the detailed history of each monastery, his study draws the relation among the abbots. The abbots of Lin Hin Luang monastery together with Pong Yang Kok monastery were the pupils under the abbots of Wieng monastery. Siriwetchaphan discovered that these abbots established an agreement together that they shall support each other including with other abbots in the same circle (Ibid., p. 47). Afterwards in the year 1774 (2317), the abbot of Lai Hin Luang became the abbot of Phra That Lampang Luang monastery (Ibid., p. 79). Hence, Siriwetchaphan proposed a hypothesis that the close relationship among monasteries allowed the transmission of crafts and carpentry work resulting in the shared common artistic aspects. But he did not explicitly discuss it. Throughout the volume, he did not use Lan Na terminology but instead opted to generally employ Siamese terms.

The second volume *Tai Lue viharns of Nan* (1987) investigates the viharn of Tai Lue, a closely related ethnic to the group of Tai Yuan people in Lan Na. In this report, Siriwetchaphan has omitted to use the term *school of carpentry* throughout the volume. Local history and historical sources have been applied to reconstruct the chronological order of selected buildings. He still employed spatial quality and formal expression to analyze a building. Setting spatial and formal articulation of the oldest building as a starting point then unfolds and traces its influence to consecutive building (Siriwetchaphan 1987, p. 66). In this study, he attempted to make reference to Tai Lue building culture in Sipsongpanna, China (Ibid., p. 17) but it was mentioned only in conceptual way.

The last relevant report is *Phayao and Nan Architectures* (1988). The title of this report might mislead the reader in some way. His survey did not mainly explore old monasteries especially in Phayao and Nan province, but took several samples from Eastern part of Lampang province. Siriwetchaphan and his team believed that this added area in Lampang can represent the character of Phayao type due to the historic interrelatedness of these two regions (Siriwetchaphan 1988, p. 3-4). The grand viharn of Sri Komkam monastery in Phayao is defined as the role model distributing stylistic development to other viharns. Siriwetchaphan considers the expression of this viharn as “small and calm” (Ibid., p. 20). The term “folk art” is underlined in order to distinct it from school of carpentry. Their building culture is characterized by the sincere and naturalistic representation. Craftsmen and carpenter did not acquire specific training because they were merely enthusiastic villagers (Ibid., p. 15). The term *school of carpentry* is used occasionally to present an interplaying between higher culture and local, for instance “the monastery of Pa Daeng Luang and the monastery of Aukhochaikiri may receive assistance from Phayao school of carpentry for planning the monasteries” (Ibid., p. 6). In concluding chapter, the report classified folk art belonging to the type of “primitive” (originally written in English). Nevertheless my critical overview sees this as an imprecise usage of the term. Siriwetchaphan might only want to imply less developed or less elaborated rather than the “primitive” in anthropological sense (see Rapaport 1969, p. 3). The technical aspect is omitted throughout the volume since the report tends to only emphasize different aspects of artistic representation.

The documentation drawings complimented to these three publications consist of critical inaccuracies at the most crucial structural parts which should be assessed here. The cross section drawing of the viharn of Lai Hin monastery in the first publication *Open-sided Viharns and its Arches of Lampang school of carpentry* (p. A-8) presents confusion between first transverse frame and second transverse frame. In this viharn, the carpenter implemented his probably unique idea resulting in the distinction from other general arrangement of aisle roof structures. None of transverse frames in this building are identical (see Fig.3.33-3.37). Siriwetchaphan’s survey seemed to be overruled by a specific typology. Thus he was not able to recognize the difference in structural arrangement in reality. Another critical mistake in Siriwetchaphan’s documentation appears in the second report, *Tai Lue viharns of Nan*. The report illustrates an incorrect technique creating curved roof plane in the cross section drawing of the viharn of Ton Lang monastery (Siriwetchaphan 1987, p. 78). In fact the rafter of the lower hipped roof form a straight roof shape, but the upper hipped and the gable are different. The carpenter employed “*tang yo*” or closed triangle system assembling inclined members as a basic structure and introduced a special setting of purlins to constitute the curved roof plane. But Siriwetchaphan’s drawing presents all of them in rafter system, illustrating straight shape. It seems his survey team inspected only a system at the lower hipped base, and then transferred their finding into the upper two levels of structure.

My study will provide detailed analyses of the structural arrangement of these two buildings later on in chapter 3 and 4. The above two samples of inaccuracy in fact share a common ground. Researchers working in the field hitherto transferred their knowledge to new objects convinced that they belong to a known typological category. They simply missed to do concrete measurement and therefore repeated wrong assumption on and on. The core problem of these three studies must be seen in their methodology. The logical implication has been used in order to categorize the building typology. The structural details are generalized to the simplest typology. Thus many unseen details were omitted and remain unrecognized so far. However, Siriwetchaphan's works paved the first step to the documentation of historic timber structure in Lan Na.

Wolarun Boonyasurat, a scholar from Chiang Mai University has published a book *Viharn of Lan Na* (2001b) contributing significantly to the field of Lan Na building research. This book is conceived as a result from long time endeavor and a consequence of several research backgrounds. *The Study of Lan Na Vihara Pediment in Chiang Mai* (1992) and *Symbol in Viharn of Lan Na* (1996) are the two importance grounding a basis for Boonyasurat. The first title is her master thesis from Silpakorn University. She conducted this study during the period when Charernsupkul held a position as university professor there. Her analytical methodology can be seen as a second improvement from Charernsupkul's work. She adopted definition of open-sided viharn and closed viharn as classified previously by Charernsupkul, then classifying the stylistic development. In the book *Viharn of Lan Na*, she selected 10 viharns that have been erected before 2400 BE (approximate 1850) and explored the relationship between planning, structural arrangement, and ornament. She proposed a hypothesis that the form of viharn evolved from opened to closed. The oldest samples that represent the opened form are located in Lampang, while the evolution to closed form found in Chiang Mai province (Boonyasurat 2001B, pp. 262-265). The content of her research findings are based on the two aspects: 1) the visual impact and structural design; and 2) the sculptural integration of art and architecture, (Ibid., pp. 355-359). In fact the conceptual idea of her second finding was previously stated by Charernsupkul (1978, p.12), but Charernsupkul did not provide detailed explanation about it. The following quotation can briefly comprehend Boonyasurat's idea: "A Lan Na temple comprises two main parts: the architectural structure and various symbolic components that are harmoniously integrated […] 'the architectural work is like a sculptural building' combining shaped components with the building itself, while the architectural structure supports decoration work such as carving, relief, stencil, or painting that present different symbolic motifs" (Boonyasurat 2005, pp. 1.T). Boonyasurat 's findings are worth some extensive discussion, but at the current stage my critical overview limits its scope only on the methodological assessment. (See chapter 6 for further discussion.)

Boonyasurat employed the term structural design throughout the volume. The usage of this term in her study means the organization of structural components (e.g. pillar, roof structural frame), not the idea of structural system (load transferring) and technical means (e.g. how structural components are assembled together). When she referred to technical aspects of viharn, her study only made reference to two sources: a) the treatises of viharn erection, published in the collection of old ritual texts *Collection of Traditional Northern Thailand Rituals Practices* by Saguan Chottisukkhsrat (n.d.) and b) an assembly drawing of the roof structure of viharn at Pong Yang Kok monastery (Department of Fine Arts 1990, pp.31-35).. This appears not much different to Siriwetchaphan's treatment of technical aspects. Boonyasurat treated technical details archetypical and universally applied inferring to all cases without the actual investigation in situ. Thus, a distinction of each structural detail remains unexplored.

Further analyses of carpentry building treatises have been carried out by Chaiyosh Isavorapant in two publications *Viharn of Golden Stencil at Phra Sign Monastery* (2000) and A study on Document of traditional architecture in Thailand (2004). The first volume is devoted to documentation work of a viharn in Chiang Mai province and the collection of building treatises, the author dedicates this volume to Charernsupkul (Isavorapant 2000, p. 4), while the second one is a chapter in his Ph.D. dissertation.

The major contribution of Isavorapant is the archival work at the Center for Social Research of Chiang Mai University. He discovered four additional treatises besides the first three which were previously collected and transliterated by Chottisukkhsrat. He mentioned in his analysis that the contents of these treatises are obscure. They require further study (Ibid., p. 10) and could not be comprehended (Ibid., p. 19). The mentioned obscurity became a critical issue in his dissertation. He translated the treatises into English but omitted all technical aspects which are described in transliterated Lan Na (Isavorapant, 2004, pp. 54-60). Only the proportion of building components and sequence of assembling process are mentioned and discussed. He has entirely omitted the description of joineries and their sensitive measurement. In essence, the treatise suggests how to carry out the measurement for each component. Upon omission of the tenon’s length, one could not correctly cut the piece. Nevertheless, my study shall point out that at the current state of the arts most of the detail descriptions in these treatises should already be accessible based on a proper reference to the linguist and philological publication, for instance *The Northern Thai Dictionary of Palm-Leaf Manuscripts* (Wichienkeeo et al. 1996). My dissertation deals with the interpretation of treatises on chapter 2.

The neglecting of such technical details in his study caused him imprecise drawings and even leads to incorrect elucidation of components. All illustrations of the connection between crosswise beam, standing pillar, and purlins are incorrect. In Lan Na building culture, the carpenter in fact halved or notched purlins above crosswise beam but did not place them directly to standing pillars as show in Isavorapant’s drawing. He seemed to overlook the triangular edges of crosswise beams that keep the purlins into place (Isavorapant 2004, pp.45-52). This mistake will immediately yield a crucial question: how could such a component seat the purlin and protect it from slipping away? In his dissertation, he also attempted to offer a hypothesis on the development of Lan Na structure (Ibid., pp.40-41), but his imprecision and neglect of technical details prevented a fruitful result of his study. My dissertation will examine his purposed hypothesis together with Boonyasurat’s findings in chapter 6.

Kriengkrai Kirdsiri, a scholar from Silpakorn University pursued to place Lan Na historic building into broader spectrum of building culture in mainland Southeast Asia. He had carried out his Ph.D. dissertation on cultural landscape of Chiang Tung, the region that was historically interwoven with Lan Na *Cultural Landscape and Vernacular Architecture in Historic Town of Keng Tung, Shan State, Myanmar* (2008). In an earlier article he compared Chiang Tung and Chiang Mai: *Cultural*

Landscape and Urban Elements in Historic Town: Chiang Tung and Chiang Mai (2006). During his field research in Chiang Tung, he had came across several historic settlements of Mon-Khmer speaking groups in the mountainous area of Northeastern Shan. Kirdsiri considered the common visual aspects between Blang's religious building and the viharn of Lan Na, thus coining the term "shared Lan Na typology," firstly mentioned in an article *The Monastery and Community of Baan Saen, Keng Tung* (2007, reprinted 2010) and *Tai Doi (Lawa) Monastery in Shan Stat: Civilization Reflected by Sacred Architecture* (2009, reprinted 2010).

In term of methodology, his approach find its place between history and iconography. He overviewed the religious chronicles relating to the expansion of Buddhist belief from Lan Na to Chiang Tung region (during the reign of King Kue Na) as well as the oral history. He used the outcome of his historical synthesis to read, compare, and interpret the motifs found in religious buildings. Finally he attempted to propose a hypothesis constructing the relation between two regions, for example, the transmission of style and school of crafts (Kirdsiri 2009, pp. 94-95). The initiation of his research is admirable, nevertheless, provokes several questions and reflects a biased attitude of supremacy towards Lan Na. My research includes the neighboring regions of Lan Na. I continue to discuss this aspect in Chapter 5.

In 2014, Vivat Temiyabandha together with Pathom Puapansakul published a photo book *Lan Na Vernacular Architecture* resulting from their field work in the late 1970s. Temiyabandha wrote a retrospective re-examining the research approach applied on Lan Na historic architecture. Looking back to the past 40 years, the introduction of space and form into the analytic approach intending to read Lan Na building appears insufficient to him. Hi is convinced that this approach cannot reveal the essence of Lan Na architecture which is in fact much related to indispensable culture and emotion. Beside the functional role, Lan Na architecture needed to serve symbolic requirement as well (Puapansakul and Temiyabandha 2014, p.28). Temiyabandha's usage of the term "symbolic" implied to specific meaning that should be clarified. In his consideration, Lan Na people perceived their natural environment (mountain, river, valley-basin, etc.) in systematic and meaningful way contributing to the Lan Na world view. Any action, for instance an erection of a house should be integrated in the whole system and must not contradict the predefined world view of their forefathers (Temiyabandha 1997, reprinted 2014).

Conclusion

For half a century of Lan Na building research development, the field of knowledge improved very well in the aspects of regional-micro history, religious symbolic meaning, and ritual belief related to Lan Na house. Nevertheless, the aspect of building technique is still lacking. A sense of practical knowledge of building is omitted and frequently misinterpreted due to missing research.

The structural system and the building technique of Lan Na historic timber building has been treated erroneously archetypically. The thematic focus of previous researches revolved around the core of formal approach resulting in findings that cannot go beyond the establishment of formal relation. The emphasis on building technique which may provide a deeper understanding of historic timber building has not yet been carried out. Therefore, this aspect presents a large void in the field of knowledge. My research pursues to initiate the empirical survey, documentation, theoretical reflection in order to fill such gaps. In the mean time, existing historical evidences in Lan Na are endangered and keep vanishing day by day.

1.3 Methodology and Research Framework

"No matter how many instances of white swans we have observed, this does not justify the conclusion that all swans are white" (Popper 1959, reprinted 2008 p. 4).

The research framework that attempts to investigate the building technique shall be set against the predominant structure-archetype. In reception of Lan Na historic structure, the structure-archetype pervasively covers not only the image of structural arrangement, but also wooden joinery, and its related terminology. It first emerged from an illustration that was produced by Sukanya Baokerd during the course of restoration project of the viharn at Pong Yang Kok monastery (2000). Later this drawing was modified and became widespread as Wolarun Boonyasurat adopted it into her famous publication "*Viharn of Lan Na*" (2001b) (see Fig. 1.2 and Fig. 1.3). She combined this drawing with the building treatises excerpted from Saguan Chottisukkhsrat's transliteration works. However she did not provide additional analysis and interpretation. Beside the aspects of imprecision seen in the first drawing, the following researches seem to use the given information merely as inference without confirming with the actual instance standing in front of them, thus blocking the way for further discovery (see Fig. 1.4).

The core logic in my research method is deductive by nature. The predominant description shall be reexamined towards an empirical investigation against our possible misconception. I use the term re-examine here instead of verification and falsification due to the fact that the scientific premise concerning historic structure was previously taken so lightly. Therefore, the conducting of field investigation in order to establish concrete information is an essence in my research action. The research framework applying to my dissertation is outlined in the following consecutive phases.

Data Gathering from Building In Situ

Field Investigation and Documentation, the field investigation have been carried out during the years 2013 – 2016 in Northern Thailand including three excursions to Shan state, Burma (2014) and to Luang Phrabang, Laos (2016 and 2017) for obtaining comparative material. The method of measuring is "hand measurement" using two tools: laser rangefinder and measure tape. The process began with the identification of different transverse frames and later focused on how different transverse frames are combined in longitudinal direction. Afterwards, I started measurement and documentation. The joineries in the building were recorded and classified by typology in order to understand the principle of its utilization.

An important process in my investigation was the searching for traces of inconsistencies that occurred in the building at times. For instance, in a symmetrical building, a comparable position between left side and right side of a structural frame that supposed to be similar, very often present incoherence in structural arrangement and the difference in type of joinery. The investigation of such inconsistency is necessary because it can lead to an interpretation of conditions that specifically played during the course of time. A typical example is the replacement of a building component that often resulted in different usages of building techniques.

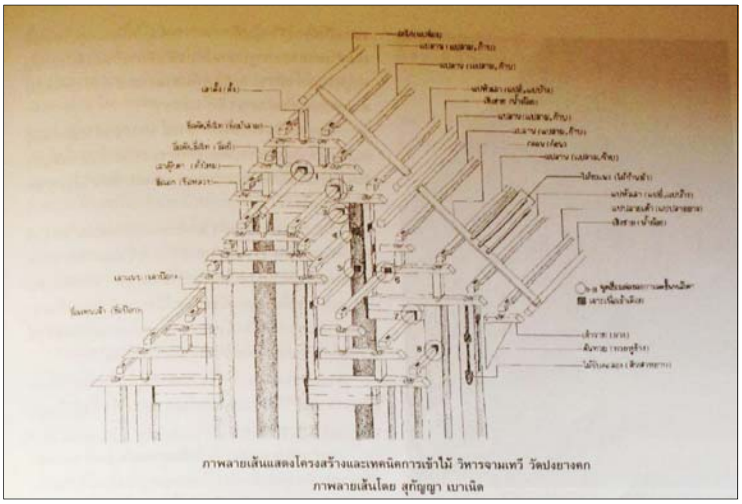


Fig. 1.2 An assembly drawing of Sukanya Baokerd presents the roof structure of the viharn of Pong Yang Kok monastery, (Baokerd 2000, p. 49)

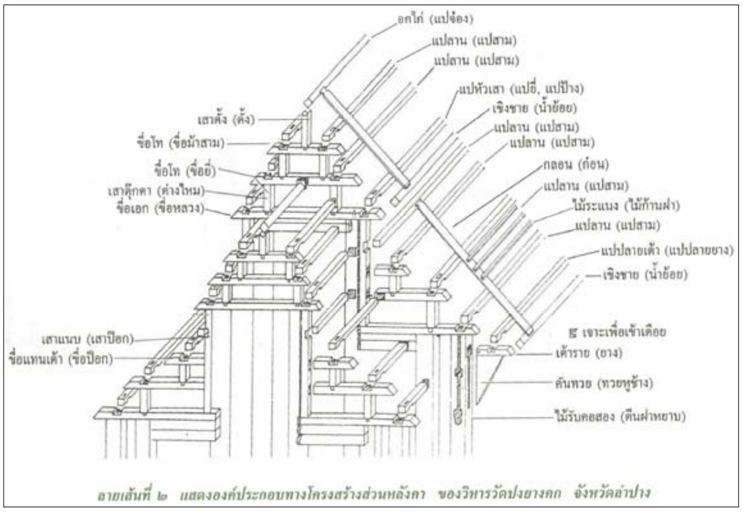


Fig. 1.3 Booyasurat redrew Baokerd's drawing and publised in *Viharn of Lan Na*, (Boonyasurat 2001b, p.34)

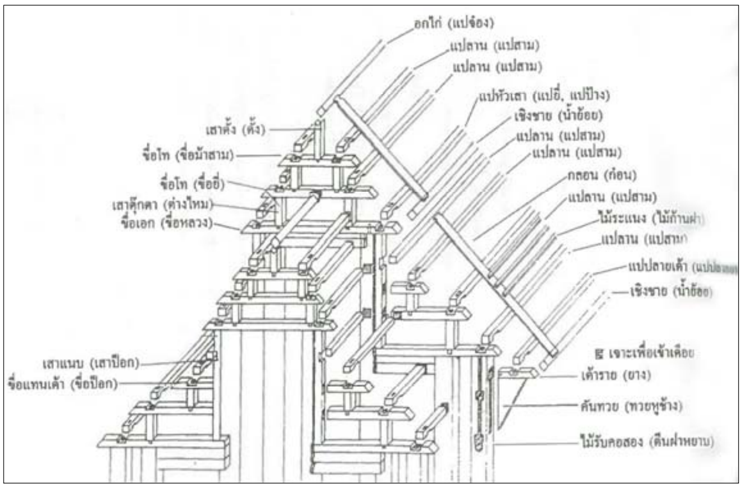


Fig. 1.4 Suraphon Damrikun used Boonyasurat's drawing to represent roof structure of Lan Na viharn in general, (Damrikun 2018, p. 196)

In addition, the inspection for a defect in a structural component displays the critical point and the weakness of a structure. Throughout the observation of several buildings my research has witnessed how a similar critical structural issue had been tackled differently by different individual carpenters. The information has paved the ground to understand carpenter's consideration and his attempt for improvement in hope of optimization.

Interview, the direct communication with the locals, especially with the carpenter brought up information of how they perceived a building in their own cultural sphere. When a carpenter explained his consideration of the building, he simultaneous reveals his priority and the pattern of his logical reasoning. We should not be surprised, many of their explanations challenged our previous understanding as our experiences were shaped differently.

Analysis of Historical Source

My research questions the validity of terminology and connotation predominantly employed nowadays. Frequently they are mixed up with the new invented terms and can mislead our interpretation. The analysis on three types of sources help to reexamine the validity of such usages: a) historical texts in general, b) stone slab inscriptions, and c) building treatises.

Historical texts (Lan Na Chronicle), my research has made extensive use of the religious and secular chronicles: *Jinakalamali, Camadevivamsa, Chiang Mai Chronicle, Nan Chronicle*, etc. The reading of these texts provides the background to the term relevant to building typology and its context of usage. Together with the interpretations from philological research, we can learn how the semantic shift took place transmitting a specific structural terminology into a word in general, and also the other way round. For instance, the term "*khue*" for crosswise beam was transmitted into a word for connoting the widthwise of rectangular, while the term "*pae*" for purlin is used for lengthwise (see following section).

To reconstruct the conceptual idea of how something was recognized in old Lan Na is one of the important tasks as they had an own unique concept of description or type ("*lakana*"), a Sanskrit term that derived from Buddhist idea. Upon an erection of a building, Lan Na "language" can connote that the building is erected following some specific description, e.g. *Jinakalamali* narrates the erections of buildings following the description of elephant and bull type (Penth 1994, p. 4). The study of such descriptions allow me firstly to refute the conjecture of contemporary research and later narrows down how my research shall read a historic building.

Stone Slab Inscriptions, while the historical chronicles provide the idea pertaining to building culture in general, the information on stone slabs presents the specific circumstance of establishing a building or monastery. When an important building was erected, Lan Na rulers often installed a stone slab for documenting the establishment indicating the date, the purpose for erection, the patron, list of the witness, in some case, the expense and list of building material.

My study used the information on stone slab inscription to contextualize the circumstance upon an erection of the building. The descriptions pertaining to the purpose of building erection are used for comparing one period with another. It presented the prevailing mentality in background of each executed work. E.g. during the golden age of Lan Na the religious was the destination, while, in the period shortly after being independent from Burmese, the purpose of building erection and restoration aimed to portray the old glory.

Building Treatises, the treatises describe the preparation works and process of erection. The texts have provided the information of terminology, the preparation of building components, relative proportions between the main components and subcomponents, the assembling process, and some explicit statement of carpenters' considerations. The analytical method employed in my research consists of close reading first; cross checking between treatises; and cross referencing to the reliable sources.

We can separate the indication of terminology in building treatises into 2 sets of terms: the building component - wooden joinery, and the verb for action. For the first set, my study has compared the given term from each treatise and catalogued the range of words connoting to a single structural component. It outlined the regional dialect and diversity in recognition of the component.

The accessibility to the verb for action (e.g. to erect, to build, to measure, etc.) required further cross checking between treatises and referencing to the dictionary. An unknown word that appears in several positions of a text can theoretically identify its meaning similarly to the treatment of a variable in different equations. The presupposition is inevitable in this process. My analysis began by assigning a hypothetical meaning of the unknown term, and then placed it to all appearing sentences for testing its plausibility.

The descriptions in treatises are reconstructed into drawings illustrating the sequence of assembling processes. All of them begin with the preparation of main crosswise beam and majority of content revolve around the designation of roof components. The logics of working process are interpreted providing clear statements that allow further discussion.

Classification

Roof Construction, the classification process commenced from grouping roof structural system of selected samples according to their logical framework. I took the roof structure as my point of departure following the priority given in building treatises.

The fundamental theory proposed by Klaus Zwerger classifies the roof structure as seen in Europe and in East Asia into a) purlin or rafter roof and b) spar roof. The first system is characterized by the purlins carrying the diagonal member (rafter), while the later is constituted of a stable triangle resulting from the arrangement of diagonal member into pair (Zwerger 2012, p. 176). The force transmission in crosswise element is of compression for the purlin system and tension for the spar system.

The roof structures evidenced in Lan Na share similarity only in the conceptual level to above theory but not in their geometrical sense as they lack diagonal rafters, Lan Na carpenter used a thin wooden board (roof shaping member, "*gon*") that is laid into curved plane instead. My study suggests to classify the roof structure according to the role that structural components have played. The roof structure that is a) carried by standing pillar and b) carried by inclined member. This suggested classification corresponds to definition in Thai terminology, "*tang mai*" and "*tang yo.*"

The core classification as suggested provides only fundamental ground for my investigation. My research did not presuppose that the cases within a system either standing pillar or inclined member should present integrity in technical aspects, e.g. the arrangement of structural component, the method of curved roof formation, and joinery. Instead, my research underlined the occurrence of difference or incoherence of a consideration in order to narrow down to a specific thought of a single carpenter and that is the emphasizing of individual work. This process also involves to the assessment of the given classification in literatures. For instance the concept of "school of carpentry" shall be verified.

Cross Comparison

The extensive investigations into the neighbor regions were carried out to collect comparable cases that are previously defined and considered to be related to Lan Na. The core of comparative method in my study remains the same. My research attempted to seek the difference that could be observed from the case that is previously recognized as "shared Lan Na type." The similar aspects that appear among the cases can suggest the shared common ground and not only simply refer to an influence. It is more important to search for the different aspects outlining the deviation between two different cultures. The internal factors that played role in elaborating building techniques diversely shall be clarified.

Considering Hypothesis

Finally my study examined the hypotheses of the development of Lan Na historic timber structure proposed previously by other scholars. I tested them against the outcomes of my analysis. Eventually, I introduced two new hypotheses that seem plausible to me. I treated my suggestion in hypothetical level, then provided self criticism and counter argumentation. I hope to provide a verifiable statement that can inspire and facilitate further study for discussing this topic scientifically.

1.4 Historical Factors and Early Lan Na Material Culture

1.4.1 Chronicles of Lan Na

Which kind of historical evidence did contemporary historians use as a source for studying the "overview" of old Lan Na history? There are two kinds of writing sources that involved the reconstruction of the past: monastic and secular chronicles. During the so called Golden Period of Buddhism in Lan Na lasting from 1400-1500 (1950-2050), the Buddhist monks were erudite presenting their competence in Sanskrit and Pali languages. They composed several Buddhist chronicles recording historical monastic events as they have witnessed. The chronicle of *Camadevivamsa* has been composed by the monk Mahathera Bodhiramsi around 1410 (1953) narrating the transmission of Buddhism and the founding of Hariphunchai, an old Mon state situated at the current location of Lamphun province (Jankajit 1997, p. 235).

Mulasasana and *Jinakalamali* are the two Buddhist chronicles describing development and transmission of Buddhism from India, Sri Lanka to Lan Na. The main story line of these two chronicles is, in fact quite similar but differed in detail outlining different priorities. *Mulasasana* and *Jinakalamali* were conducted from two rival Buddhist sects. Historians presumed that the *Mulasasana* was composed approximately in 1425 (1968) by the abbot of Suan Dok monastery in Chiang Mai under the Sinhalese sect (Stratton 2003, p. 90). Thai historian Prasert Na Nagra considered *Mulasasana* as one of the best source used for portraying relationships and religious affairs between Lan Na and Sukhothai. Since the main Buddhist sect in Sukhothai was also Sinhalese, the author of *Mulasasana* obtained first hand information by his travelling and handed down witnessed events in Sukhothai (Na Nagara 1997, p. 44).

Jinakalamali or literally translated as "Sequence of Events in Buddhism" was composed by monk Ratanapanna, of "New" Sinhalese sect of Pa Daeng Luang monastery in Chiang Mai. The first part of *Jinakalamali* was composed during the year 1515-1516 and the final part in 1526. Historian analyzed the biography of monk Ratanapanna from given information in the text and suggested that he was born in 1473, ordained to become a monk in 1493 and composed *Jinakalamali* when he was 43 year olds (Penth 1995, reprinted 2007). Monks of New Sinhalese was erudite obtaining well-stock libraries at their disposal (Penth 2004, p. 109). *Jinakalamali* provides a reliable source for Lan Na historiography nowadays. According to the credential information in *Jinakalamali*, contemporary scholars paid respect in recognizing the author, monk Ratanapanna as a historian (Ibids., p. 42; Grabowsky et al., p. 7).

Secular writing in old Lan Na ranges from dynastic chronicle, law, horoscope, medical recipe, etc. *"Chiang Mai Chronicle"* is a compilation work depicting the events from legendary period until approximately the year 1805 (2348).The authorship of *Chiang Mai Chronicle* is unknown. The chronicle comes down to us in the form of palm-leaf manuscript. Philologists discovered some 100 versions in Northern Thailand. The full version of Chronicle ranges 7 to 8 fascicles (the most complete one). They were the copies after copies. The copyist sometimes indicated the dates of his completion of copying. The oldest known copied version is 1806 (2349) in Tai-Yuan language of Lan Na and in 1762 (2305) for Burmese language (Wichienkeeo and Wyatt 1998, p. 4).

The form of composing chronicles in Lan Na is comparable to the compiling work carried out over generations. Philologist Hans Penth and David Wyatt, a historian who translated *Chiang Mai Chronicle* into English observed the narrating pattern, rhetoric and given details in the text and supposed that the compilation of *Chiang Mai Chronicle* probably started during the reign of King Tilok (rule:1441-1487). Even though the writing bears the word “chronicle,” in its title; Wyatt suggested to consider it as a historical writing due to its compiling method. For example the author sometime criticized the validity of other historical sources (Ibid., p. 13).

In the year 2008, the German historian Volker Grabowsky collaborating with Chinese and Thai philologists used Chinese sources to verify the information given in *Chiang Mai Chronicle.* Two sources were used in their research: *Zhengshi* or Standard History and *Shilu* or “Veritable Record.” The Chinese historical sources connote Lan Na differently. Chinese called it “*Babai Xifu*,” and describe different configurations of the territory (Grabowsky et al., 2008, p. 25). But the information of Lan Na’s rulers as reflected on the records of tribute mission from Lan Na to Chinese court is comparable to the *Chiang Mai Chronicle* (Ibid., p. 31-33).

1.4.2 Before Lan Na

The actual region where Lan Na had emerged can be divided into Eastern and Western parts. The Western region consists of the current Chiang Mai-Lamphun, Chiang Rai-Phayao, and Lampang basins, while Nan and Phare basins belong to the Eastern regions (Ongsakul 2012, p. 33). Even before the well evidenced historical period, the region was by no means an empty land. A report conducted by a Swiss archeologist presents the stone axes dated 12,000-7,000 years ago in Jom thong district, of Chiang Mai basin (Setthakul, 2009, p. 7). The Legendary Period, a term in Lan Na historiography, refers to the events that are depicted in several folk tales or local chronicles. Hitherto no supporting historical evidence is available (Penth 2004, pp. 9-12). *Tamnan Phra Chao Liap Lok* (The Chronicle of Buddha’s Journeys around the World) narrates the travelling of Gautama Buddha through the Lan Na region and predicted the prosperity of the land in the future. In fact, there is no credential information to corroborate that Buddha had visited the region.

The legend in this category frequently told a story of an encountering of a local to Buddha. Thereafter such encounter resulted in the establishment of a religious edifice (see for example, the chronicle of *Chronicle of Phra That Chae Hang* in *The Collection of Lan Na-Thai Chronicles*). The construction of the legend during Lan Na is a type of retrospective reasoning intended to provide “background stories” in order to give their own environment sense. The legend often made use of historical facts combining them with several tales and beliefs for the purpose of bridging the story line from present to legendary time. The legend *Tamnan Phra That Lampang Luang* or the Legend of Grand stupa of Lampang Luang monastery depicts an encounter between Lawa, an autochthonous Mon-Khmer speaking people with the Gautama Buddha. He received a single hair from Buddha and then kept it in a “golden container.” The ruler lord of that time had built a stupa for enshrining it. The legend proceeds by connecting legendary tale to the events recorded historically (e.g. records of the periodical restorations of the Stupa). Henceforth, the stupa of Phra That Lampang Luang monastery has become as we have seen it nowadays (Chottisukkhsrat 1975 reprinted 2013, pp. 553-566).

The *Chiang Mai Chronicle* commences with the come down of a god from heaven as he has been sent to earth to rule a land that lacked the ruler. He, Lao Jong, became the first king of Lao dynasty ruling a kingdom “Mueang Ngoen Yang” (Wichienkeeo and Wyatt 1998, p. 25). Penth suggested, if we try to correlate this legendary tale to the Lan Na factual history, the legendary period shall fall approximately of 500 -1200 AD (Penth 2004, p. 9).

The early historical period of Lan Na region begins with the establishment of Hariphunchai, an ancient Mon kingdom, located on the west side of Ping River in Chiang Mai-Lamphun basin. The contemporary historian interpreted the foundation of Hariphunchai as an expansion of Lavapura (currently Lop Buri province), a Mon Empire on Chao Phraya alluvium plain towards the north (Setthakul, 2009). According to the *Camadevivamsa* chronicle, the city was founded by the hermit Suthep approximately in AD. 750. The hermit defined the territory of the town inspiring by the configuration of a “conch shell” (Bodhiramsi, transliterated by Dept of Fine Arts. 1967, p.23). The hermit invited a princess Camadevi (Jam Thevi in Thai language) of Lavapura to rule the city. At that time, she just married and was pregnant. However she decided to keep her fate in the North. The chronicle continues to mention that Camadevi brought 500 Buddhist Monks and another 500 companions (Ibid., p. 33). Historians agree that such an episode may refer to the first installation of Buddhism in the region prior to the emergence of Lan Na (Na Nagara 1997, p.35). The group of other 500 companions is considered including the different guilds of craftsmen from Lavapura (Penth 2004, p. 14). An alternative view of Queen Camadevi derived from the name “Lavapura” which is consonant to the autochthonous people “La-wa.” Some thought Camadevi might be Lawa, a daughter of a hermit, travelled to the South in order to study Mon culture. Upon her return she ruled the city in Lamphun. Although the views regarding Camadevi’s background are diverse, Historians seem to share a consideration that the development of Hariphunchai material culture resulted from an acceptance of foreign influence (e.g. Indian) expanding Northwards from the peninsula through the central plain. Trading and religion brought along with technology refined local and tribal society (Setthakul, 2009, p. 31).

The Mon or Mon-ization of Hariphunchai practiced Theravada Buddhism. The Buddhist sculptures present the artistic style of late Gupta implicating Indian Influence (Amranand and Warren 2000, p. 24). Other archeological evience discovered in Lamphun that were common in Hariphunchai are unglazed wares decorated with black and white incision (Ibid., pp. 28-29). The cross historic sources between Lan Na and Chinese provide a clue that the Yuan Dynasty might have recognized Hariphunchai as “Nueren” meaning a “kingdom of female ruler” (Grabowsky et al., 2008, p. 47).

In addition the *Camadevivamsa* chronicle depicted a battle during the reign of Camadevi against Lawa king Wilangkha. The Lawa king fell in love with Camadevi but was rejected. Then he became furious and tried to seize Hariphunchai. Two sons of Camadevi fought against and defeated the Lawa king. Wilangkha eventually fled (Bodhiramsi, translated by Dept of Fine Art., p.34). Some elements relating to Wilangkha story are well preserved in the oral history of the Mon-Khmer speaking people in Chiang Tung, Myanmas (Renard 2015). Besides the conflict with the Lawa king the *Camadevivamsa* chronicle presents the image of a plural society where different groups of peoples had settled side by side. “The town of Mikkasanka people is situated on the western side of Hariphunchai, while Ramaneeya Manta Nakorn is situated on the southern [side], the Lawa families live inside the boundary of city moat” (Setthakul 2009, p. 35). We do not have any historic timber structure from Hariphunchai descended to our time, but some stone-brick construction such as squared-based stupa remains.

During the hayday of Hariphunchai in Chiang Mai-Lamphun basin, the Tai settlement established in Kok river valley of Mueang Ngoen Yang. Monk Ratanapanna Pali-nized this town in *Jinakalamali as* Yonnarattha (Setthakul, 2009, p. 42). The sources describing the arrival of Tai in Lan Na region and their city-state formation belong a lot to legend and belief. The historian cannot verify the period easily. We have mentioned earlier the legend of Lao Jong who descended from heaven and was consecrated to be the first king of Muang Ngoen Yang. The *Chiang Mai Chronicle* indicates the year of this event in 639 (Wichienkeeo and Wyatt 1998, p. 30). Historian suspect a “true” reason that drove Tai people Southwards and made them settle in this region. One assumption is the Mongol’s expansion toward the South (for example see Grabowsky et al., 2008). Penth believed Tai migration’s occurred in different fluxes from Southern China into Lan Na region and suggests the date for the event from approximately 1050 onward (Penth 2004, p. 35).

Mang Rai was a prince of Lao Jong’s dynasty who later became the founder of Lan Na. From Mang Rai’s period onward, the information given in religious and secular chronicles becomes corresponding, thus accountable. Dates were indicated clearly and events were described in greater details allowing historians to verify and cross check the given information from different as well as against archeological evidence. Many are corroborated, while many other left open. This period was called historical time by historians. Mang Rai was born to Lao dynasty on 2 October 1238 (1781). He was consecrated to be 25th king of Lao dynasty after his father died in the year 1259 (Wichienkeeo and Wyatt 1998, pp. 36-37) His mother was a princess of Mueang Lue of Sipsong Panna, thus the Mueang Lue king was his grandfather.

1.4.3 Early formation of Lan Na material cultures

The city-state formation of Lan Na through consolidation and decline spans from 13th-19th century. Penth divided the history of Lan Na into six periods: The making of Lan Na (1281-1371), the ascent of Lan Na (1371-1441), the golden age of Lan Na (1441-1526), the decline and loss of independence, the fragmentation (1526-1775), the Renaissance (revival) and integration to the part of Siam (1775-present). Penth also outlined an early phase in Lan Na history as the establishment of Lan Na "Hochkultur" (High Culture). By the term Hochkultur Penth refers to an ability to produce "advanced spiritual culture founded on abstract principles and written authority, based on an administration that incorporates more than only neighboring villages, and accompanied by a major material culture able to create, for instance, important buildings or other technical items" (Penth 2004, p. 56). He presupposed the development of Lan Na material culture took place from the beginning of Lan Na until approximately 1375. The Tai Yuan of Lan Na began to live side by side with the Mon of Hariphunchai, they had adopted and "digested" Mon material cultures. Eventually they established their new political power and developed the features of their own new culture (Ibid.).

Chiang Mai Chronicle illustrates the early phase of Mang Rai's reign as the consolidation and expansion of his power. He conquered the city-states surrounding his native town Muang Ngoen Yang. According to the chronicle, Mang Rai's motivation to attempt to unite the lands is explained that "any land with multiple rulers is a source of great suffering of it people" (Wichienkeeo and Wyatt 1998, p. 48). He conquered and occupied the following respective settlements: Mueang Mop, Mueang Lai, Chiang Kham, Chiang Chang.

Mang Rai commenced his new project of city founding in 1262. The chronicle describes the Mang Rai's consideration of city planning referring back to the legendary history. He recalled how his great grandfather founded the old Mueang Ngoen Yang. The city-state located in the valley between three hills envisaged a prestigious location. Henceforth, Mang Rai founded the city moat around a small hill doi Chom Thong (hill Chom Thong) and used the central hill as the navel of the town symbolizing the city pillar (Ibid., p. 40) His newly founded city so called "Chiang Rai" or the city of (Mang) Rai. Siam historian Chit Phumisak considered that Mang Rai might have adopted this principle from Khmer idea. Setthakul interpreted further that the adoption of Mang Rai's city pillar concept probably reflected his intention to show his recognition of Lawa element as he integrated it into cityscape. He might have gained acceptance from autochthonous people by incorporating them into Lan Na realism (Setthakul 2009, p. 44).

In thirteenth century Hariphunchai of Lamphun had reached its golden ages. Mang Rai cannot conquer Hariphunchai easily by force. He had to set up a spy mission destructing the administration of Hariphunchai from inside the court. His plan was succeeded in the year 1281. The chronicle narrates this episode in detail (see additional information on *Chiang Mai Chronicle*, pp. 41-43).

Instead of transferring his court to Hariphunchai, he ruled it only shortly and then assigned Khun Fa as the new ruler of Lamphun. Afterwards in 1286, he modified an old Mon satellite settlement in the vicinity of Lamphun, located at the junction of Ping River into the city “Kum Kam.” Contemporary archeologists and historians believe that this Kum Kam city was his “trial” of city planning before founding Chiang Mai. The configuration of the city is quasi-geometric and used part of the natural stream as a side of city moat (Valliphotama 2015). *Chiang Mai Chronicle* has narrated the episode of Kum Kam city-building which is worth to quote here: “He built the moat around the city on all four sides, channeling the flowing water of Mae Raming [Ping River], he built palisade on all four sides of the city and had a great many dwellings and buildings constructed. King Mang Rai built his extensive royal dwelling, palace and hall(s), /spreading all around that site; and it has been called the New Village [Ban Mai] to the present day” (Wichienkeeo and Wyatt 1998, p. 62).

Those following the researches on Lan Na historic building might be familiar with an episode in Kum Kam, when Mang Rai called in his carpenter to erect a viharn (a typology of Buddhist edifices). The chronicle depicts how the carpenter Kan Thom assembled the roof structural components together. “He had the timbers cut for *pae aye* [first purlin] *pae yi* [second purlin] *khue mah* [aisle beam] *tang mai* [standing pillar] in Chiang Saen. He raised the pillars but had not yet finished the building [in Kum Kam]; and when the pieces [building components] sent from Chiang Saen [to Kum Kam], they fitted perfectly,” (Wichienkeeo and Wyatt 2001, reprinted 2004, p. 37). The English translation of Wichienkeeo and Wyatt (1998, p.68) omitted the term “*tang mai*.” Therefore I have to instead referring to their Thai transliteration work. The building components described in this text illustrate a typical roof construction of Lan Na religious building which is prefabricated. The expression ‘fitted perfectly’ means that the structural components were not adjusted minutely causing troubles during assembling on-site but also not to lose.

I suggest to pose a simple question here for our critical reading of this text: How was carpenter Kan Thom able to erect the so called unique Lan Na building typology since the early period of Lan Na? Or did he follow some well formulated principle? Historians have agreed that the early inhabitant of Kum Kam was Mon comprising previously three villages: Baan Klang, Baan Lum, and Baan Ham. Hariphunchai was also the centre of Buddhism in the region (Vallibhodhama 2015, p. 28-29). My study suggests two possibilities read out of these historical assumptions. First, the knowhow of erecting a religious building such as viharn already existed since Hariphunchai. Nevertheless we do not know how it looked like, whether it was identical to the historic viharns standing in situ nowadays. The second possibility resulted from the method of historiography of the chronicle. The historians such as Penth, Wyatt, Wichienkeeo believe that the *Chiang Mai Chronicle* was started to be composed during the golden ages of Lan Na (Penth in Chottisukkhsrat 1971), in which the unknown author compiled information from different sources. Thus we may assume that the building components as described in the episode of Kan Thom were in fact the portraying of a contemporary building technique common to the author.

The Thai Department of Fine Art carried out excavation work in Kum Kam city during the years 1984-85 (Praicharnjit et al., 1991). The investigation results point out the ruin of a foundation platform intended to make a reference to the building of carpenter Kan Thom as described in the chronicle. A supportive reason for this claim was the discovery of a stone slab inscription left intact

Fig. 1.5 Platform that is believed to be the based foundation of Kan Thom's viharn

Fig. 1.6 Pillars'base at the platform, approximately 20-25 cm high

next to this platform incised the name Kan Thom on it (see inscription of Kan Thom in Department of Fine Arts 2008, pp.162-187). Afterwards this platform is called the platform of the viharn of Kan Thom (see. Fig. 1.5). Some scholar questioned the conclusion of Fine Arts' Department arguing that the mentioned stone slab was not stuck into the earth. They discuss the possibility that the stone would have been found somewhere else (Srisuwan 2002, p.72). A researcher at Chiang Mai university pursued to reconstruct the viharn of Kan Thom in 3d drawing based on the premises provided by Department of Fine Art in the research work "*The Architecture in Wiang Kum Kam Historical Area: A study of Wat Kan Thom*" (Ibid., 83-84). For the conclusive chapter, his study compares the foundation platforms of the ruins left in situ on Kum Kam historical site.

At the referred platform in Kum Kam city, we find a pillar's base in square configuration made from brick, approximately 20-25 cm high (see Fig. 1.6). The English translation of *Chiang Mai Chronicle* describes that the carpenter Kan Thom "raised" the pillar. The transliterated Thai version of Wichienkeeo uses the old Lan Na verb "*pok*" (literally translated to English as "to erect") and not with the verb "*kor*" (literally translated to English as "to build up" by brick laying technique). "*Pok*" and "*kor*" are two old Lan Na verbs addressed to two different construction methods.

Apart from pillar's base, we can presume that there were upper timber pillars erected upright from this lower base. The erection technique of pillar during the early Lan Na seemed to be completely different from what we see nowadays that the timber pillar had been driven into earth. A different usage of the verb as used in the Chronicle pertains to a construction in Kum Kam city as well. In 1288, Mang Rai had their people build the Chetiya, evidenced nowadays as Cedi Liam monastery (square based stupa). The Thai transliterated version shows the word "*kor*." It is worth to note additionally that the style of this stupa relates to the one of Hariphunchai. Setthakul considers this as the same strategy that Mang Rai employed city navel for Lawa case, but this stupa for Mon people (Setthakul 2009, pp. 43-44).

Chiang Mai Chronicle tells the background story of how craftsmen and guilds had come into being in old Lan Na. The chronicle narrates an episode that Mang Rai paid a visit to the king of Phukam-Ava (supposedly in Burma). The king of Phukam-Ava offered Mang Rai different skillful guilds, as listed in the chronicle: bronzesmiths, silversmiths, goldsmiths, and ironsmiths all together 500 families. Mang Rai settled these people in different regions of Lan Na. The chronicle depicts: "Mang Rai had carried out the division of crafts and posted [them] in different regions Mang Rai sent goldsmiths to Chiang Tung, the bronzesmiths and their guardians to Chiang Saen, jewelers and ironsmiths in Kum Kam" and concluded with the sentence: "and so all these craftsmen were henceforth in the Land of Lan Na, to the present day" (Wichienkeeo and Wyatt 1998, p. 69). The final sentence can be seen once again as a retrospective reasoning, thus implying that the chronicle is a compilation work conducted after the event. In addition, the historian detected a contradiction and stated an interesting observation. Phukam-Ava kingdom had in fact been established almost 75 years after Lan Na, approximately in 1365. Therefore the true identity of Burmese king as mentioned in the chronicle remains unknown (Lieberman suggested to Wyatt in Wichienkeeo and Wyatt 1998, p. 68).

According to the chronicle, Mang Rai started to build the city of Chiang Mai on 27 March 1296 (Ibid., p. 78). He had inspected previously five locations but was not satisfied until he went out for hunting and came across the supreme auspicious area for founding his city (Penth 2004, p. 44). The land was a field of “thick” thatch grass, at the foot of Suthep Hill. He interrogated the locals concerning the past of this land. *Chiang Mai Chronicle* narrates “Then […] King Mang Rai had the elder of domain/ assembled […] and asked ‘Is this a good place’ […] they replied […] ‘we have heard this: this place/ has been called a special place, where all the ruler of yore came” (Wichienkeeo and Wyatt 1998, p. 74). The philologist analyzed this episode by cross verifying with information from other chronicles and folklores, e.g. *“Tamnan Phra That Doi Kham*,” and suggested that the group of people which Mang Rai had encountered were Lawa and the Chiang Mai city had been built exactly above the Lawa legendary settlement called “Noppaburi” (Wichienkeeo 2002, p. 5). An anthropologist Ronald D. Renard, explained the meaning of Noppaburi further by referring to another legendary tale *Tamnana Mahatera Fa Bot*. The word Noppaburi means nine settlements of nine clans of Lawa (Renard 2015, p. 27). The *Chiang Mai Chronicle* does not mention anything about old Lawa settlements but gives a hint that Mang Rai had to seek a position for erecting a city pillar (navel), an important Lawa’s ritual practice for setting up a city (Wichienkeeo and Wyatt 1998, p. 75).

An interesting terminology, yet obscure was used in the chronicle to indicate edifices erected by Mang Rai: “He had a great many large and small dwellings constructed what are called low and high dwellings, and the Burmese call *mayang churawa*” Victor B. Lieberman, a British historian suggested the most closest term for “*mayang churawa”* is “*su-yon thodara”* meaning a store house (Wichienkeeo and Wyatt 1998, p. 75). In transliterated Thai version Wichienkeeo compared the sentence with the Burmese version of the Chronicle of Chiang Mai *Zimme Yazawin* and found the expression “*myint-pu zwa*,” literally translating as high-low-village (Wichienkeeo and Wyatt 2004, p. 42). Does this expression signify the difference between a building erected on stilt and the one erected directly on the ground? Still we have no clear answer for it.

In order to define the clear territory of Chiang Mai, Mang Rai invited his two allied kings: the king of Sukhothai and the king of Phayao to be advised. In the beginning Mang Rai considered that the territory should extend beyond the central auspicious site to the North, East, West, (the word South is missing) 1,000 fathoms on each side, thus a side of city should be 2,000 fathoms. But two allied kings disagreed and suggested that 2,000 fathoms on a side would be too wide to defend against enemies. They suggested only 1,000 fathoms on a side and Mang Rai agreed (Wichienkeeo and Wyatt 1998, pp. 75-78). In fact the depiction in the chronicle of this episode contains important architectural notions, but was omitted in the English translation of Wyatt. He translated as follows “That being so, I will measure it 1,000 fathoms long [author’s underline], by 900 fathoms wide [author’s underline].” Whereas Thai transliterate states “1, 000 fathoms *lung pae* [author’s underline], by 900 fathoms *lung khue* [author’s underline]” (Wichienkeeo and Wyatt 2004, p. 44). The term *lung* means “to measurement along a side” while *pae* and *khue* mean “purlin” and “crosswise beam” respectively.

Temiyabandha, read above expression of the terms: *"pae"* and *"khue"* and interprets the symbolic meaning as well as their semantic shift. He began his explanation: "The shorter sides of the city are oriented to the direction of North-South, the fortified wall of this wide side called '*khue mueang*,' [crosswise beam of the city], while the fortified wall of longitudinal sides are oriented to the east-west called '*pae mueang*,' [purlin of the city]. Traditional Lan Na houses were erected in North-South direction. This reflects an old saying: "do not place purlin [of the house] against [the purlin of] the city," that must not be contradicted. Topographic setting of Lan Na presents mountain ranges lying along the North-South direction providing origins of river and natural resources. The river flow downward from the mountain creating the fertility to the alluvium plain. Hence, old Lan Na recognized north-south direction as the symbolic axis of fertility (Temiyabandha 1996, p. 55). The crosswise beam and purlin provided an orientation of a house and were used interchangeably with the words crosswise and lengthwise. Along the line of the expansion of a settlement from a cluster of houses, a village, and a town, these connotations had been transmitted and eventually used to provide an orientation of the city (Ibid., p. 55).

Chiang Mai Chronicle presents the background of the relationship between Mang Rai, king of Sukhothai and king of Phayao pertinent to the personal reason narrating how Mang Rai resolved the personal conflict between the king of Sukhothai and Phayao (Wichienkeeo and Wyatt 1998, pp. 51-52). Nevertheless the information in Chinese source provides another clue that could lead to a different conclusion. During the year 1253-1257, Mongol army invaded Sipsong Panna, the native town of Mang Rai's mother (Penth 2004, p. 46). Thus Mang Rai should have noticed the change of political climate in Yunnan province, China. The research of Grabowsky and Liew-Herres refers to the *Yuanshi 23* that mentions "Yuan court sent two commanders to lead an army to conquer Lan Na." Another Chinese source obtained from stone inscription, incised on the cliff of Mekhong River stated that "Yuan sent troops to conquer Babai-xifu [Lan Na as Yuan connoated it], Zhiyuan 29 (1292)," (Grabowsky et al. 2008, pp.47-48). Liew-Herres analyzed the calligraphy on this inscription and believed that this inscription was unofficial and not belong to the Yuan court. It was probably written by a soldier. The German and Chinese researchers supposed that Mongols sent troop to Lan Na in respondse to Lan Na's conquest of Hariphunchai. Yuan source always considered Hariphunchai as one of their tributary states. Mongol army did not reach Lan Na because Kubilai Khan died in 1294, thus the mission was abolished (Ibid.).

The international political climate in Southern China might have provoked Mang Rai to certain degree. The situation drove him to ally with another T(h)ai states in order to resist the tension of Yuan force. The best sample to present the relation and cultural exchange between Lan Na and Sukhotai can be seen in the shape of Chiang Mai showing a square configuration in difference to the previous "conch shell" of Hariphunchai and Kum Kam.

Chapter 2

Construction Works in Old Lan Na and Building Treatises

Current chapter consists of two sections: 1) construction works in old Lan Na as described on stone inscriptions and 2) analysis of Lan Na building treatise. The first section deals with historical narrations revealing intentions behind an establishment of a building and its circumstances; and the second analyzes specific descriptions for material preparation and building erection. The first section is taken partially from my previous article *From Convention to Tradition: An Overview on Use and Abuse of Building Techniques in Historic Timber Structure Restoration Project in Northern Thailand*, submitted for ICOMOS conference in 2015 and published in the proceeding *Timber Heritage and Cultural Tourism: Values, Innovation, and Visitor Management* (2016). In this article, I intended to investigate the transformation of the concept of "tradition" according to construction and restoration works from old Lan Na period until contemporary. Thus, not all contents discussed in the article are relevant here. I introduce partly of section concerns historical analysis and revised them for presenting the historical circumstances that shaped Lan Na building culture.

2.1 Construction Works in Old Lan Na

Building researcher can learn in certain extend from the source evidencing on stone inscriptions. In parallel to the movement of Lan Na cultural studies in 1970s, linguists and philologists made significant progress transliterated and translated Lan Na inscriptions into modern Thai. A group of researcher from Social Research Institute, Chiang Mai University has published a series of *Corpus of Lan Na Inscription* from 1997 onwards. Another collection of comparable information is *Lanna inscriptions Part I-II*, compiled by The Department of Fine Arts, the latest revision was issued in 2008. In old Lan Na, three types of scripts were used for composing and writing a piece. The Old Mon script was an oldest type derived from Haripunchai, Proto Thai was a script shared among Sukhothai and Lan Na, and Tham script. The latter Tham script was unique to Lan Na and originally reserved solely for religious purpose but later was adopted to secular writing as well (Penth 2004, p. 58). These scripts were mostly incised on stone slab and palm-leaf. Occasionally, the philologist found them on wooden board or the base of Buddha images (See for example, *Inscriptions under the base of Buddha Images in Chiang Mai*, Penth 1976).

Many transliteration and translation works provide great resources for researching old Lan Na building culture. The ceremony for erection and restoration of religious building was one of important events that deserved to be recorded as evidenced in Lan Na old inscriptions. The narrative structure of such event consists of 1) date of inscription; 2) principal and list of witness; 3) purpose of event; 4) endowment and donation; 5) merit; and 6) expense. In the later period of Lan Na, author of inscription clarified the "expense" for erecting a building in more detail, breaking them down to a list of building materials, its quantity, and cost (see for example Inscription of Phra That Chae Hang monastery, dated 1585 (2128) in Wichienkeeo 2006, p. 23). Such information enables the building researcher to obtain in depth information concern building terminology and raw materials required in a construction.

The word "*ja-ruk*" means stone slab inscription in modern Thai. The etymological root in old Tai Yuan language of Lan Na was "*ja-lit"* (จารีต –จ๋าลีต). The word connotes to two meanings: a) convention and b) stone slab inscription. Researcher of Social Research Institute explained the semantic shift of these two meanings as: the term "*ja-lit*" implies to a text or documentation containing Royal Order for endowing a land or an object to the monastery (convention of royal court). Their objective is to manifest and to embed Royal Merit to the future society. As "*ja-lit*" was often written on the stone slab, thus the word signifies the stone inscription was well (Penth, Khrueathai & Ketphrom 1999, pp. 97-111). The following example presents the usage of the term *ja-lit* in an inscription showing twofold connotation: "Shall [affiliate] the abbot with the *ja-lit* (convention) of the monastery…Jao (local ruler) Muen Suwan and Jao Muen Noi Khum Khadee received an order from Overlord to install *ja-lit* (stone inscription) with the monastery in order to maintain the Buddhism…" (Khrueathai, Pinngoen & Sitha 2004, pp. 13-21). In brief, the term *ja-lit* reflects the process of manifestation of practical procedure conceived into written form.

In the following section, I select some excerpts from transliterated stone slabs to present the purposed and initiation of construction work in old Lan Na. I categorize the sources on inscription according to its purposes: building erection and building restoration.

2.1.1 Building Erection

Inscription: Wat Phra That Lampang Luang, 1476 (วัดพระธาตุลำปางหลวง พ.ศ. 2019)

> "November, 4th 1476 [inscribed date]…Jao Muen Kam Pet has ruled Nakorn Lampang, restored the Buddhism belief, and repaired Wat Phra That in Lampang. [Jao Muen Kam Pet] made the order to build up a wall [fortress] and to build up a viharn. Then, casted a Buddha image which weights 120,000 unit of gold [132 kg], and enshrined [this Buddha image] in the viharn. [Afterward]…assigned four families to take care of this Buddha image…On the basis of these merits, the Overlord wishes to become an enlightened Buddha in the future …. " (Khrueathai, Chapana & Sitha, Sarawut 2004, pp. 12-20).

Insription: Wat Si Sutthawat, 1503 (วัดศรีสุทธาวาส พ.ศ. 2046)

> "February, 1st 1503 [inscribed date], Jao Muen Noi Yan, Jao Roi Hin, Jao Sib…[including with additional group of principal and committee] … donated 1000 teak wood log. Shall build the Kam Ruen monastery, Pa Daeng monastery, Chetuwan monastery, Luang monastery…At Pa Daeng

> monastery, 730 logs [had been] used…Jao Panna Lang Yanawisarot asked a permission from Phaya Kaeo and … erect a grand viharn…" (Ketphrom & Techasiriwan, Apiradee 2008, pp. 37-51).

Inscription: Wat Phaya Ruang, 1535 (วัดพญาร่วง พ.ศ. 2078)

> "March 11th, 1535, late morning [inscribed date]. The Overlord [Phaya Ket] made an order to the ruler of Mueang Phayao [Phayao city], to build a grand '*mandapa*', Sophist: Phrahat seeks a good day [for erecting the grand *'mandapa'*]… after built up this '*mandapa*,' [the ruler] assigned slaves to serve [the mandapa]… do not allow them to work otherwise" (Penth & Khrueathai 1999, p. 279).

Undoubtedly, the development of Buddhist belief had consolidated a practice in construction and restoration work. An architectural historian pointed out the parallel concurrency of the progress of Buddhism and architecture in the Golden Age of Lan Na (Temiyabanaha 1969, reprinted 2014). As we have seen on the samples of inscription, the system of ceremonial practice of building erection seems to be very conventional, but the information concerns an actual execution is always lacked from the inscription source. My study further investigated the viharns erected according to the first mentioned inscription of Phra That Lampang Luang monastery in chapter 3.

In *Jinakalamali*, an important religious text, the characteristics of building*, "lak"* are described in term of types: bull-type ("*asupalak*") and elephant-type ("*kachalak"*) (Penth 1994, p. 4). The bull-type implies an open hall (rectangular plan of viharn). Elephant-type is interpreted as a cross plan or mandapa (Peths interpreted mandapa as an open pavilion). Since Jinakalamali is a religious text, so there is no detailed description regarding construction system and technique of these two types (see Fig. 2.1).

The erection of mandapa is often associated with New Sihala Sect of Buddhism: Wat Pa Daeng (redwood grove monastery). The first mention of erecting a mandapa according to *Jinakalamali* was in 1517 at Wat Pa Daeng monastery, Chiang Mai during the reign of King Kaeo (rule 1495-1525). The building had a golden and bronze roof tiling, the prose in this text illustrates this mandapa as "*…*shining by decorative jewelry and arousing by beautiful painting" (Ratanapanna & Monwithun trans, reprinted 1997, p. 146). Thereafter, the type of mandapa seems to be conventional and frequently mentioned. An important "*maha*"-mandapa or great mandapa was erected at Wat Phaya Ruang in 1535, Phayao (currently Wat Pa Daeng Bunnak- see inscription above). The ruin of this mandapa indicates a configuration of square base building with four outlying porches. Beside this base foundation, we do not have further evidence of the wooden structure raised above.

However, Penth referred to an oral history in Lampang describing a standing pavilion with four porches at Wat Pong Sanuk, Lampang, a duplication from Wat Pa Daeng Bunnak in Phayao (Penth

Fig. 2.1 Mural painting in the viharn of Nam Tame at Phra That Lampang Luang Monastery presents a drawing of mandapa

Fig. 2.2 viharn of Pong Sanuk monastery characterized by four outlying porches; Penth assumed that this building represents the mandapa type

1994, p. 230). If this assumption can be confirmed and the one at Wat Pong Sanuk was whole structurally imitated entirely, it shall present the structural evolution in the Golden Age of Lan Na. Basically, this pavilion employed the same structural principle as viharn but the carpenter applied them to solve the complicated form –they both are based on *tang mai* system. The emergence of mandapa, a new building type could imply to a higher level of utilizing building technique that open more possibility to implement a new typology. According to historical evidence, the patron and carpenter made no reference to the other beside the religion. The purpose of action contributed to the sake of religion on its own and the wish of merit expressed to the religion will. Unfortunately, the mandapa, of Pong Sanuk monastery was completely restored in 2006 (see Fig. 2.2). The restoration work erased important traces of old building technique prohibiting my investigation to explore the invention of carpenter.

2.1.2 Building Restoration

Inscription: Wat Phra Sing, 1794 (วัดพระสิงห์ พ.ศ.2337)

> "…Thus call in all carpenter and painter, made an order to restore the old Foot Print, which is deteriorated and broken out. Shall build up the panel, shall lacquer with natural resin [for protecting wood], shall paint with bright red [colour], delicate, accurately as an old style…the Foot Print shall be paid respected and worshiped by all men and angel until year 5000th BE" (Penth and Khrueathai 1998, pp. 35-52).

Inscription: Wat Phra That Lampang Luang, 1796 (วัดพระธาตุลำปางหลวง พ.ศ. 2339)

> "…patronage by his Majesty, the great faithful… thus built up an iron fence by forming the border line. Then erected [the fence] elegantly and stand still until year 5000th BE, as if a priest, a sophist, an aristocrat, an overlord …whom all passed away; had continually practiced in enshrining the Dhatu, the Stupa and viharn….(list of material) each vertical iron costed 50 silver, each horizontal iron costed 22 silver, there are 130 pieces of vertical and 35 pieces of horizontal [iron]. Total expense is 5000 silver" (Penth and Khrueathai 1998, pp. 77-96).

Inscription: Wat Phra Sing, 1812 (วัดพระสิงห์ พ.ศ.2355)

> "..Then invited and consecrated the abbot to be a principal, all together with the faithful, have erected the grand Ubosot, [built up] glided brick housing [for principal Buddha image], [they are] decorated with ornament [สุวรรณกาญจนคำแดง] exquisitely, as practiced by the old Kings: Saen Mueang Ma

> [accession: 1401], Phra Mueand Kaeo [accession: 1495]….the list of material and expense [are]: natural resin [for protecting wood], crimson, gold leaf, decorated glass…, sugar cane, mortar, iron [nail], clayed tile, brick,…ceremonial fee for craftsmen. In total, spent 107,300…"(Penth and Khrueathai 1998, pp. 117-185).

Inscription: Wat Doi Than Phra, 1814 (วัดดอยแท่นพระ พ.ศ. 2357)

> "…Having seen this viharn, it was already becoming aged and decrepit for some years. Its column, purlin, roofing shaping member, roof subcomponent, as well as the tiles were fallen and broken down already some period of time. Therefore, we, together have a willing to restore and repair, [then] exchanged: the pillar, purlin, roofing shaping member, roof subcomponent, roof tile, decorative elements, roof finale, and pediment. [We] replaced surrounding iron fence and wooden fence…. [we repair and make [the viharn] more delicate… it shall be paid respect by all men and angels until year 5000th BE" (Penth and Khrueathai 1998, p. 233).

These excerpts of inscriptions derived from the period of Lan Na Revival after the Burmese rule. The history of Lan Na in this period presents a long struggle. Chiang Mai had been abandoned for such a long time, the city was in debris. Therefore, it was not possible to maneuver Royal Court and population back immediately. Chiang Mai and Lan Na needed to be completely revitalized. Not until 1796, Chiang Mai resumed to be capital of Lan Na once again. The scopes of Lan Na revival in this period had been carried out not only physically, but also culturally as well. According to Sarassawadee Ongsakul's study, Kawila pursued his consecration and associated himself into the lineage of glorious Mangrai's dynasty (Ongsakul 1994, reprinted 2012). He reestablished several old ceremonies, among them: the ceremony of ascending to the throne, the ceremony of erecting the royal palace, the ceremony of procession ceremony of Buddha's relic, etc. These historical events and their consciousness became an important factor that shifted the concept of construction and restoration work in Lan Na. The implications to tradition and to history come into play explicitly as seen in above excerpts. There are three topics that could be observed and discussed:

1) Historical implication: the event of restoration can be seen in two parts: a) ceremony and b) executed restoration work. The sources for reviving the ceremonial practice undoubtedly derived from inscriptions on stone, palm-leaf manuscript, city chronicle, and available oral history. But, in order to convey a conventional appearance of a building, what shall be the sources for actual restoration work in structural and in technical aspects? Even though some record mentioned that the rulers of Burma allowed Lan Na to maintain their own convention and norm (Ongsakul 1994, reprinted 2012, p. 262), but since the main patron of the project was missing. The proficiency of work is questionable. Furthermore, many skillful craftsmen had already emigrated to work in Burma (Ibid., p.269). We have to

suppose that the status of building know-how in this period was fragmentary. Thus we must assume an effort of reestablish the lack. The carpenters of Kawila's Royal court might have to travel through the regions, in search of available sources. The resulting re-compositions executed in this period should present trait of source reconciliation. We must assume that they were executed in contemporary fashioning techniques. Re-erection and reconstruction were done according to the current state of knowledge and professional skill. However, some study on character of the building built in this period still find a similarity on an exterior appearance with the one in Golden Age (Malai 1997, p. 300).

2) Images of restored buildings: how did a restored building look like? There should be no doubt that the building should be durable. The intention to prolong the age of a building until the year 5000th Buddhist is remarkably widespread. In the inscribed text, there exists the set of expression elaborating how beautiful the restored-decorated buildings should be "สุวรรณคำแดงแสงงานเรือ" (see inscription of Wat Phra Sing 1794) "สุวรรณกาจณคำแดงแสงงาม" (inscription of Wat Phra Sing 1812) and "สุวรรณคำแดงแสงด้วยแก้วมณีแหวน" (see inscription of Wat Chedi Luang 1805). These expressions are almost identical and can translate to English literally as illuminated (valuable) by gold and crimson (and jewelry and diamond)" Although, the concept of historical implication come into play, the restored building does not appear ancient.

3) List of material, primarily: the main purpose of such listing was to present the merit and efforts of the patron and donator. However, the list could further be interpreted on two aspects: a) social condition and b) status of building technique. The economy in Lan Na seemed to be not a subsistence economy anymore. Many items such as clay tiles, bricks, mortar, which were believed to be capable product but needed to be purchase. The widespread use of iron indicates the status of new phase of building techniques.

An endeavor of reviving Lan Na tradition paved way to an important construction project during Jao Kawilorot (rule: 1856-1870). Viharn and mandapa of Ton Kwen monastery in Chiang Mai have been erected approximately in 1858. The compound presents a middle course of the route between Wat Phra That Jom Thong and Chiang Mai –where the ceremonial procession of a Buddha relic passed by. From Jom Thong district to central Chiang Mai, it takes around 58 km. Thus the parade had to spend a night on route and the relic shall be temporally enshrined. Mandapa of Ton Kwen monastery has been built to serve this purpose (see Charoenmuang 2008). The configuration of this mandapa is a square based plan with four outlying porches. An elevated core structure defines the crossing point of the hip orders. The structural system of this mandapa is not *tang mai*, but the one so called *tang yo* –a closed triangle frame system. My study will present an investigation of this mandapa in chapter 4.

2.2 Building Treatises

Apart from the descriptions of building establishment recorded on stone slab inscriptions, philologists found specific document that describe exclusively the preparation of building components and erection process of viharns in old Lan Na. Hitherto, there are seven building treatises known to Thai scholars. The first three building treatises are resulted from collections and transliteration works of local historian, Sanguan Chotisukharat during 1970s. Chotisukharat worked together with a monk who was fluent in Tham script of Tai Yuan language (Penth in Chotisukharat 1966, p.VI). He has published them in the book *Collection of Traditional Northern Thailand Rituals Practices* (no date). From now on, my study will address Chotisukharat's texts as building treatise: Nr.1, Nr.2, and Nr.3. In general, Chotisukharat's intentions were to collect, preserve, and introduce Lan Na's historical "stories" to his contemporary. Thus he provided no further explanation and interpretation in his transliterated building treatises.

Other four building treatises are published as the result of research collaboration between art historian, Chaiyosh Isavorapant and Social Research Institutes of Chiang Mai University. The transliterations of these four building treatises are published in *Viharn of Golden Stencil at Phra Sign Monastery* (2000). The original digitalized palm-leaf manuscripts are published in the Appendix 2 of Chaiyosh Isavorapant PhD's dissertation (2004). Henceforth my study addresses transliteration work of Isavorapant's and Social Research Institutes as the building treatise: Nr.4, Nr.5, Nr.6, and Nr.7. In the previous section, I have already criticized the deficiency in technical aspect of Isavorapant's interpretation of treatises, thus I shall not repeat it here.

My study attempts to extract the content out of these building treatises in highest possible extent underlining the well established technical descriptions in the texts. An unknown expression can be accessed through the consultant with specialized dictionaries: *The Northern Thai Dictionary of Palm-Leaf Manuscripts* (Wichienkeeo 1996) and *Royal Institute Dictionary* (Royal Society of Thailand 2009). In addition, we compare an obscured passage in treatise to the buildings in situ in order to make sense what the text probably implies to. In case two possibilities of interpretation cannot out weight each other, I propose them as the hypothetic variations.

Technical aspects of timber construction have played a crucial role in my reading of building treatises. My study offers English translations from Thai transliteration. I consciously attempts to maintain original forms of description, thus I separated my own interpretations out of the core text. The assembling processes as described are presented through illustrated drawings. In the final part of this chapter, I provide the comparative terminology derived from different building treatises.

Building Treatise Nr. 1

"…To cut a viharn, take the main crosswise beam ("*khue luang*") as a main reference. Measure ("*tak*") and chop the head ("*hua*") of the main crosswise beam as it is, create the place for purlin *("pae")* [1], and form the middle point [2]. Divide the main crosswise beam into six parts and take four parts as second crosswise beam [3]. Raise the standing pillar ("*tang mai"*) [4], with additional tenon at upperside. This tenon (*"khe")* is square and do not make it too difficult to insert (*"twaak")*. For the aisle beam ("*khue mah*"), take the length of main crosswise beam from the middle point and add a tenon [5]. For the second aisle beam, turn the head of the main crosswise beam to the aisle beam, mark an overlapping point and that is the [length of] second aisle beam [6].

[The length of] third aisle beam is defined by subtracting the head of second crosswise beam from the head of second aisle beam [7]. The wooden component which was divided into six parts, take away two parts, that is the flanking pillar *("sao sagoen"*"), [8]. Take one part as a neck part ("*kor geeb*"), [9] on the external axis. Halve the purlin *("yam pae")* on the previous piece that was taken away by two [10]. Set up standing pillar and purlin for third aisle beam [11]. That is it.

The first purlin ("*pae aye*") of the roof on rear side adjoins to the flanking pillar. Divide the neck part into eight subdivisions, leave the upper two and define the point, this first purlin joins there [12]. Project the measurement and define the neck part of the roof on rear side [13]. To define the eaves arm *("yang")*, refer to the previous division of eight parts, divide [neck part] again into lower two parts and upper eight parts fixing the tenon of eaves arm [14]. The length of tenon is equal to the foot of standing pillar. The lower eaves arm consists of small supporting pillar, the previous upper eaves arm is stacked by the purlin (*"yang sone pae*")[15]. To define the position of the lower eave element, take the roof [on the rear side] into consideration, project the alignment of the upper eave along the flanking pillar downward, fix the lower eaves arm at the intersected point

So to say, let the first purlin [from the forth roof] attach to the main pillar [16], let the second purlin joint to the additional beam (*"khue thum"*) of main crosswise beam [17], the third purlin joint to the lowest of footing *("teen")* of small standing pillar. Adjoin the neck part to the main pillar [18], and then project [the aisle purlins] accordingly. In the compound of aisle structure, the [attached] positions are not so precise, so let the three purlins attach wherever they are!"

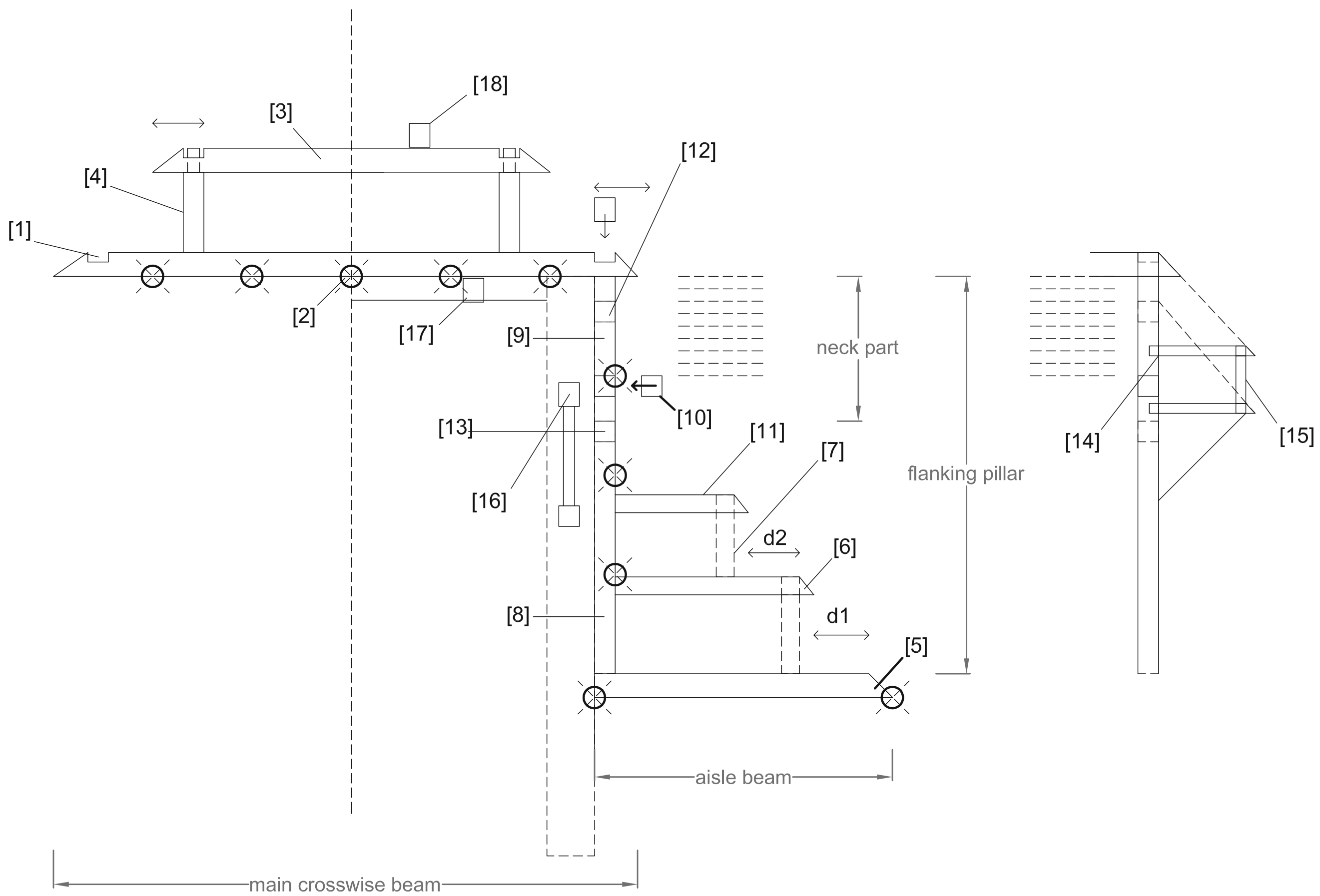


Fig. 2.3 The interpretation of assembling process according to the building treatise Nr.1

Fig. 2.4 *yang sone pae*, a sample from the viharn of Suchada monastery, Lampang province

Fig. 2.5 *yang sone pae*, a sample from the viharn of Sri Luang Chae Sone monastery, Lampang province

Interpretation: Building Treatise Nr. 1

For an erection of viharn, building treatise Nr.1 suggests to begin with the preparation of a main crosswise beam, cutting the edge of timber for the beam to triangular shape and notching the seat for the purlin. The treatise presupposes, readers shall know beforehand how the head of this main crosswise beam looked, it is merely mentioned with the word “as it is” in the sentence. Then, the treatise continues to describe the proportion of building components in relation to this main crosswise beam. The second crosswise beam is four-sixths from the main one. It should be observed that the treatise does not mention the position for assembling the standing pillar on this crosswise beam, as the person in charge shall know that the second crosswise beam is stacked by keeping the central alignment. The treatise repeatedly emphasizes that the measurements of tenon is not included in this described proportion, the executing person shall consider it appropriately. A reason might be that the thickness of the component cannot be indicated, since it depends on the available resources. However, the measurement of the head of the main crosswise beam is taken into account when defining the aisle beam. The aisle beam is half of main beam. The tenon has to be added to this length. The method of defining second aisle beam is to subtract the measurement of the main crosswise beam’s head from the measure of the aisle beam.

The preparing of the third aisle beam follows the same logic as of the second aisle beam, but in this case applying for second crosswise beam and second aisle beam. The treatise starts referring to the component addressing by its proportion instead of name. “…The wooden component which was divided into six parts, take away two parts, that is the flanking pillar [8].” The previously divided into six parts” concerns the main crosswise beam, of which the flanking pillar is four-sixths. The flanking pillar consists of four divisions that are counted from the six of the crosswise beam. We shall spare a part for the neck and halve the purlin there. The text notes, this purlin should be placed on the external axis of the flanking pillar, because there is a different method that the purlin adjoins to the flanking pillar by a tenon.

Starting with the third paragraph, the treatise describes how to fasten purlins of attached smaller transverse frames to the main frame. The overall height of the attached frame is reduced compared to the main one. The neck part of the main frame is divided into eight parts; we are told to connect the lower main purlin two measuring unit below the flanking pillar’s top end. Afterward, the text just mentions briefly that all the other purlins of the attached frame are connected to the main one accordingly, because all purlins on the attached frame are in alignment with the structural components of the main one. For assembling the cantilevering eaves element, the treatise suggests to divide the neck part once more, this time into ten divisions, spare the upper two divisions and fix the eaves element via a tenon there. We can observe that the mentioning of the length of tenon is deep in comparison to the size of the eaves arm. My analysis supposes that the treatise considers the bending moment occurring in this point, therefore, we read “…the depth of tenon is equal to the foot of standing pillar.” The purlin at the eave part is generally halved in width above the eaves arm. Hence the position of purlins running from lower frame to the higher frame needs a special technical treatment for combining them. The treatise suggests to form a compound of eaves arms, consisting of two levels eaves arms, strengthened by a small standing pillar called “*yang sone pae.”* This pillar is put back from the triangular chamfered beam’s ends (see samples on Fig. 2.4 and Fig. 2.5).

In the final paragraph, the treatise does not indicate the structural member’s position it is mentioning. But the observation of the arrangement of components allows to assume that the text refers to the adjustments of the set of purlins expressing height and span of the attached smaller frames. The main purlin actually should be situated in alignment with the short pillar flanking the main pillar. Yet, generally speaking, the assembling of the transverse frame with different height and span is a complicated task. All the purlins belonging to the smaller transverse frame hardly have any chance to be placed in alignment with the purlins of the larger frame. Consequently, the treatise offers purposeful instruction only for the purlins above the nave: “Let the second purlin joint to the hanging/supporting beam of main crosswise beam, the third purlin joint to the lowest footing of small standing pillar.” Concerning the aisle’s roof structure, the treatise refrains from clear statement. It admits ti decide on site “…so let the three purlins attach wherever they are!”

Building Treatise Nr. 2

“At the moment, shall describe how to cut wood for a viharn. Shall first cut the main crosswise beam (“*khue luang*”). Shall take a wood measure stick *(“mai take”)* and divide into five parts [1]. Take one part *(“pud”)* as a standing pillar (“*tang*”) [2], this measurement includes the tenon *(“deal nai”*) and footing (“*teen*”), also set up the footing *(“teen”)* there [3]. The footing hole is to cut down (*“bak bane”)* [4] and the head of the standing pillar is a tenon characterized by core wood [5] *(“gon song jai”*).

The standing pillar on the second crosswise beam is taken one part from the divided three parts [7], add on the length of tenon *(“deal noak”)*, and set up the footing there. The footing of the standing pillar on third crosswise beam is to cut down (“*bak bane*”) [8] and the head is the recess with tenon (“rim rung-tang nai”) [9]. The whole ridge purlin *(“jong”)* is placed above the tenons on this recess. In the principal roof *(“sod luang”)*, the dimension of tenon and footing shall be added to the ridge supporting pillar.

Divide the aisle beam into three parts, take one part and divide again into 3 parts [10]. Raise up one part *(“tum”)* as a small standing pillar, extended by the measurement for a tenon [11]. Also set up the foot and cut down into the aisle beam (“*mah khue*”). Adjusting the hole on the head of aisle beam corresponding to the external nose (“*ru dang noak”)*, then insert *(“twaak”)* it into the [main] pillar, then enter in the hidden wood *(“lai lom mai)*.

Divide the second [aisle] beam into three parts and divide again by three. Take and raise it up as standing pillar with additional length for footing [13]. The [length of] flanking pillar *(“sagoen*) is equal to the aisle beam, extended by tenon and footing [14]. The position of eaves arm is two parts taken on flanking pillar, the length of eaves arm on flanking pillar is one unit [15], the length of eaves arm on aisle part is of double units [16]. The main purlin of front roof shall be put via tenon into the central axis of the main pillar [17]. That is it, shall finish here!”

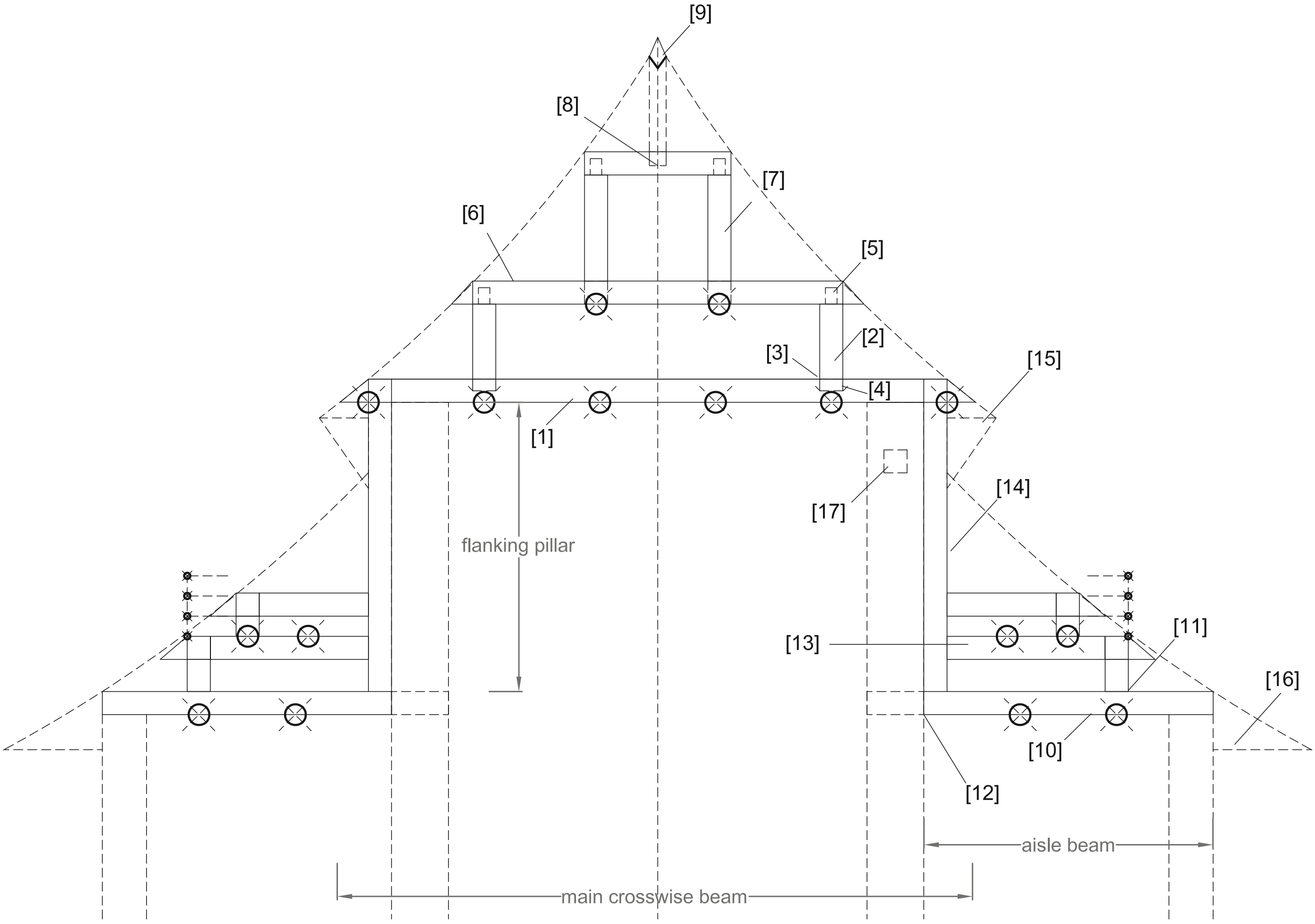


Fig. 2.6 The interpretation of assembling process according to the building treatise Nr.2

Fig. 2.7 Ridge supporting pillar presenting v-shape recessed with additional tenon

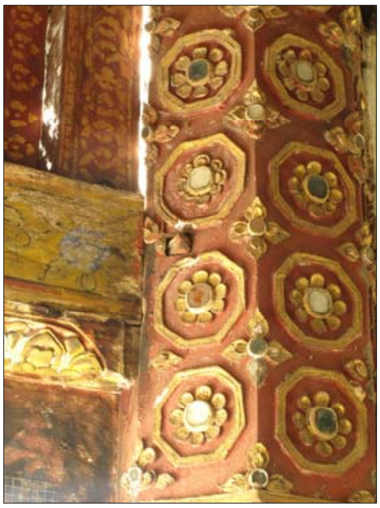


Fig. 2.8 The Connection of aisle beam's tenon secured by wooden nail. My study supposes that these elements are “tenon head,” “external nose,” and “hidden wood,” as indicated in building treatise, the sample taken from Suchada monastery, Lampang

Interpretation: Building Treatise Nr. 2

The treatise starts to describe how to prepare the structural elements for erecting a viharn. It suggests to begin by cutting a crosswise beam, and introducing a reference wooden stick for ratio transferring. The length of the crosswise beam is divided into five parts. The treatise suggests to take one unit as the height of a standing pillar and to erect this pillar one unit inside the crosswise beam's outer end. The given ratio for the standing pillar includes the length of tenon and footing. Thus when the position of the standing pillar is defined, the length of the second crosswise beam is given. The concept how to assemble the structural components is kept briefly: "…The footing hole is to cut down and the head of the standing pillar is a tenon…"

The treatise has suggested the dimension of the standing pillar above the second crosswise beam which differs in method from the lower standing pillar on main beam. It suggest that, since the length of the second crosswise beam consists of three parts from the main beam, we shall take one part as a standing pillar, but we should add additional dimension for tenon head, "*deal noak*." This indication implies that the standing pillar on the second crosswise beam is higher than the lower one, thus the profile of roof plane starts to steepen. The location of the standing pillar on the second crosswise follows the same logic as the lower standing pillar. We shall move inside one unit from the two ends of the second crosswise beam, thus defining the location of the pillars. Hence the length of the third crosswise beam is immediately implied. For a moment surprisingly the treatise does not indicate explicitly the high and the placement of the uppermost standing pillar above the third crosswise beam. However, if we follow the logic of this treatise, we can assume that it should correspond to the general typology of the viharn. Instead of indicating the ratio of ridge rupporting pillar, the treatise attributes the dimension of tenon head and its footing by suggesting that we shall add an additional dimension of them for the principal roof.

In brief, the given proportion of the standing pillar on the main crosswise beam includes the dimension of the tenon head and its footing, while we shall add additional dimension only of tenon head to the height of the standing pillar above the second crosswise beam. Eventually, we must add both dimensions to the ridge supporting pillar from the given ratio. It goes without saying the profile of the roof from in this treatise is turning steeper towards the roof ridge. The treatise attempts to describe the configuration of the seat for ridge purlin which shall be executed as a v-shaped seat with tenon for fixation of the purlin (see Fig. 2.7).

In the third paragraph, the treatise does not mention the proportion of the aisle beam in referring to the main crosswise beam as it seems the measurement of the aisle beam in itself should provide a starting point for the transmitting of proportion, e.g. on the fourth paragraph. The treatise suggests that the measurement of flanking pillar is equal to the aisle beam. The treatise continues describing that the aisle beam shall be divided into three parts to define the position of the standing pillar above exactly one unit inside the beam's outer end. The height of this standing pillar is rather short. Its height is supported as one third of one of three units into which the aisle beam shall be divided. Again the carpenter shall add the necessary length of the tenon. The assembling process of aisle beam to main pillar is attributed by the same verb “twaak” as in the treatise Nr.1.But it elaborates more detailed how it should be carried out. In a way, this description is rather obscure. The sentence “…adjusting the hole on the head of aisle beam corresponding to the external nose, then insert it into the [main] pillar, then enter in the hidden wood” comprises the following nouns: “[tenon] head,” “external nose,” and “hidden wood.” These terms are far from being common. We have no idea what they mean. My study pursues to interpret this sentence by comparing to some relevant executions in situ. I realized that the most probable explanation has to be seen in the jointing aisle beam’s tenon into the main nave pillar. Following this conviction “head” means tenon, “external nose” means nail hole appearing on the outside of the pillar (intended to take the keying nail). Finally “hidden wood” is the nail itself. The whole intention therefore explains the fixation of the aisle beam in the main pillar resistant against pulling stress. This is realized by using a nail holding tightly the tenon of the aisle beam’s inner end in the main nave pillar (see Fig. 2.8). .

In the final paragraph, the treatise describes the setup of the standing pillar above the second aisle beam following the same logic as with the lower aisle beam. The second aisle beam shall be divided into three parts. The erection place of the standing pillar above the second aisle beam is fixed one third inside the beam end. There needs to be calculated additional length for the footing. The height of the flanking pillar is equal to the aisle beam. Nevertheless, the treatise suggests to add the extra dimension of its tenon head and footing. The position and portion of the eaves arm has been treated only roughly. The eaves arm on the flanking pillar shall be placed two-thirds from its footing. And the proportion of the lower eave element on aisle part is of double size to the one on the flanking pillar. The final advice of this treatise concerns the adjoining position of the purlin from the frontal transverse frame to the principal roof, “The (main) purlin of the front roof shall be and put via tenon into the central axis of the main pillar.” This sentence refers to the structural challenge of a transverse frame’s reduction in height and in crosswise directions.

Building Treatise Nr. 3

The treatise Nr.3 elaborates how to erect a viharn focusing on the structural element called *wai* beam. The treatise contains several uncommon terms that demand interpretation e.g. *wai* beam, *pong*, *aye* pillar-beam. Hence, my study has to demonstrate all possible ways of reading the treatise and then compare it with the actual building in situ. Two possibilities are suggested here: in variation A, the word "*pong*" implies to a small spacing between a pair of standing pillars, while in variation B "*pong*" refers to the span between a pair of standing pillars that define the crosswise dimension of the nave roof. Two different interpretations of this "*pong"* illustrate two possible settings of the *wai* beam. In variation A, *wai* beam functions as a part of the aisle's roof structure, and in variation B, the *wai* beam is a wide span element.

Variation A:

> "Will describe how to cut a viharn with *wai* beam ("*khue wai*"). Shall cut *wai* beam first and then use as a main reference. Divide it into four parts [1], one part for pillar capital [2] ("*sa tuang*"), two parts for central span. A pair of pillars with a gap ("*pong*) positioned at defined point [of pillar capital]: let the [main] standing pillar ("*sao tang*") stand there [3.a], first standing pillar ("sao *aye*") goes straight up on the external axis of pillar capital, until the [level of] footing of standing pillar above [4], the [length of the] large crosswise beam above is projected upwards from the footing hole of the first standing pillar, and that is it, the [length of the] first beam ("*khue aye*,") [5]. [to be continued] …"

Variation B:

> "Will describe how to cut a viharn with *wai* beam ("*khue wai*"). Shall cut *wai* beam first and then use as a main reference. Divide it into four parts [1], one part[s] for pillar capital ("*sa tuang*"), two parts for central span [2]. Take the two parts in the middle ("*pong*), define the two positions for the footing[s] of the standing pillar (*"sao tang*") [3]. The height of first standing pillar ("*sao aye*,") reaches the [level of] footing of standing pillar above [4], The [length of] large crosswise beam above is projected upwards from the footing of first standing pillars, and that is it, the first beam ("*khue aye*") [5] [to be continued in the next paragraph]…"

Continuation of A and B

> "…Divide first crosswise beam into four parts, take three parts as a second crosswise beam [6]. Divide second crosswise beam into three parts, take two parts as a third crosswise beam [7]. As a point for consideration, the height of ridge supporting pillar is equal to the third beam crosswise [8]. The

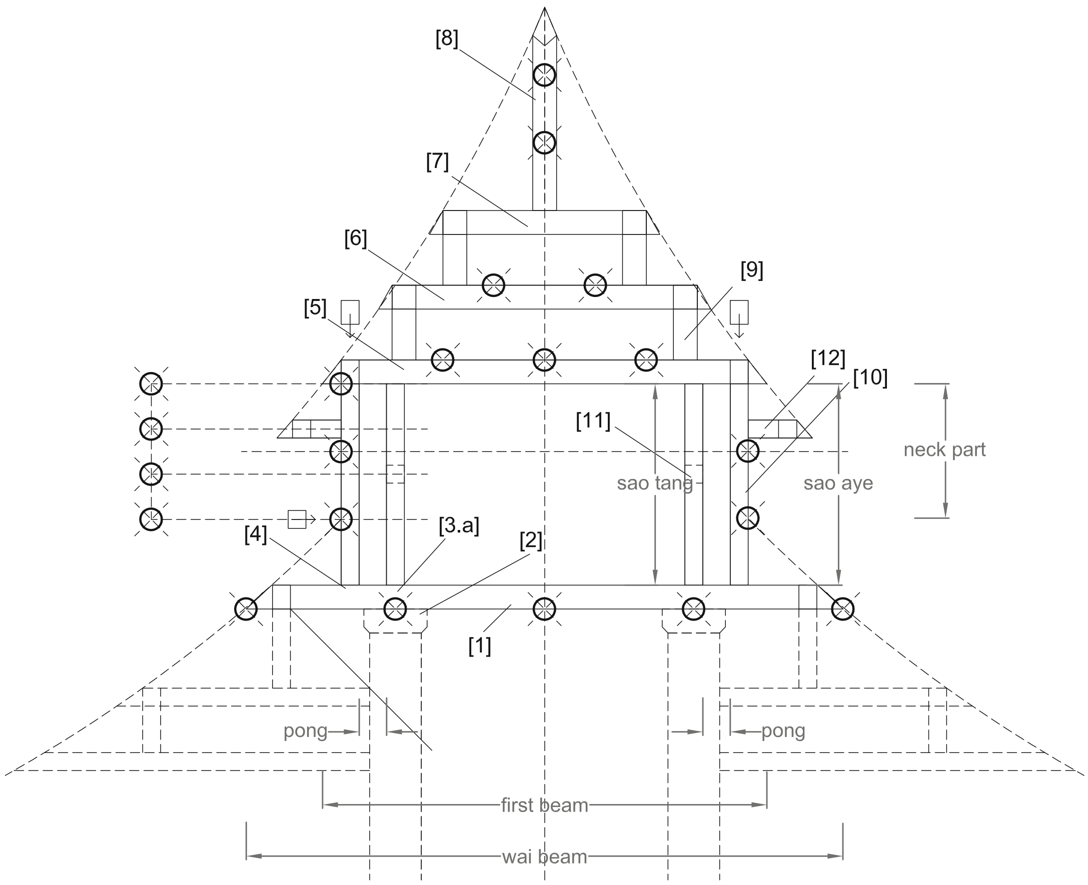


Fig. 2.9The interpretation of assembling process according to the building treatise Nr.3: varitation A

The standing pillar and small standing pilar jointed inside the first crosswise beam, thus the tenon of standing pillar shall not obstruct to the footing of small standing pillar on first beam.

Fig. 2.10 The result of interpretation drawing (variation A) could be compared with roof structure of the viharn of Lai Hin Luang monastery, Lampang province

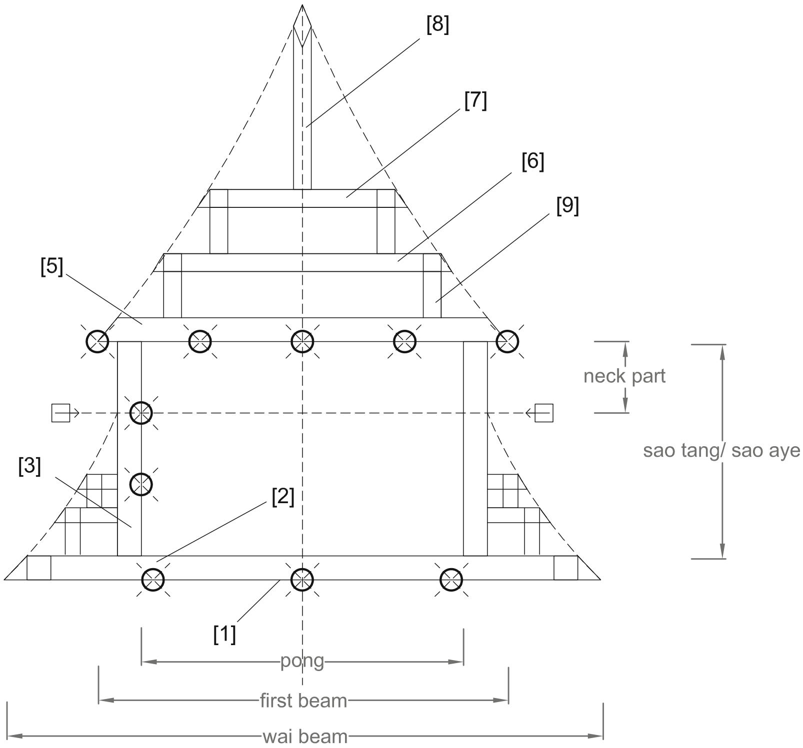


Fig. 2.11 The interpretation of assembling process according to the building treatise Nr.3: variation B

Fig. 2.12 The result of interpretation drawing (variation B) could be compared with roof structure of the viharn of Kor Sound monastery, Pusang district, Phayao province

height of small standing pillars underneath equals the dimension of the beam's edge to the standing pillar [9]. Divide the height of the first standing pillar into three parts and take two parts as a neck part ("*korgeeb*") [10], one part for trampling half purlin-half beam ("*yam khue kham pae*"). For second aisle beam, measure from the edge of large beam *("khue luang"*) and define the position for standing pillar. For third aisle beam, measure from the head of second aisle beam, and define the position for standing pillar. The height [of this standing pillar] is equal [to the measurement from the head of second aisle beam].

The main purlin of the roof on the rear side adjoins to the principal roof. Shall divide the neck part of the principal roof into three parts, keep the upper two parts, mortise [the main purlin of the roof on the rear side] [11], project the rest [of purlins] accordingly. [In order to set up] eaves arm *("yang")*, take the upper one and leave the lower two from the previous division [of the neck part] and insert [the eaves arm] [12]. Also similar for the eaves arm at the aisle [roof]. The roof on the rear side is inclined ("*kanleang*"). Please considerate carefully; [all are] fully completed."

Interpretation: Building Treatise Nr. 3

Variation A

The treatise suggests an erection of viharn by beginning with the preparation of *wai* beam. This beam shall be divided into four parts. One part measured from the *wai* beam's outer end defines the place where the pillar's capital supports the *wai* beam. The central two parts define the nave roof. Then the treatise suggests to place a pair of standing pillars above the axis defined by the pillar's capital detailing to leave open space in between the pillar pair. The treatise does not explain where these two pillars should be positioned. My drawing reflects observation of examples that gives an idea how the carpenters used to do it. The treatise denotes the pillar standing outside "he "first standing pillar" or "*sao aye*," the word "*aye*" means first/ main/ older brother, while the inner one is simply called standing pillar "*sao tang*."

The statement concerning the assembling of first standing pillar is ambiguous, not to say impossible. The treatise states that: "…first standing pillar goes straight up on the external axis of pillar capital, until the [level of] footing of standing pillar above [4]," My analytical drawing proves that this instruction does not make sense if followed word by word. The intended roof shape would not be possible if the carpenter would align the two structural components: first standing pillar and small standing pillar. The nave roof could not be formed. Thus according to my knowledge, a comparable structural arrangement presenting a pair of standing pillars with spacing in between can be found at the viharn of Lai Hin monastery in Lampang province. The external standing pillar (or the first standing pillar as the treatise denotes) is situated along a different alignment to the small standing pillar. Nevertheless, the author of treatise might probably intend referring to the standing pillar ("*sao tang*") instead. As we have seen from the viharn of Lai Hin monastery, the standing pillar and small standing pillars are joined inside the main crosswise beam (see Fig. 2.10.). As the tenon on top of the standing pillar would get in the way of the footing of the second standing pillar, carpenter suggest to reduce the tenon to a length not obstructing the footing of the structural element standing above.

My study points at an additional observation. The narration of this treatise follows a structure appearing strange to us. The treatise tends to describe the assembling of a structural components prior to denoting its name, e.g. "…the [length of the] large crosswise beam above is projected upwards from the footing hole of the first standing pillar, and that is it, the [length of the] first beam ("*khue aye*,")…." I suppose that the author of this treatise is well aware that this structural arrangement is not so common when he composed the text. Thus he might have thought that he should explain how the components are composed before coining its terminology. He began the treatise with the statement "Will describe how to cut a viharn with '*wai*' beam…" This statement could imply that several viharns had been erected without *wai* beam and this treatise is an introduction to the *wai* beam system.

The treatise continues with the description of ratios for nave roof components. The main reference is the first crosswise beam which shall be divided into four parts. Then, we shall take three parts as the second crosswise beam. From the second to the third crosswise beam, we shall take two out of three divisions. The height of the ridge supporting pillar is equal to the third crosswise beam with additional dimension for the tenon. We can observe that the transmitting of proportion in this case is different from the previous two cases. For the treatise Nr.1 and Nr.2, we can take the described proportion and project upwards immediately, while for this current treatise, we have to take the proportion and adjust it into the central vertical axis e.g. take three out of four units and take two out of three units. In order to define the fixation point of standing pillar, we must project the dimension down to the component below, and then we shall measure the projected intersection point up to the edge of the corresponding component, that is the measurement for the height of the standing pillar.

It would be possible to simplify the given instruction. I give an example. The treatise asks to divide the main crosswise beam into 4 parts cut of one part and use the three left part as length measurement for the second crosswise beam. This second crosswise beam has to be positioned symmetrically and therefore needs to be shifted into alignment of the main vertical axis. My consideration is a division of the main crosswise beam into eight parts and cut off the left and right most outward part. Then it only needs to projects this length upwards.

The first standing pillar in this treatise has functioned similarly to the flanking pillar of the previous two treatises as the neck part is forming there. Whereas this treatise starts to vary the terminology by addressing the previous "first standing pillar" with the term "main standing pillar." In addition, the treatise does not indicate the measurement of this component. It only suggests that we shall divide it into three parts and take the upper two parts as the neck, and then tramp the purlin to the one on the lower part. The expression "*yam khue kam pae*" can literally translated as "tramp down half beam half purlin" describes the mounting of the purlin recesses half height to fit with the crosswise beam recessed half height respectively.

Variation B:

Variation B derives from a different interpretation of the term "*pong*" together with the reading of the structural arrangement in the treatise that revealed the specific characteristic. While the variation A suggests a spacing in between a pair of standing pillar above the capital of the nave pillar, the variation B considers the much wider pair of standing pillars that define the nave span.

The last three sentences of second paragraph "…for second aisle beam, measure from the edge of large beam and define the position for the standing pillar…" presents the specific structural trait of *wai* system. The second aisle beam is measured in relation to the principal *wai* beam as the aisle beam does not exist. The *wai* beam is laid down along the full crosswise axis, thus functioning as the wide span element. The ratio of standing pillar supporting second aisle beam is defined toward the same principle as of nave part. The treatise suggests to set back from the edge of the large beam (*wai* beam), and measure that distance, then apply as the height of the standing pillar. The process is repeated for defining the third aisle beam as well. Although this conceptual explanation of the aisle structure sounds reasonable, the drawing resulting from this description raises an issue on the proportion of the aisle roof structure as it seems to be too small. Therefore, the variation B cannot completely outweigh the interpretation of variation A.

Final Paragraph: Longitudinal integration

The final paragraph of the treatise is dealing with the adjoining of the purlin from different transverse frames to the principal transverse frame. A division of the first standing pillar into three parts allowed to create the neck of the upper two parts. The treatise suggests dividing the neck part into three subdivisions demanding to assemble the main purlin of the rear side frame at the height two units below the upper end of the neck. All the other purlins shall be adjusted accordingly. This instruction implies to the roof connection that is only reduced in height and being consistent in crosswise measurement. Thus the purlins from the lower roof are in alignment with the pillars of all frames. Therefore the adjoining needs no complicated further technical solution.

Building Treatise Nr. 4

"Description for making ("*pang*") a viharn, first make a main crosswise beam *("khue luang")*. Bring in a rope to divide main crosswise beam from its [outer] edge of purlin recess ("*rim ong*"). Divide it into four parts [1] and take two and a half parts to become the ridge supporting pillar *("dang")* [2]. Take the rope to divide the main crosswise beam into six parts, take away two parts and take [the left] four parts to become the first crosswise beam (*"khue aye"*) [3]. Divide first crosswise beam into four parts, take away one part, and take three parts to become the second crosswise beam(*"khue yi"*) [4]. Divide second crosswise beam into two, and that is the central axis of ridge supporting pillar [5]. Divide the ridge supporting pillar into three parts and take away one part and that is the aisle beam ("*mah tang mai")* [6]. Divide the aisle beam into six parts, take away two parts, and that is the flanking pillar *("sao sagoen")* [7]. Divide the flanking pillar into three parts, take one part as a neck part ("*korgeeb*") [8]."

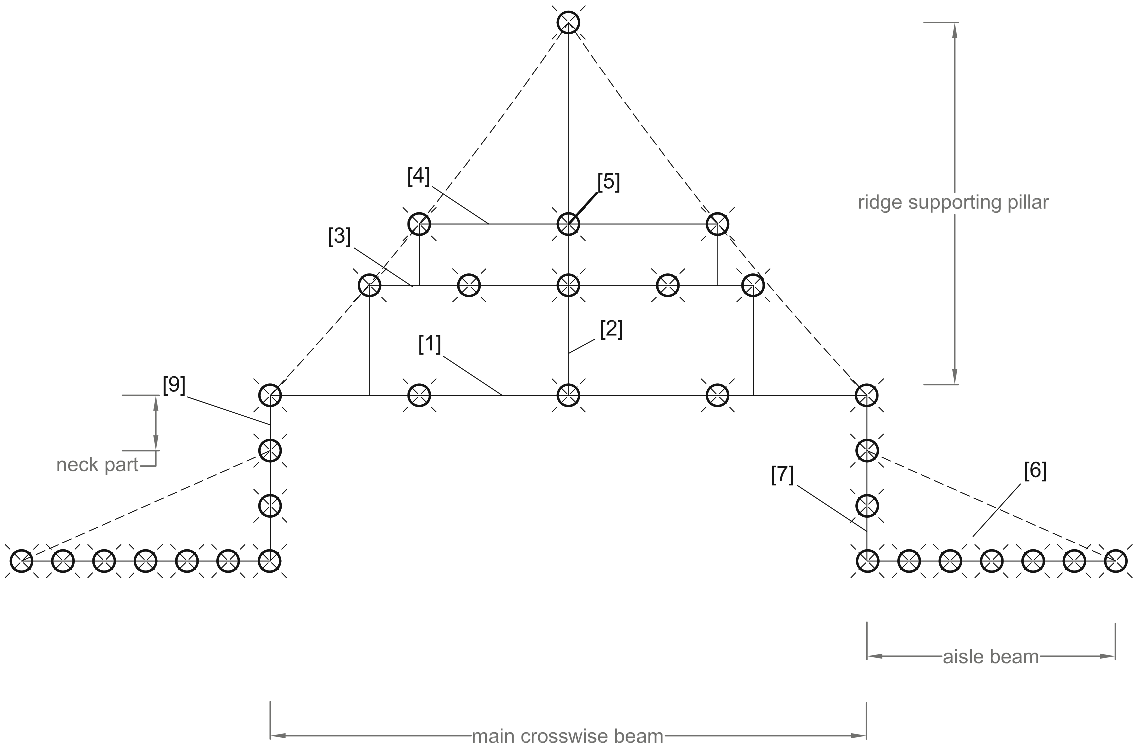


Fig. 2.13 The interpretation of assembling process according to the building treatise Nr.4

Interpretation: Building Treatise Nr. 4

At for the beginning, the treatise suggests to prepare the crosswise beam. We shall use a rope to divide the crosswise beam into six parts, measuring from its purlin seat "*rim ong*" and then we shall take four parts and a half for the ridge supporting pillar. The given ratio is relatively high in comparison to the previous treatises Nr.1-Nr.3. The treatise does not indicate where we should place this ridge supporting pillar, but if we follow the ongoing description, we will realize that the ridge supporting pillar should be placed on the main crosswise beam, otherwise, the geometry of the roof will immediately make no sense.

The treatise asks to divide the crosswise beam again, but this time, we shall divide it into six parts, and we take another four parts to be "*khue aye*," or first crosswise beam *"aye*. This sentence might cause terminological confusion, since generally, we address the immediate upper level of crosswise beam as the "second crosswise beam" not the "first." The passage in treatise continues with the division of this "first" beam into four parts, and then takes away a part to become the second crosswise beam, which is the uppermost level of beams. The aisle beam shall be made by referring to the ratio of the ridge supporting pillar. It should be divided into three parts, and we should take two parts to become the aisle beam. The aisle beam is transmitting the ratio to the flanking pillar. As the treatise suggests we should take four-sixths out of it. The flanking pillar is divided into three parts, the uppermost part is the neck "*korgeeb*."

This treatise differs in terminology as well as in its structure describing the making of a viharn and not giving advice concerning the preparing of structural elements. However the result does not look really different. An outstanding characteristic can be seen in the position of the ridge purlin that is carried by ridge supporting pillar put directly on the main crosswise beam. The treatise does not mention how it is fixed and more important how it penetrates the upper two crosswise beams. Such an arrangement is unknown to historic timber structures standing in Lan Na. The only comparable construction method we would find is offered by the building culture of a Mon-Khmer people in the Northeastern part of Shan state in Myanmar. The samples present both: standing pillar that penetrate through different levels of crosswise beams and standing pillars that are notched to the beams. See chapter 5 for further discussion.

Building Treatise Nr. 5

“Description of the viharn, shall take the [measurement of] main crosswise beam from both sides of purlin seat (“*rim ong*”), divide it into six parts [1], take five and a half as the ridge supporting pillar *(“dang”)* [2], place it on the crosswise beam, cut the tenon and footing [3]. Repeatedly divide the main crosswise beam into five parts, take away *(“kwang”)* two parts, take three parts as an aisle beam [4]. Divide the aisle beam into six parts, take away one part, take five parts as a flanking pillar (“*sao sagoen*”) [5]. Placing the flanking pillar over aisle beam until [uppermost aisle] purlin seat (“*pae lin harn*,”) [6]. Divide the flanking pillar into three parts, take away two parts, and take one part as the neck part (“*korgeeb*”) [7]. Divide the neck part into five parts, take away three parts, and take two parts above the [uppermost aisle] purlin seat for defining the central axis of eaves arm (“*yang*”) and that is it! The treatise of the viharn of Lan Ka Rim Ping monastery”

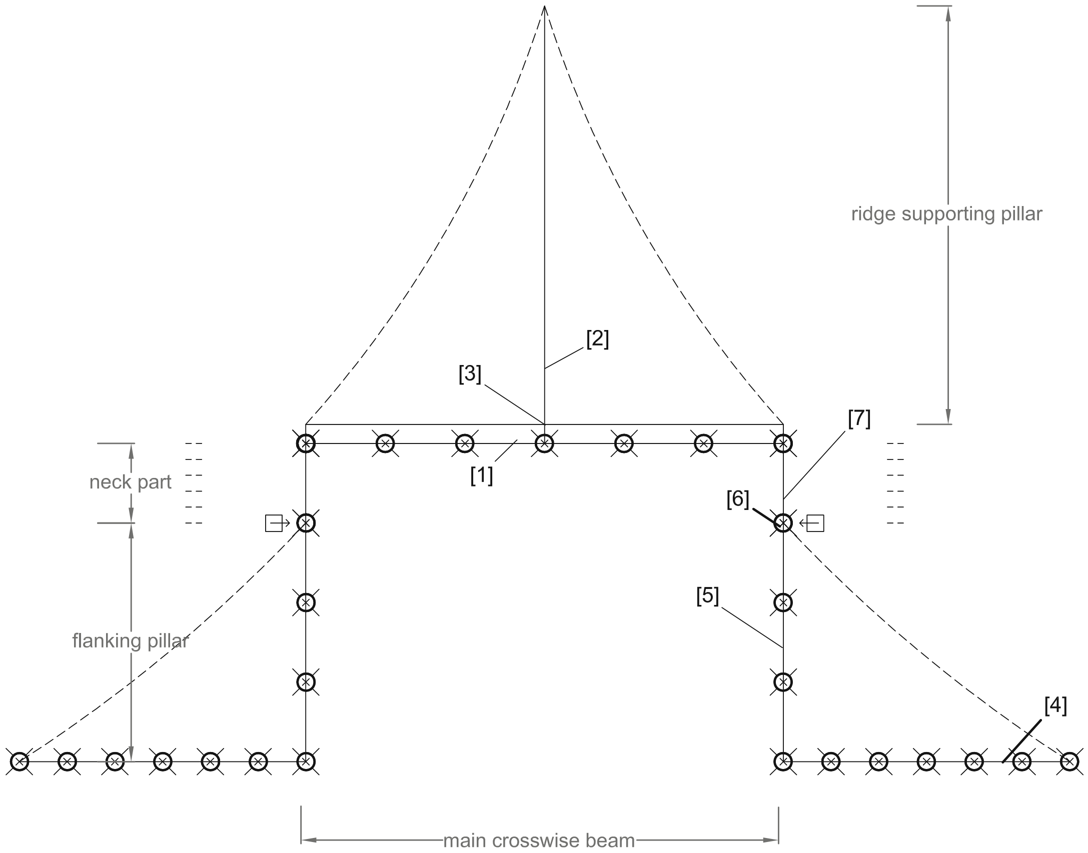


Fig. 2.14 The interpretation of assembling process according to building treatise Nr.5

Fig. 2.15 A sample from a comparable structural setting of building treatise Nr.5 from the viharn of Klong Kak monastery, Mae Cham district, Chiang Mai province

Interpretation: Building Treatise Nr. 5

The treatise begins the description with the division of crosswise beam. We should measure the crosswise beam from both sides of its purlin seats, and then divide it into six parts, and take five parts and a half as the ridge supporting pillar. The current treatise Nr.5 has stated explicitly that the ridge supporting pillar is assembled on the crosswise beam adjoining by its footing. But it this case, as it differs from Nr.4, the structural arrangement does not consist of any upper level of crosswise beam. This arrangement characterizes the inclined member system ("*tang yo*"), i.e. two inclined components are placed against each other together with the horizontal beam forming the closed triangle frame (Fig. 2.15). In many case, the ridge standing pillar is assembled in between. Nevertheless, the treatise omits to indicate this component, since mostly the treatises tend to emphasize on the ratio of component and the assembling of elements.

The description continues demanding a division of the crosswise beam into five parts. We shall take three parts as linear dimension for the aisle beam. The linear dimension of aisle beam is to be divided into five parts. Three parts define the flanking pillar. The treatise mentions a terminology of an important preparation on flanking pillar, "*pae lin harn*" The term implies to a vertical purlin seat with the additional small tenon used for seating the uppermost aisle purlin and secured it against pulling stress (Fig. 6.9 and Fig. 6.10). In some cases, the carpenter prepared this seat a little bit larger that the dimension of purlin in order to facilitate the assembling process. He had to place it from the upper side and let the tongue sit into the prepared groove. As the word tongue is called "*lin*" in Thai, thus this purlin seat is connoted by the term.

We must mention a contradiction in this treatise. The height of the flanking pillar cannot fit in the way as described. The treatise narrates that the flanking pillar is reached only until uppermost aisle purlin seat, but the neck is a part of flanking pillar, and the level of eave arm is two-fifths above uppermost aisle purlin seat in the area of neck. My study supposes that, in fact it shall mention that the flanking pillar is raised up until purlin seat on crosswise beam. The building treatise completed by stating that this is a text from the Lanka Rim Ping monastery, in Chiang Mai. The mentioned viharn had been completely re erected, thus it is not possible for any cross checking.

Building Treatise Nr. 6

"The character of viharn at Pa Larn monastery is as follows: The main pillar is raised from the ground, [the measurement from the ground] until the bottom edge of the aisle beam ("*khue mah*") is eight cubits ("*sok*") and two breadths of finger ("*niu*") [measurement 1]. The measurement from upper edge of aisle beam until the bottom edge of main crosswise beam is five cubits and one finger span ("*khuep*") [measurement 2]. The main crosswise beam is measured from the outer edge of the purlin seat on both ends as eight cubits and eight fingers [on the] long [side] ("*nui pard*") [measurement 3].. The aisle beam ("*khue mah*") measures from the main pillar to the outer edge of its purlin seat full five cubits [measurement 4].. The flanking pillar is placed above aisle beam; [measures from its bottom edge] to the central axis of the purlin ("*pae lin harn*,") is four cubits by a little less ("*yom*") of a breadth of fingers [measurement 5].. The measurement from the central point [on the upper edge of] of purlin to the [upper edge of] neck part ("kor-geeb") as a cubit and a finger span [measurement 6]. [The distance between of the bay of] aisle pillar ("*sao rabieng*") is nine cubits in length and nave pillar is eight cubits and a finger span. The head of purlin ("*hua pae*") is two cubits and a long finger."

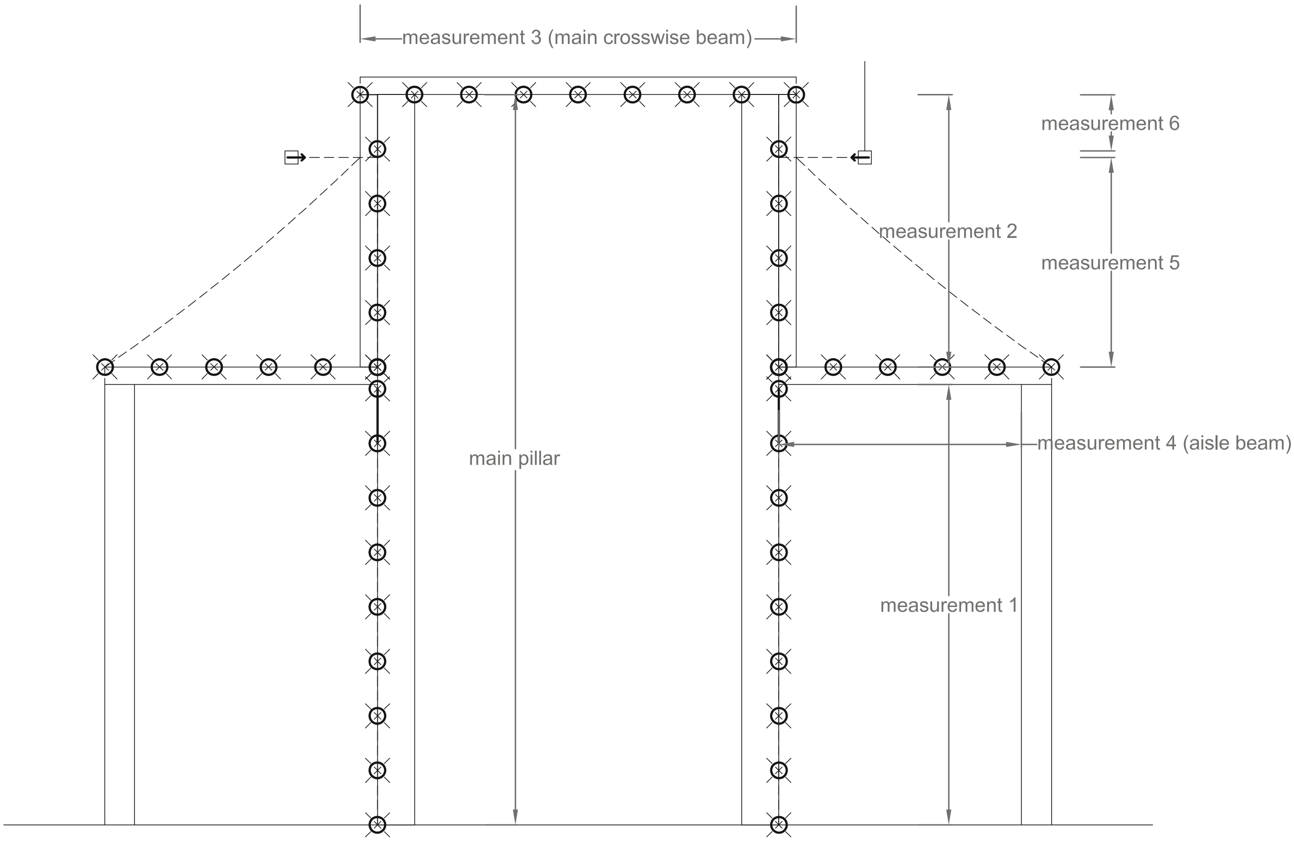


Fig. 2.16 The interpreation according to building description of the building treatise Nr.6

Fig. 2.17 The cantilevering purlin's edge or "*hua pae*" as mentioned in building treatise Nr.6;
a sample from the viharn of Ton Kwen monastery,
Hang Dong district, Chiang Mai province

Interpretation: Building Treatise Nr. 6

Instead of describing the erection process, the treatise Nr.6 elaborates the measurement of the viharn. The treatise begins describing the vertical measurement along the main pillar from the ground to the bottom edge of aisle beam ("*khue mah*"). This shall be eight cubits and two breadths of fingers ("*niu*"). A philologist interpreted measurement units in Lan Na and suggests 43-45 cm, as a distance measuring from the elbow to the tip of the little finger and a breadth of finger as 1.5 cm (Penth 1994, pp. 318-320). Thus the bottom edge of aisle beam should be assembled approximately 2.18 m from the ground.

The description continues with the measurement from the upper edge of the aisle beam until the bottom edge of the main crosswise beam, which are 5 cubits and one finger span. In the mentioned interpretation of measurement unit, the finger span is about 20 cm. Thus the dimension as described on the treatise equals 2.35 m. In fact, this given measurement shall also be equal to the measurement of the flanking pillar which the treatise describes later on and therefore offers us a possibility to verify the described figures. Along the flanking pillar, the measurement from the bottom edge of the flanking pillar to the central axis of the purlin is four cubits minus one finger breadth. From the upper edge of this purlin up to the upper edge of the neck part is one cubit and one finger span, which should be 63 cm. Therefore, the equation taken from this description is drawn as: five cubits plus one finger span = four cubits that minus *a* finger long + half height of the purlin (the treatise omitted to mentions it!) + one cubit plus one finger span. It is possible to conclude from the final interpretation of this text, that the half height of purlin equal a finger length. Therefore the height of this purlin is two fingers long. The philologist Aroonrut Wichienkeeo interpreted the unit of one finger length from different treatises of Buddha image casting and suggested that it shall be approximantly two inches Imperial Unit or approximately 5.08 cm, (Wichienkeeo et al. 1996, p. 367). In case, we apply her suggestion into our interpretation, the height of the purlin in question shall be approximately 10.2 cm. This seems to be slightly smaller compared to field survey. Information collected in surveys show the dimension of a purlin in this position varying from 11-15 cm.

Another measurement that involves the unit of finger length is the main crosswise beam. The treatise describes it as 8 cubits and 8 fingers long, which supposes to be 3.85 m. The aisle beam measured from main pillar until its edge of purlin seat is full 5 cubits or 2.15 m.

Measured along the longitudinal axis the distance from one outer pillar to the next one, the space in between two transverse frames measure full 9 cubits or 3.87 m. In contrary the distance between two adjacent nave pillar counts just eight cubits and one finger span equally 3.64 m. Thus, we can calculate that the nave pillar is around 11.5 cm. thicker than the aisle pillar ((3.87-3.64)/2). An important term that this treatise provides is "*hua pae*" or translated literally as head of purlin in longitudinal direction. The treatise refers to the cantilevering purlin's end beyond the outermost transverse frame (see Fig. 2.17). The provided measurement is two cubits and a long finger, which is 91 cm.

Why does the treatise omit to describe the width and thickness of each structural component? My investigation considers a relation to the production process and representation of the viharn. During old Lan Na period, the wooden components in a viharn were prepared by hand tools. Similar or even equal structural components were only equal to a certain amount. Components at different viharns had to be adjusted during their installing process –another reason producing unequal diameters, distances, and lengths. Such “tolerance” could sum up. Thus, the essence in the description is to represent the structural arrangement in terms of external-clearance-dimensions narrating them as a recipe, for the current treatise the recipe of the viharn of Pa Larn monastery.

Building Treatise Nr. 7

"…Successful Action! ["*Sittikariia*"] If one wishes to cut the timber for viharn, shall prepare the offerings [list of offers]. Then [the execution] will be succeeded. Shall first cut the main crosswise beam [1], divide the main crosswise beam ("*khue luang*") into ten parts (*"tum*"), take away one part, and that is [the length of] ridge supporting pillar *("dang")* [2]. Divide the main crosswise beam by half, and that is [the length of] small crosswise beam ("*khue noi*") [3]. Divide the main crosswise beam [again] into thirteen parts, take away three parts, and that is [the length of] lower aisle beam ("*khue mah lum*") [4]. Divide the aisle beam into ten parts, take away four parts, and that is [the length of] the upper aisle beam [5]. The length of upper aisle beam is equal to the flanking pillar ("*sao sagoen*"). Divide the upper aisle beam into four parts; take one as the upper eaves arm ("*hwang yang*"). Divide the small crosswise beam by a half and that is the [height of] infill panel at the [frontal] eave cantilever ("*phang lair")*, the mount ("*pak lair*") [8] [of the infill panel] is equal to the main purlin ("*pae sod*"). Divide the smaller crosswise beam into three parts, take away two parts, and that is the [lower] eaves arm ("*yang*"). Divide the eaves arm into ten parts, take away two parts, and that is the [diagonal measurement] of bracket ("*naga tan*")."

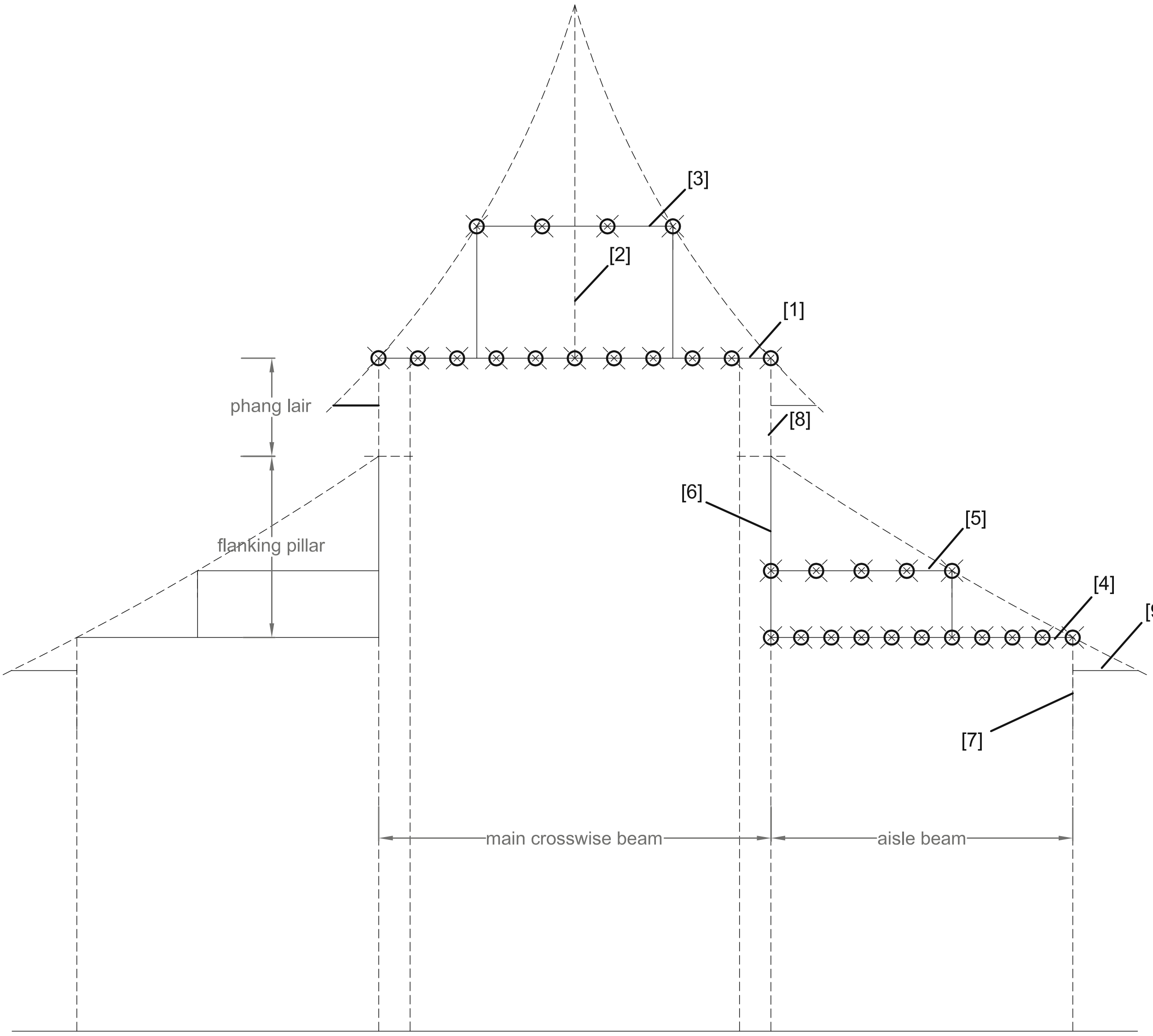


Fig. 2.18 The interpretation of assembling process according to the building treatise Nr.7

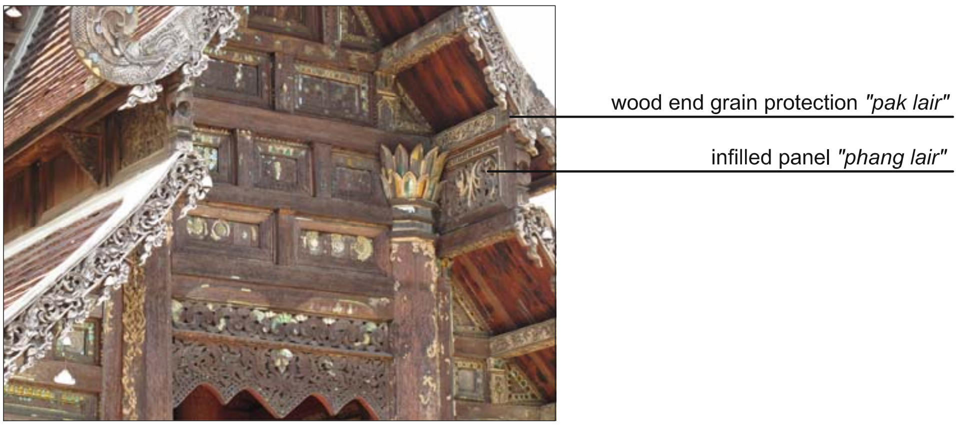


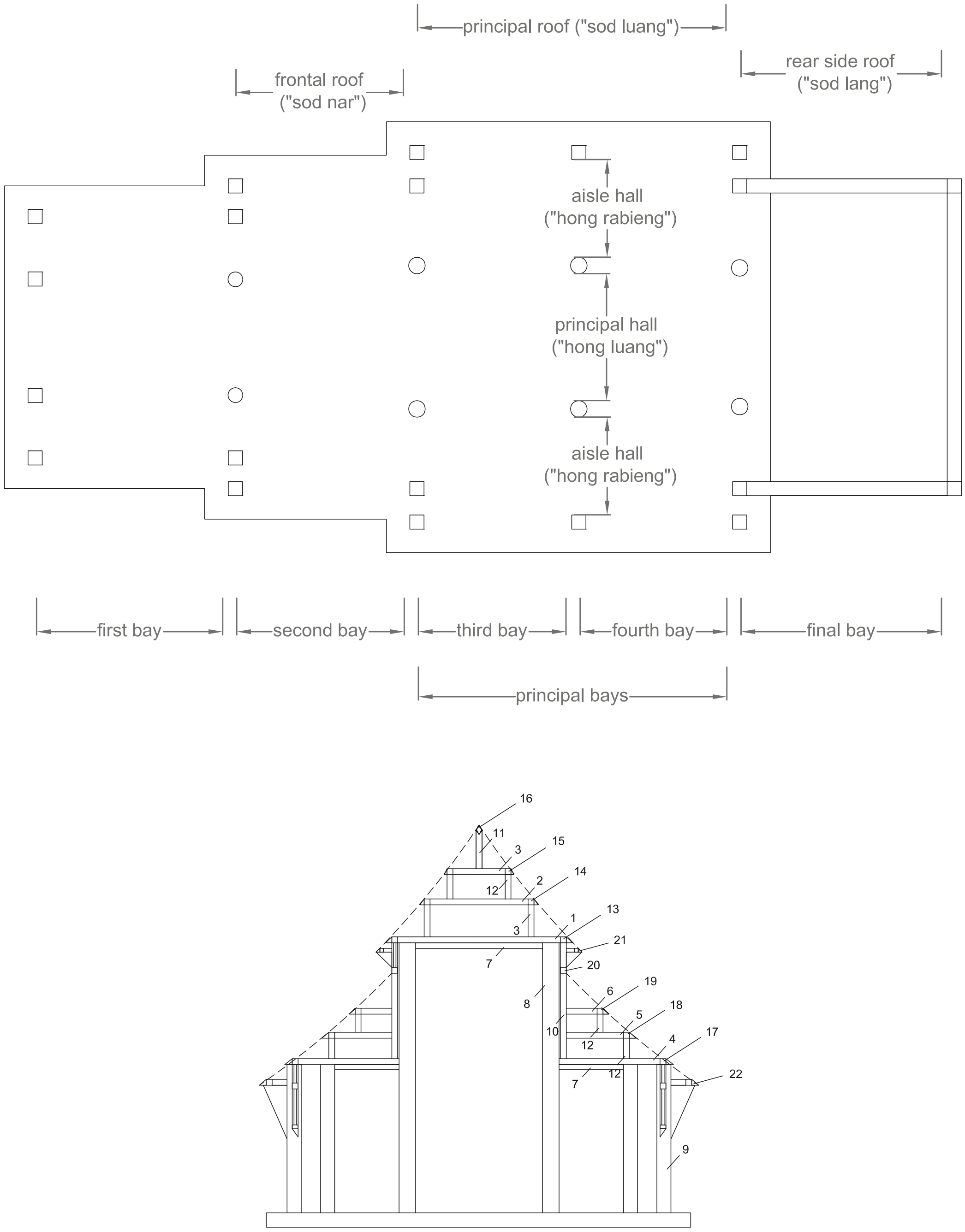
Fig. 2.19 Decorative elements as mentioned in treatise Nr.7; sample from the viharn of Ton Kwen monastery, Hang Dong district, Chiang Mai province

Interpretation: Building Treatise Nr. 7

Treatise Nr.7 presents entirely different narrative structure and terminology. The description begins with a Sanskrit term blessing for the successful execution. The author indicates the list of offering that the carpenter shall prepare prior to the beginning of erecting process. The treatise suggests to start with the crosswise beam ("*khue luang*"), we shall divide it into 10 parts and take 9 parts for the ridge supporting pillar ("*dang*"). It is not so clear if the treatise means the height of the ridge supporting pillar or the level. The smaller crosswise beam ("*khue noi*") or the second crosswise beam ("*khue yi*") as generally denoted in other treatises is a half of the main crosswise beam. We shall divide the main crosswise beam again into thirteen parts and take ten parts for the length of lower aisle beam ("*khue mah lum*") and the measurement of upper aisle beam is six-tenths of lower aisle beam ("*khue mah bon*").

The critical sentences occur in the description of the flanking pillar and neck part: "…the length of upper aisle beam is equal to the flanking pillar ("*sao sagoen*"). Divide the upper aisle beam into four parts; take one as the upper eaves arm ("*hwang yang*"). Divide the small crosswise beam by a half and that is the [height of] infill panel at the [frontal] eave cantilever ("*phang lair").*" The treatise uses the term *phang lair* instead of *korgeeb* to address the neck part of the building. The term *phang lair* in fact implies to the decorative element in filled in between main nave purlin and uppermost aisle purlin at the gable side of viharn (see Fig. 2.19). Moreover, the treatise sees the flanking pillar and neck part as separated elements in contrary to the reality that the neck part is a part belonging to the flanking pillar. The author tended to emphasize only eye catching elements describing *phang lair* and *pak lair* which are the decorative elements of the façade. My study interprets the lack of proficiency in the description and suspect that the author might not be a carpenter.

2.3 Definition of Buildings and its Components



1. main crosswise beam
2. second crosswise beam
3. third crosswise beam
4. main aisle beam
5. second aisle beam
6. third aisle beam
7. added beam
8. main pillar
9. aisle pillar
10. flanking pillar
11. ridge standing pillar
12. standing pillar
13. main nave purlin
14. second nave purlin
15. third nave purlin
16. ridge purlin
17. main aisle purlin
18. second aisle purlin
19. third aisle purlin
20. uppermost aisle purlin
21. upper eaves arm
22. lower eaves arm

Fig. 2.20 Definition of buildings and its components according to the building treatises

Terminology in English/ Old Lan Na	Nr.1	Nr.2	Nr.3	Nr.4	Nr.5	Nr.6	Nr.7
Main crosswise beam	*khue luang*	*khue luang*	*khue luang*	*khue luang*	*khue luang*	*khue luang*	*khue luang*
Wide span beam			*wai beam*				
Second crosswise beam	*khue yi*	*khue yi*	*khue yi*	*khue aye*			*khue Noi*
Third crosswise beam	*khue sam*		*khue sam*	*Khue yi*			
Aisle beam	*khue mah*	*khue mah*		*khue mah*	*khue mah*	*khue mah*	*khue mah*
Second aisle beam	*khue mah yi*		*khue mah yi*				*khue mah bon*
Third aisle Beam	*khue mah sam*		*khue mah sam*				
Standing pillar	*tang mai*	*tang*	*tang mai*				
Ridge supporting pillar			*dang*	*dang*			
Flanked pillar	*sao sagoen*	*sagoen*	*sao aye*	*sagoen*	*sagoen*	*sagoen*	*sagoen*
Neck part	*korgeeb*		*korkeeb*	*korgeeb*	*korgeeb*	*korgeeb*	*pang lair*
Purlin	*pae*						
First purlin	*pae aye*	*pae aong*	*pae aye*			*pae*	
Second purlin	*pae yi*						
Third purlin	*pae sam*						
Ridge purlin		*jong*					
Uppermost aisle purlin	*pae*		*pae*		*pae lin harn*	*pae lin harn*	
Nave eaves arm	*yang*	*yang sagoen*	*yang*				
Aisle eaves arm		*yang rabieng*			*yang korgeeb*		*yang*
Supporting of main beam	*tum khue luang*						
Tenon head (upper)	*khe/ khe Take*	*deal*			*deal*		
Footing (lower)	*teen*	*teen*	*teen*		*teen*		
Wooden nail		*lai lom mai*					
To insert	*twaak*	*twaak*	*take*				
Halved/ Lap	*yam*		*yam khue kam pae*				
Purlin seat				*rim-ong*	*rim ong*	*rim ong*	
Roof plane	*sod*	*sod*	*sod*				
A Part		*pud*		*pud*			*pud*
Bay						*hong*	
Aisles			*rabeang*			*rabeang*	
Principal Hall		*sao luang*				*sao luang*	

Fig. 2.21 Romanized Lan Na's terminology according to the Building Treatise Nr.1-Nr.7

Chapter 3

Tang Mai: Standing Pillar System

3.1 Analytical Framework

Tang mai would be translated as "standing pillar" or "put a pillar into upright position." In principle, the *tang mai* system is based on three dimensional organizations. A transverse frame in the system is characterized by stacking of crosswise beams that are carried by pairs of standing pillars, representing the load bearing task of the structure. A seat for purlin is prepared at the intersection of beam and *tang mai*. In each level of stacking in upwards direction, the length of the crosswise beam decreases, thus purlin seats are moved inwards to the central axis of the transverse frame. The purlins in *tang mai* system play roles in twofold way. Firstly, they define the supporting points for the roof shaping member forming of curved roof plane. Secondly, they combine different transverse frames and provide the structural basis for longitudinal stability. In most case, the standing pillar system is applicable in religious buildings attributing to the central nave roof and aisles roofs on both sides. The dimensions of each transverse frame can be varied in a building in favor of emphasizing hierarchical space pertaining to the concept of ritual and ceremony.

The core of my analysis revolves around the conceiving of technical solutions as well as structural inventions that actually had taken place in response to structural needs and specific requirement. Upon an implementation of standing pillar system, the carpenters in old Lan Na had to deal with the structural considerations. According to the working procedure described in treatises, the aspects of carpenter's considerations can be divided into the considerations along the "transverse" and "longitudinal" axis.

"Transverse" consideration

- How can the structural components in *tang mai* system be arranged in order to realize the desirable proportion and composition? The intersected arrangement of *tang mai* and crosswise beam defines the seat for the purlin that constitutes the formation of the curved roof and the connection in longitudinal direction. If a purlin is positioned improperly, the curve would fail as well as raise the problems in structural integration (see position A in Fig. 3.1).
- How is the *tang mai* assembled with the crosswise beam in combination with the prepared seat for purlin? (see position B in Fig. 3.1)
- A transverse frame consists of the central nave structure and the attached aisle structure on both sides. They had to be locked firmly. A significant thought in the construction is that an aisle structure is pulled outside separating from the nave structure. How can such case be prevented? The carpenter had to introduce a joinery method at this position that can resist the pulling stress (see position C in Fig. 3.1).

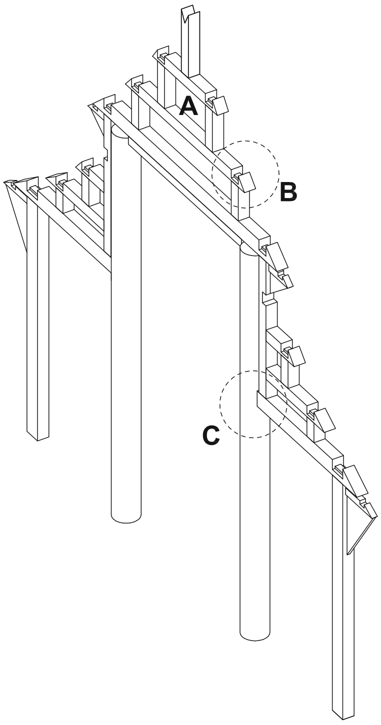


Fig. 3.1 "Transverse" consideration;
position A: arrangement of components in roof structure
position B: junction between crosswise beam, *tang mai*, and purlin
position C: connection betweem aisle beam and main nave pillar

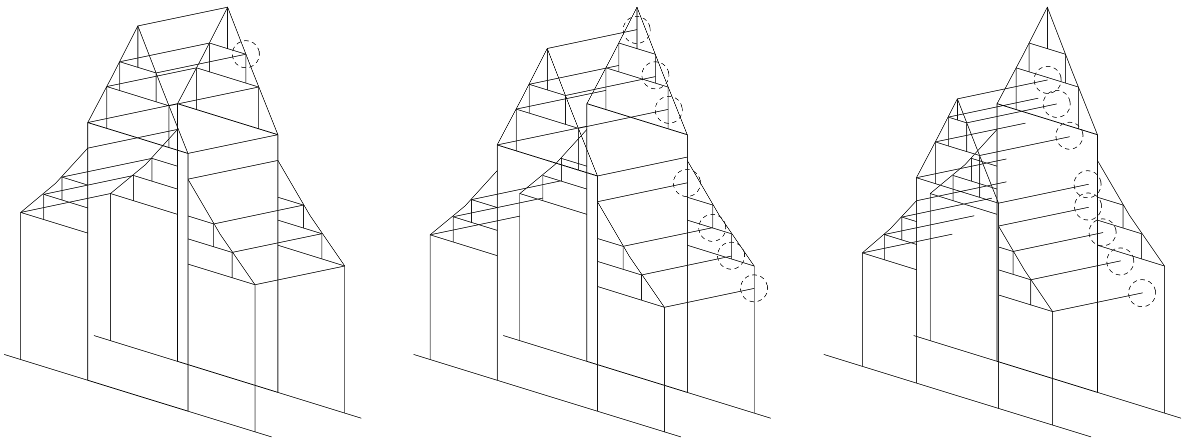


Fig. 3.2 "Longitudinal" consideration: connection of purlins from different transverse frames

“Longitudinal” consideration

- How can the different dimensions of transverse frames be combined? If two transverse frames are identical, the purlin can be assembled on its seat connecting both frames as the two positions of seat are in the same alignment. But if the dimensions of two frames vary in height, the purlins of the smaller frame cannot be assembled similarly to purlins of the larger frame as they meet the larger frames at lower points. As long as the width of the two different frames is the same the purlin of the lower frame meet the corresponding *tang mai* of the higher frame. The carpenters face a much bigger problem if the higher frame is larger in crosswise direction as well. That means nave pillars and aisle pillar are not aligned. In such cases the purlin have no corresponding structural element in the larger frame (see Fig. 3.2).

3.2 Scope of Case Studies

Tang mai system’s unique is evidenced mostly in religious buildings as the viharn and the ubosot for instance. Previous researches categorize the types of viharn according to their appearance and coin the term “school of carpentry” (see Siriwetchaphan 1982, reprinted 2003). However, a clear investigation of the structure system and its building techniques that contributed to such characteristic and appearance has not yet been carried out. The pervasive categorization dominating the sphere of public and researcher’s receptions up to date divided the viharn into the “opened-side viharns” of Lampang, and the “enclosed viharns” of Chiang Mai region. My categorization in this chapter shall follow this given geographical premise, not for the purpose of acceptance but for re-examining in the structural framework according to the analytical criteria explained above. Apart from these two main groups, it is necessary to investigate examples that can offer us the different possibilities of implementation.

<u>Lampang Region</u>: Three viharns of Phra That Lampang Luang monastery include viharn of Phra Putt, viharn of Nam Tame and viharn Luang; viharn of Wieng Thoen monastery; viharn of Lai Hin monastery; and the viharn of Pong Yang Kok monastery.

<u>Chiang Mai Region</u>: viharn of Ton Kwean monastery, viharn of Tung Aor monastery, and the viharn of Prasat monastery.

<u>Other Regions</u>: viharn of Hong Ngaer monastery and viharn of Chiang Khong.

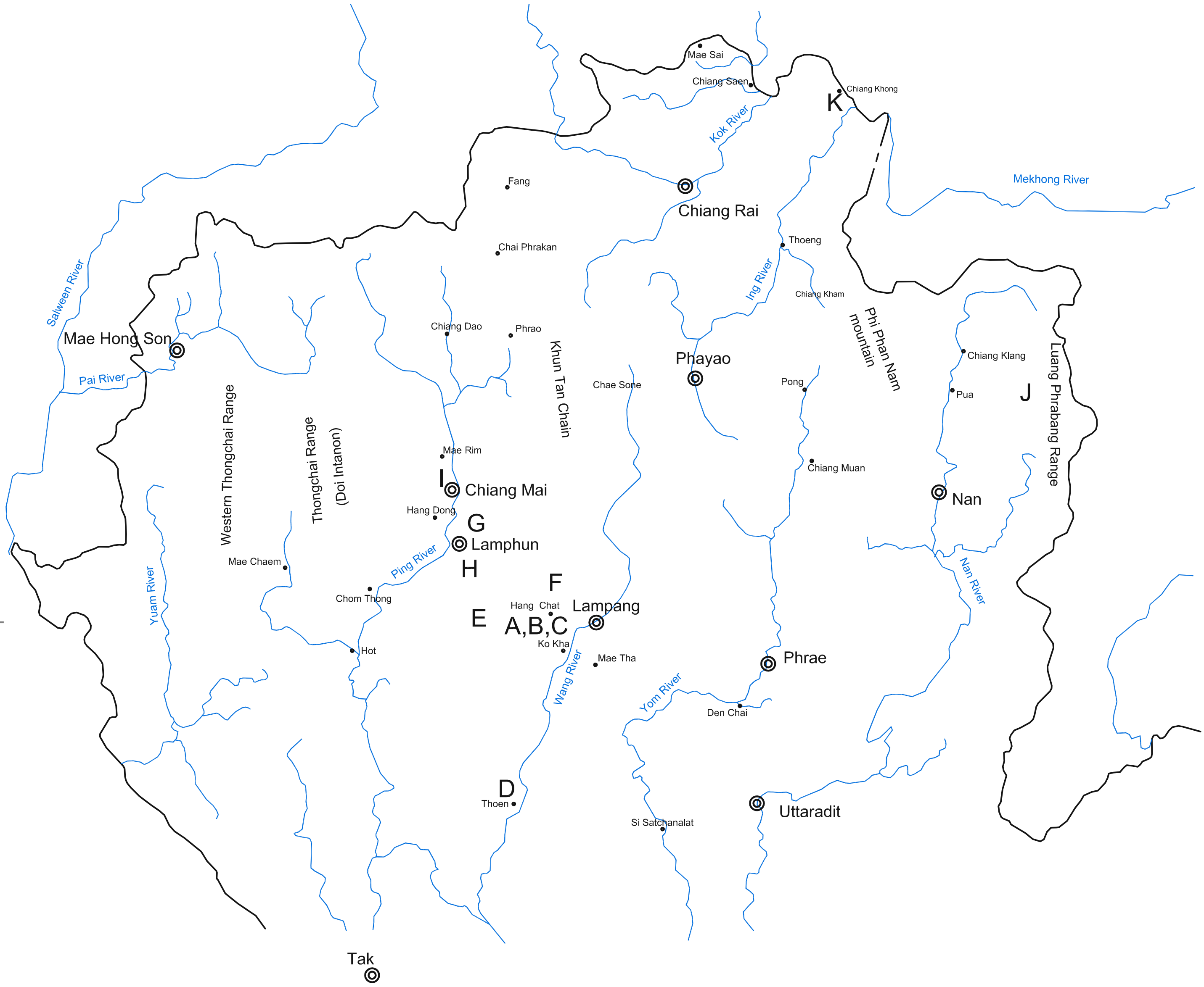


Fig. 3.3 Location of viharns selected as case studies

A. Viharn of Phra Putt at Phra That Lampang Luang monastery
B. Viharn of Nam Tame at Phra That Lampang Luang monastery
C. Viharn Luang of Phra That Lampang Luang monastery
D. Viharn of Wieng Thoen monastery
E. Viharn of Lai Hin monastery
F. Viharn of Pong Yang Kok monastery
G. Viharn of Ton Kwean monastery
H. Viharn of Tung Aor monastery
I. Viharn of Phrasat monastery
J. Viharn of Rong Ngar monastery
K. Viharn of Chiang Khong monastery

3.3 Lampang Region

Viharn of Phra Putt at Phra That Lampang Luang Monastery, Lampang Province

The inscription source LP-01 (see Khrueathai, Chapana & Sitha, Sarawut 2004, pp. 12-20) indicates an event of erecting a viharn in the year 1476 (2019) on the southern side of the main stupa of Phra That Lampang Luang monastery. The historians interpreted this indication implying to the viharn of Phra Putt stands in situ. They made reference to its correspondence in the positions and description of the principal Buddha image (Boonyasurat 2001b, p. 96). Nevertheless, we cannot be so certain that the current standing viharn of Phra Putt is exactly the same like the one mentioned in the inscription. The current one might be re erected after the old one or the building might have gone through different phases of modification and restoration that could have transformed the building completely.

The structure of the viharn as we have observed is comprised of six transverse frames, dividing the building into five bays. The carpenter enclosed the outer edge of the viharn with brick wall beside the first bay of the frontal entrance that functions as a porch. The dimension of the central four transverse frames are the largest constituting the principal hall. The viharn's front and rear side are characterized by reduced height and span compared to the central frames (see Fig. 3.4). The articulation of each transverse frame consists of nave structure in the central and aisle structure on both sides. The nave roof structure is comprised of three levels of crosswise beams (see Fig. 3.5 and Fig. 3.6). The main one is placed above the pair of nave pillars, while the upper two levels are carried by pairs of *tang mai*s. The aisle roof structure also consists of three levels of horizontal members. The main aisle beam is fixed above the head of the outer aisle pillar on its outer side and fixed to the nave pillar on the inner side. The upper two crosswise beams are each carried outside by *tang mai* and connected to a flanking pillar. I introduce the term flanking pillar to describe a structural device developed by the carpenter to facilitate assembling the aisle beams. The flanking pillar stands outside the main pillar detached from it as a distance of approximately 3 cm in crosswise direction. This flanking pillar is clamped between the main aisle beam and the protruding end of the main crosswise beam. Nave pillars are round, aisle pillars are rectangular. The aisle beams are the only horizontal elements that tied the aisle structure up to the central nave structure. We cannot observe any trace of securing wooden nails at the connection point of main pillar and aisle beam. Did the carpenter only insert the tenon from the aisle beam to the nave pillar and leave it without any securing against pulling strength?

In order to clarify above question, we need to take other evidence into our consideration. During the year 2010 -2011, the viharn of Phra Putt was restored, some pillars were replaced. In the course of my investigation in 2013 – 2014, many old pillars of this viharn were laid inside the colonnade on the Southern side of the building. The positions of the old mortises on these pillars correspond to the connecting positions of components as observed in viharn of Phra Putt, e.g. the distance from the head of the pillar to the mortise holding the aisle beam's tenon is 2.45 m. The tenon's traces of the aisle beam in the mortise present a unique pattern of geometry –from the bottom

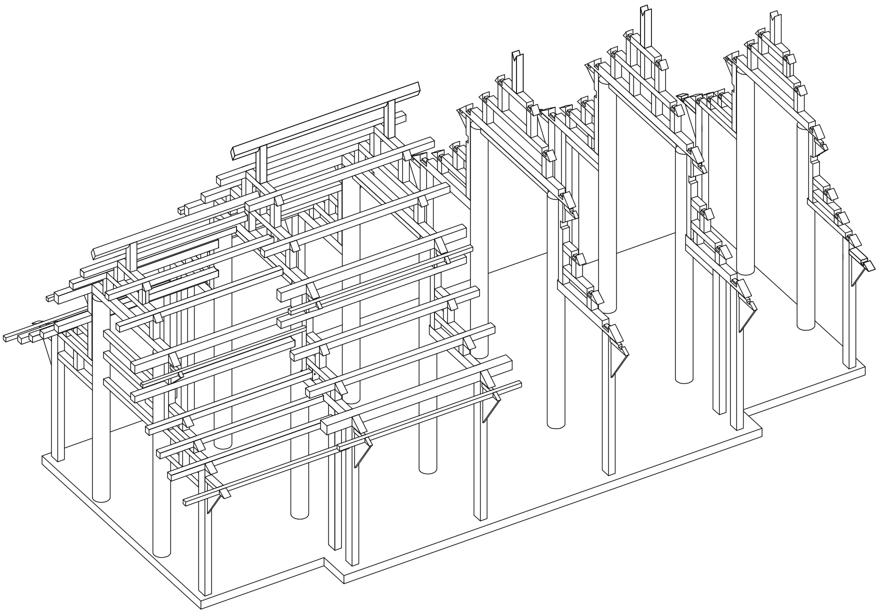


Fig. 3.4 Axonometric view of the viharn of Phra Putt

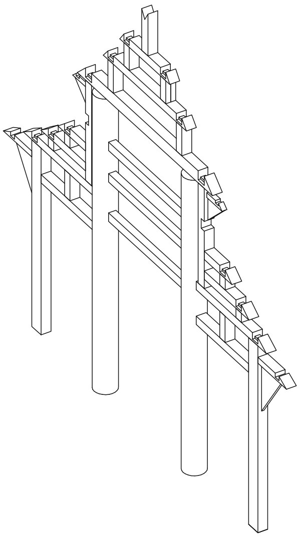


Fig. 3.5 First Transverse frame

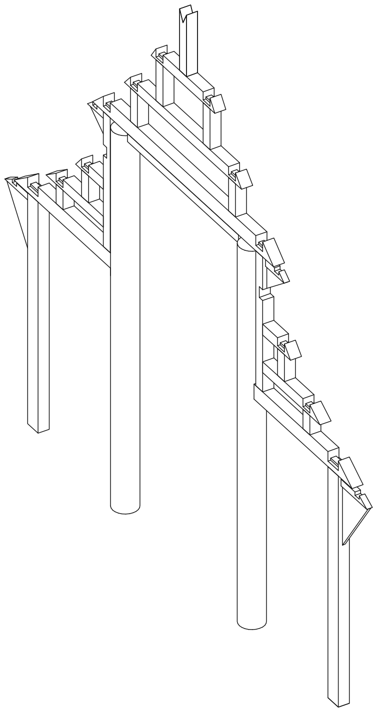


Fig. 3.6 Second Transverse frame

of mortise up to its height. The mortise hole is not an ordinary hole with straight cheeks. The hole is divided vertically into two parts. The upper four-fifths show parallel cheeks while the lowest one-fifths present cheeks tapering from inside to the outside of the pillar. Familiar with reading and interpreting joints I realized to have found the explanation how the carpenter had managed to connect the beam to the pillar resisted against pulling stress without leaving any traces. Apart from this observation I recognized another detail. Considering how the beam's tenon was inserted into the pillar's hole giving the two-part execution sense. I became aware that the beam's height measured just four fifths of the pillar's hole. Only this allowed the carpenter to push the beam's tenon horizontally into the pillar's hole and having reached the intended depth to push the beam downwards (see Fig. 3.7). The difference of beam's and pillar hole's height allowed this manipulation. When the beam had reached its intended position, the carpenter closed the gap in the pillar above the beam with a 5 cm wedge. This wedge locked the dovetail and there by the beam in the pillar.

We just considered the insertion of the crosswise oriented aisle beam. I made a similar observation of the old mortise at the junction where the main purlin of the smaller transverse frame meets the larger frame. The immediate task is the same. The carpenter has to ensure resistance against pulling stress in longitudinal direction as well. Due to the fact that the aisle beam's size is much bigger than the purlin's size, the carpenter had to adjust the solution with the dovetail. Thus finds its expression in the shape in the joint. The width of the aisle beam is approximately 20 cm. The dovetail's head measures only 5 cm (see Fig. 3.8). at its most narrow part. The purlin's width is part 11-12 cm and its most narrow part 3.5 cm. Accordingly the purlin's tenon is significantly shorter than the aisle beam's one. To understand the problem of the carpenter, we must be aware that both horizontal elements are attended to a round column. In order to give this strengthen dovetail a nice appearance to the observer's eye the tenon is recessed. A simple recession alone would create a undesirable gap between pillar and beam's cheeks. This gap would firmly force to look at this point. The carpenter hided it by adapting the beam's end grain parts defining the recess zone beside the tenon to the curve of pillar. Hence we meet the important difference between aisle beam and purlin. In the purlin's case, the carpenter had to modify the dovetail's shape to be able to prepare the concave shape of the purlin's end grain parts securing the column's surface left and right of the tenon. He gave the dovetail a concave shape as well thus enlarging the space for executing the different adaptation.

The first consideration of a problem that must hit the eye of a building researcher must not distract us from analyzing the structure in its entirely. I shed light on the most interesting part of the connection: the transition of smaller and larger roof shape in longitudinal direction. The smaller and the larger transverse frame of the viharn of Phra Putt vary in height and in span. Thus the purlins from the smaller frame cannot simply connect to the *tang mai*s of the larger frame since their positions are on different alignments. The carpenter had to seek an arrangement to bring these two frames together. This was another sophisticated task. The results at the viharn of Phra Putt display the combination of joinery methods, which can be described from the lowest position to the uppermost as follows (see Fig. 3.9): The carpenter introduced an additional pillar in alignment with the out most aisle pillar of the smaller frame in order to have a place where to fix the main aisle purlin. It is held in

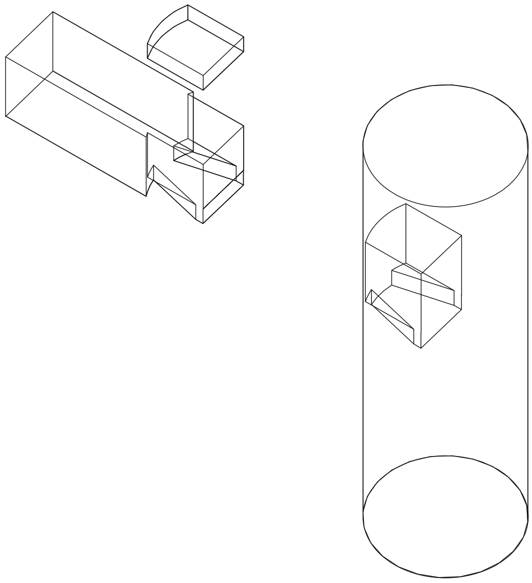


Fig. 3.7 Tenon with recessed dovetail

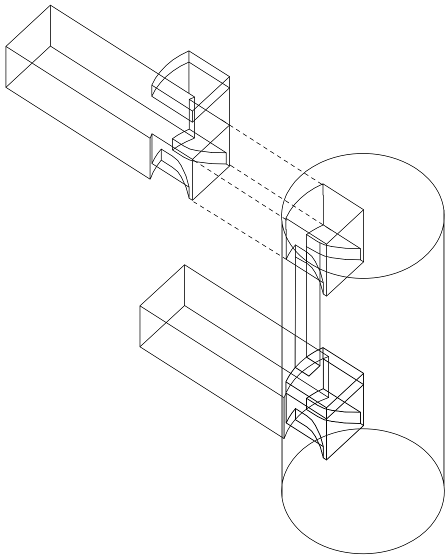


Fig. 3.8 Tenon with recessed dovetail with neck

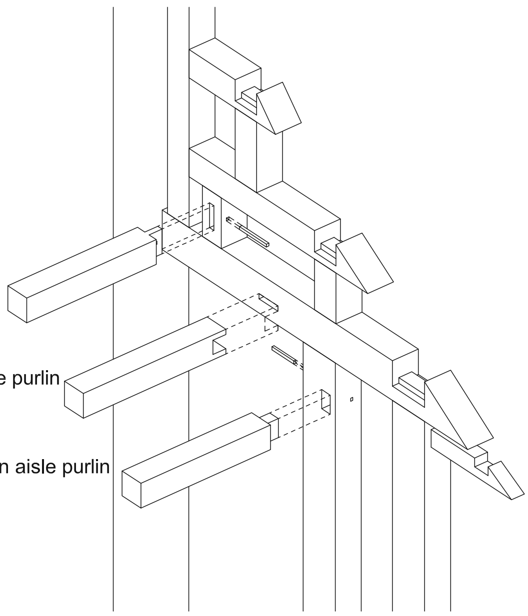


Fig. 3.9 Purlins from the first bay meeting the second transverse frame in aisle roof

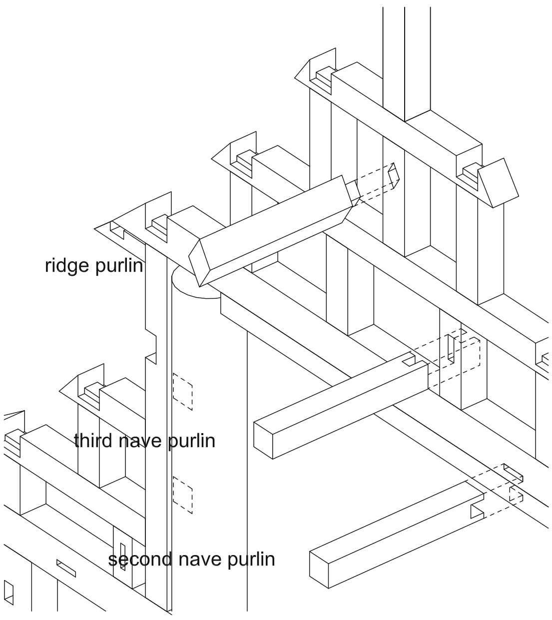


Fig. 3.10 Purlins from the first bay meeting the second transverse frame in nave roof

place by tenon recessed on all sides and locked by a nail. The second aisle purlin is connected differently. The purlin's end is forked. The upper tenon is put into a hole in the aisle beam while the lower end encompresses the aisle beam from the underside. The third aisle purlin is attached similarly to the first. Again the carpenter had to insert a vertical component just to allow the purlin's fixation. In this case, the tenon is only recessed on the vertical sides. It is keyed again by wooden nail.

The main purlin of the nave is fixed to the main pillar in the way just described in detail of dovetail. The second nave purlin is connected to the main crosswise beam in the same way I described for the second aisle purlin. The third purlin is jointed to a vertical pillar inserted between main and second crosswise beam. This third purlin is forked again, this time vertically. The inner tenon finds its place in a central hole in the pillar. The outer tenon encompasses the pillar on its outward side. Once more the carpenter solved the problem of an unaligned matcing counterpart to allow the mounting of the ridge purlin. He inserted a central pillar between second and third crosswise beam to house the purlin tenon recessed on all four sides. Like all ridge purlin, it was turned 45 degree to facilitate the application of the roof covering.

Viharn of Nam Tame at Phra That Lampang Luang Monastery, Lampang Province

An art historian estimated that the erection of viharn of Nam Tame should fall during 21-22 Buddhist century after erecting the viharn Luang (grand viharn) of Phra That Lampang Luang monastery (Boonyasurat 2001b, p. 124). Chronicle of the monastery depicts the event of casting the principal Buddha image weighting 30,000 units of gold and afterwards the enshrining of this Buddha image at the viharn on the Northern side of the main stupa (Chottisukkhsrat 1972, reprinted 2013, p. 563). The above description in the chronicle seems to correspond to the setting of the current viharn Nam Tame as well as the connotation to its principal Buddha, named "Buddha image of 30,000 units of gold."

The structure of viharn of Nam Tame is comprised of six transverse frames, divided into five bays. The viharn has open sides with exception of the final part where the principal Buddha image is enshrined. There the carpenter had built up a brick wall surrounding the three sides of the final bay. It can be seen as the backdrop of this Buddha image. The dimensions of the three transverse frames in the central area are the largest, attributed to the principal hall. The dimensions of the transverse frames are reduced in height and span off this central hall: twice toward the frontal and once toward the rear side (see Fig. 3.11). The reduction of the structural frame's size has been carried out by shortening the length of the crosswise beams step by step in relation to lowering down the level of the ridge purlins. The composition of each transverse frame consists of a central nave structure and an aisle on each side. The flanking pillar is placed adjacent to the nave pillar at a distance of around 3 cm on each side. It might become 5 cm in the fifth transverse frame in front of the principal Buddha image. The nave pillars are round, while the outer aisle pillars are rectangular entirely made of brick.

From the second to the final transverse frame, the composition of structural components in each frame displays a clear separation between nave and aisle structure. Whereas the situation in the first transverse frame of the frontal façade seems ambiguous (see Fig. 3.12-3.14). The third aisle beam is extended to cover the whole span of this frontal frame. The beam is placed directly on the pair of nave pillars. Another interpretation would state that this pair of nave pillars has reached up to the height of the third aisle beam. Above this beam the carpenter erected another pair of standing pillar carrying the main crosswise beam that defines the span of the nave roof structure.

What was the benefit of arranging the structural components in such a way? Let us compare this arrangement to a typical one as for instance in the second transverse frame. There is a clear difference concerning the position of the standing pillar in relation to the nave pillar. The frontal frame's standing pillars stand directly above the nave pillar thus in the same axis. Apart from this first frame the standing pillar stands adjacent to the nave pillar in all other frame. Due to its position, we call it a flanking pillar. This irregularity of crosswise frames should raise several questions. Why did the carpenter leave the nave pillars in the first frame so short and did not let them reach the main crosswise beam? Why did the carpenter leave the structural pattern of introducing a flanking pillar receiving the staggered aisle beams? Why had the nave pillars in the first crosswise frame a square-shaped section in contrary to all other round pillar? My investigation leads me to the following interpretation. The arrangement we have analyzed up to now presents an idea of disassociation the

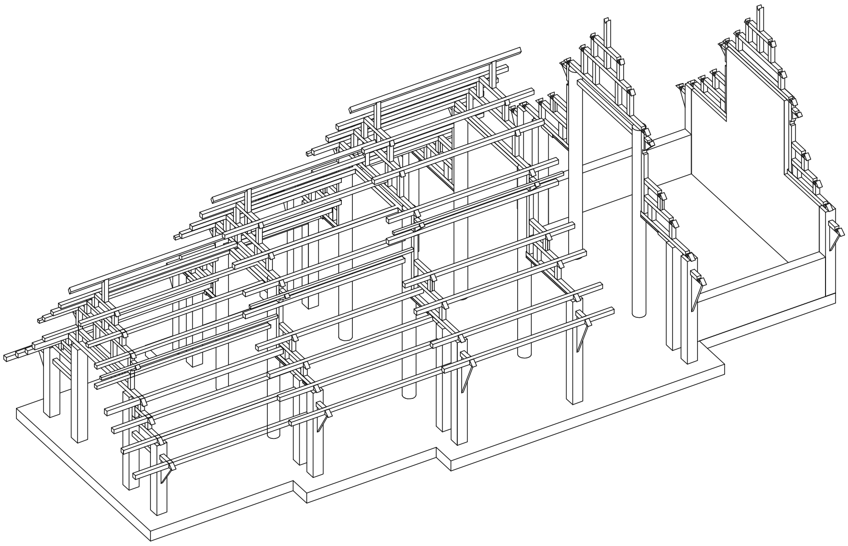


Fig. 3.11 Axonometric view of the viharn of Nam Tame

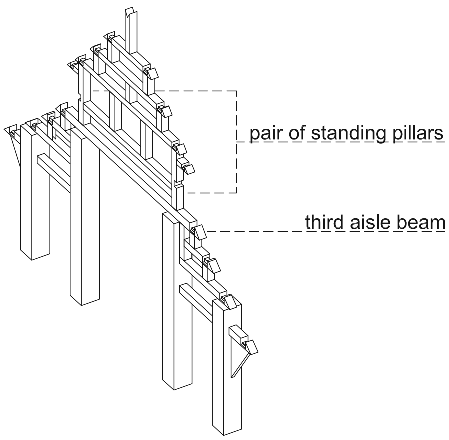


Fig. 3.12 First transverse frame

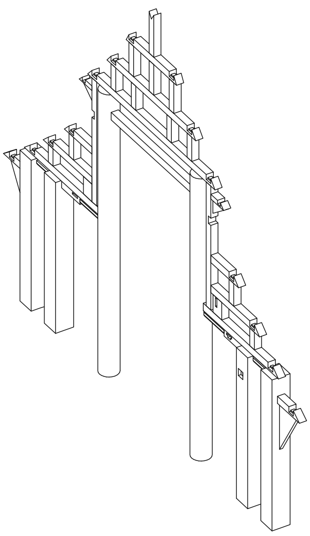


Fig. 3.13 Second transverse frame

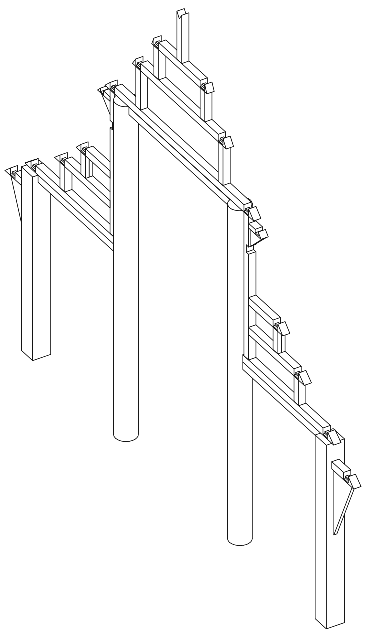


Fig. 3.14 Fourth transverse frame

span of paired nave pillars from the span of the nave roof structure. When looking at the drawing, the current structural arrangement allows possibility to adjust the distance between the pair of pillars in certain level without disturbing the span of nave roof structure. If the carpenter had erected the first frame's nave pillar with adjacent flanking pillars in the way like all other frames the distance between the pillars would become more narrow. Probably too narrow to meet the carpenter's idea what is expected of a viharn's main entrance. Even though the dimension of the nave roof is differed in first and second crosswise frame the span of the nave pillars is identical. They are aligned exactly behind each other.

A close observation of the jointing technique reveals a usage of tenon with recessed dovetailed base connecting the aisle beam pulling strength resistant to the nave pillar similarly to the one of the viharn of Phra Putt. The standing pillar is fixed on the lower horizontal beam by recessing one third of section in both sides in longitudinal direction thus forming a tenon footing. Its upper end terminates as a tenon recessed on all four sides. The seat for the purlin is prepared in shape of halved joint recessed on two sides. The structural arrangement how the purlins connect smaller to larger crosswise frames is more complicated in this viharn compared to the one of Phra Putt. The building in discussion consists of three differently dimensioned transverse frames. However, the core principle presents some degree of coherence between the two. The carpenter set up an additional pillar to receive the main aisle purlin from the smaller frame (see Fig. 3.16-3.17). The second aisle purlin is forked in between the aisled beam and added beam, tightening the connection by wedge. For the third aisle purlin, the carpenter assembled an additional component to hold it. But in this case, we cannot observe the wooden nail element as a vertical crack along the wood grain is seen at this position. The main purlin of nave roof is mortised to the main pillar secured by recessed dovetailed with neck as could be observed from beneath. The second nave purlin is tenon to drop down horizontal beam. The carpenter combined additional components in to the frame to hold the third and the ridge purlin (see Fig. 3.15).

Fig. 3.15 structural transition from second bay to principal hall

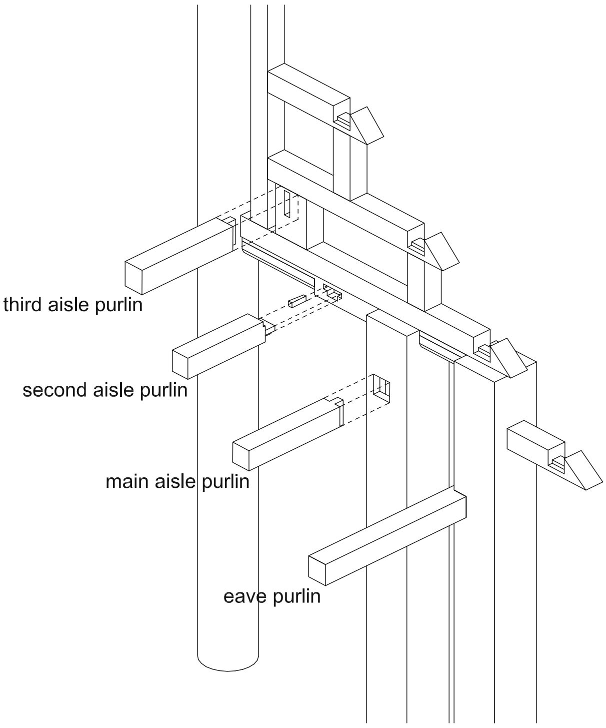


Fig. 3.16 Purlins from the first bay meeting the second transverse frame in aisle roof

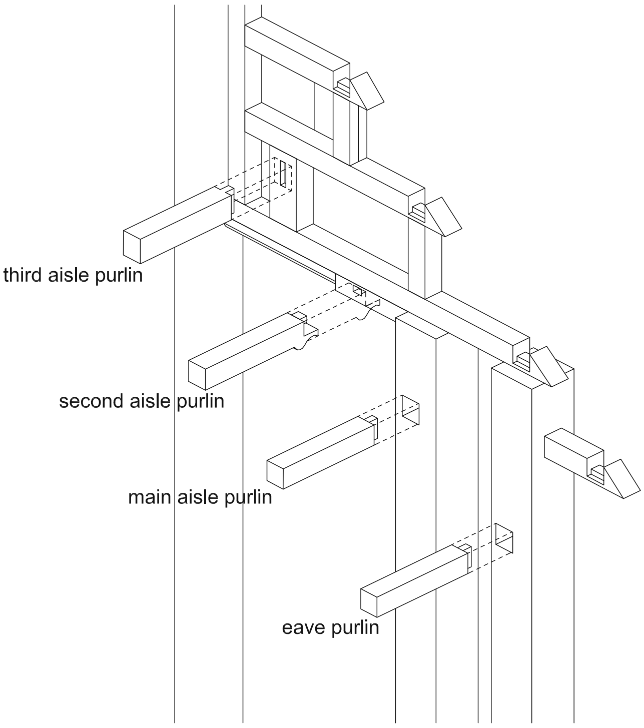


Fig. 3.17 Purlins from the second bay meeting the third transverse frame in aisle roof

Viharn Luang of Phra That Lampang Luang Monastery, Lampang Province

Historians conceded the erection period of viharn Luang at Phra That Lampang Luang monastery during the year 1496-1503 (2039-2046) according to the information provided on a stone slab inscription LP-02 (see Khrueathai, Chapana & Sitha, Sarawut 2004). The inscription source depicts the sequence of events from the viharn's erection to the casting of the principal Buddha image, called "the lord of million units of gold" (Department of Fine Arts 2008, pp. 204-205). The size of this Viharn Luang presents one of the largest existing samples of historic timber building in Lan Na. The term *luang* is connoted to the meaning "big" or "grand" (Wichienkeeo 1996, p. 727). The span along transverse axis is measured approximately 15.7 m and the length along longitudinal axis is 34 m. The configuration of the viharn's ground floor plan seems to be comparable with the typology of "*asupa lak*" meaning "grand hall in bull description," which is mentioned in *Jinakalamali* (Ratanapanna and Sang Monwithun (trans) 1527/1997). The described dimension in *Jinakalamali* indicates the measurement of ground floor plan at 32 elbows ("*ratana*") and 1 finger-span ("*visatthi*") in crosswise direction or equally 14.9 m; and 78 elbows and 1 finger-span in lengthwise or equally 33.74 m. The conversion of unit from the old measurement system used in *Jinakalamali* to the modern units had been carried out by Hans Penth (1994).

The structure of this grand viharn has open sides, comprised of ten transverse frames, dividing the structure into nine bays. The largest structural part defines the principal hall consisting of four transverse frames and occupying three central bays. The Principal Buddha image is enshrined there. The transverse frame's dimension is reduced twice to the front side and once to the rear side away from the principal hall (Fig. 3.18). The reduction of the structural frame had been carried out by shortening the main crosswise beam step by step as the lowering the level of the ridge purlin similarly to the method employed at the viharn of Nam Tame. The dimension of each structural frame is much larger and the number of frames is higher. The largest transverse frame measures 15.7 m. Such a wide span had challenged the carpenter's ability to design the nave and aisle structure and his knowledge concern timber's strength. If the carpenter divided the proportion of nave and aisle in the same way that was done in the viharn of Phra Putt (1.44: 1) or at the viharn of Nam Tame (1.2:1), the nave span of this viharn luang would be up to 6.5 m. A span increased so significantly demands a stronger beam meaning a beam with a larger cross-section. The building relies on proportion as a whole. Thus a thicker crosswise beam induces taller pillar; taller meaning larger as well as heavier. The carpenter introduced a ratio of 1.1:1 to define the proportion of nave and aisle. We deduced this measure from our building survey. The nave span and aisle span measures 4.75 m and 4.4 m respectively.

As the consequence of this division, the carpenter had to solve another issue of the massive size of aisle. The curved roofing above would have been too deep to (maintain its proportion??) leave its misincorporated. The carpenter introduced a double layered roof to deal with this problem. The introduction of a neck ("*korgeeb*") allowed a pleasant roof inclination consistent with the nave roof (see Fig. 3.23). It goes without saying, the numbers of purlin are increasing from 3 positions (belong

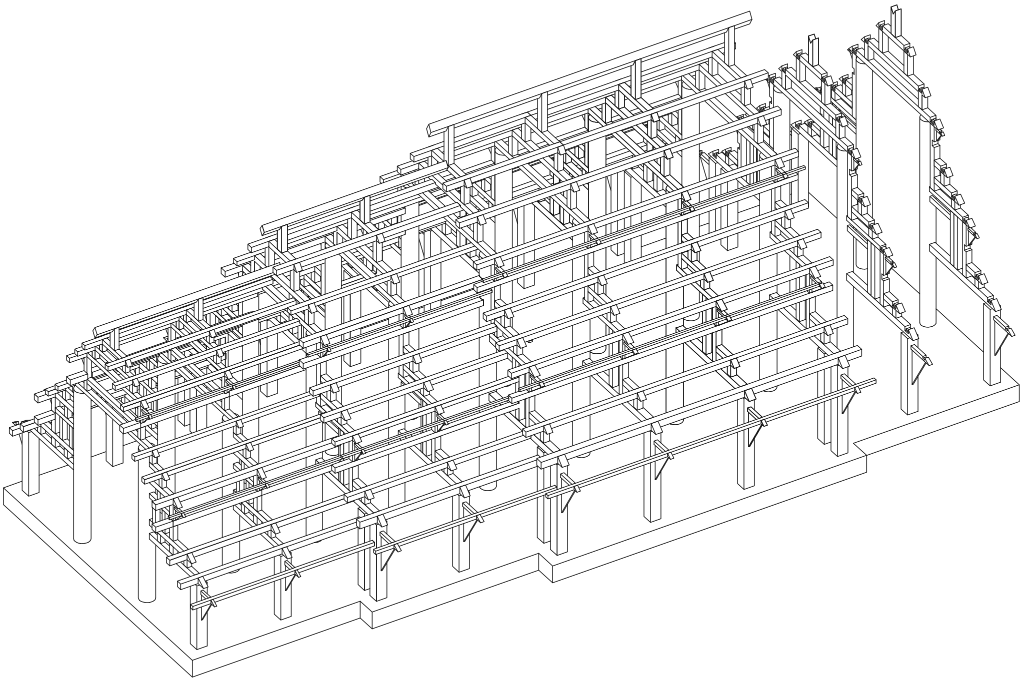


Fig. 3.18 Axonometric view of the viharn Luang (grand viharn)

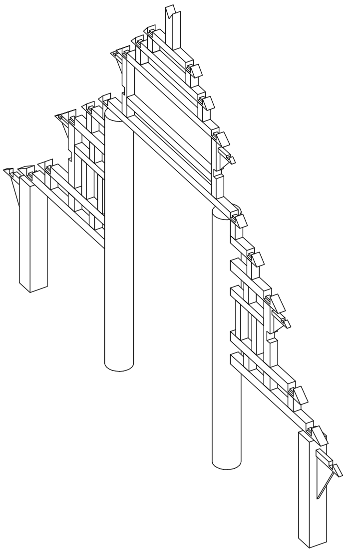


Fig. 3.19 First transverse frame

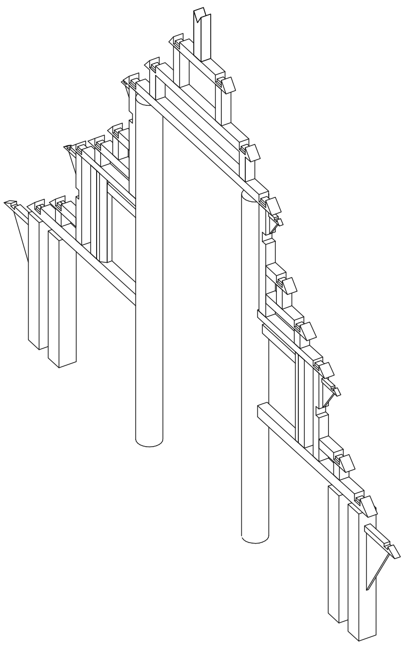


Fig. 3.20 Third transverse frame

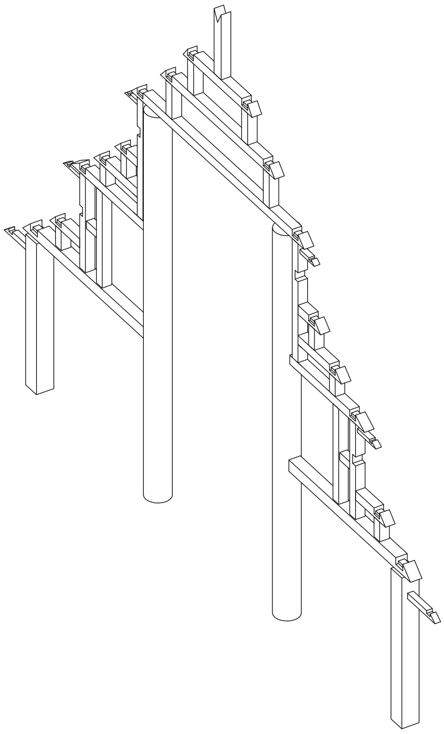


Fig. 3.21 sixth transverse frame

the main, the second, and third aisle beam) to six positions! Thus the task of attaching purlins of a smaller transverse frame to a larger frame shall be more demanding and sophisticated.

With great regret I realized during my work that the current situation of grand viharn cannot offer much evidence of methods that the carpenters employed to connect the purlins from smaller to larger frames because the building had undergone several modification phases. The most radical one was carried out in the year 1923 (2466). The monastery had installed a wooden ceiling at the level of main crosswise beam, modified the façade, and plastered the previous octagonal pillar into round shape (Pindavanija 2006 and Temiyabandha 1969 reprinted 2014). But we can still trace back by cross checking with an old photograph published in the literature (for instance, "*Architecture in Thailand*" by Phothiprasard 1944). Despite the distortion resulting from such modifications, there are some positions that still maintain traces of details. These details were sufficient to analysis and to draw an outline of the method employed by the carpenter. The main aisle purlin is held by an additional pillar that the carpenter additionally combined. The second aisle purlin is attached to the main aisle beam of the larger frame, apparently without additional securing technique. The third aisle purlin or the uppermost at the outer aisle structure as well as the fourth purlin positioned in the same alignment are jointed to the standing pillar by a tenon. The fifth purlin is forked to the added beam of the larger frame, secured with the wedge; the attachment position appeared as flat rectangular surface, while the rest of the added beam is chamfered. And the final sixth purlin of the aisle part is tenon to the addition component that the carpenter assembled especially to hold this purlin (see Fig. 3.24).

The strategic arrangement that disassociates the span of nave pillar from the span of nave roof structure as analyzed in the case of viharn of Nam Tame becomes lucid at the viharn Luan*g*. The carpenter did not only employ standing pillars to define the nave roof structure at the frontal transverse frames, but also implemented this in the second transverse frame as well. Such an arrangement created consistency in crosswise direction of the nave pillars as well as provided pillar's alignment from frontal entrance to the forth transverse frame, regardless to the enlargement of nave roof's size that has already occurred from the third transverse frame onwards (see Fig. 6.2).

Fig. 3.22 The principal Buddha image "the lord of million units of gold" enshrined in a gilded brick housing (*khong prasat*)

Fig. 3.23 Double layered aisle roof structure with additional neck part (*korgeeb*)

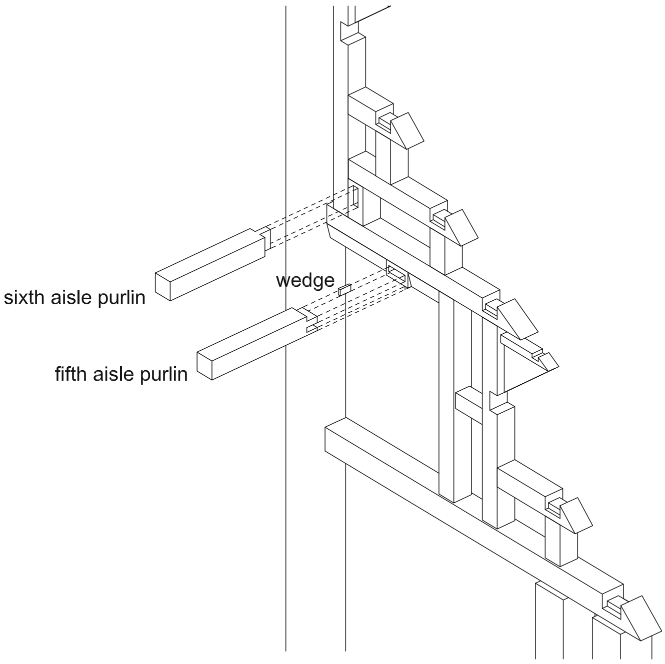


Fig. 3.24 Purlins from the fourth bay meeting the fifth transverse frame in aisle roof structrue

Viharn of Wieng Thoen Monastery, Thoen district, Lampang province

The old chronicle of Wieng Thoen town indicates the founding of the monastery in the year 1649 (2192), but did not specify when the viharn had been erected (Siriwetchaphan 2003, p. 66). Art historians classified the architectural style of the viharn and estimated that the work might be executed during 21-23 Buddhist century (Boonyasurat 2001b, p. 176). The viharn is open to all sides with exception of the final bay that the carpenter closed with a brick wall. The structure of the viharn comprises seven transverse frames, and thus is divided into 6 bays. The principle hall is constituted by the three largest bays in the centre that is the space in between the third and the sixth frame. From the principal hall, the dimension of transverse frame is reduced twice to the front and once to the rear side caused by shortening the crosswise beams and lowering the level of ridge purlins (see Fig.3.25). A particularity of this viharn is the addition of second aisle structures in the second up to the seventh transverse frames.

In comparison to the viharn Luang, the composition of viharn of Wieng Thoen monastery displays a different method in arranging nave and aisle structure. The measurement along the span of the transverse frame in the principle hall is approximate 12.7 m. The structural composition of a transverse frame is defined by the central nave and two staggered layers of aisle beam on each side. The inner aisle stands on the same floor level as the nave structure. I refer to the second transverse frame. The outer aisle is lowered by 0.5 m. The structure of outer aisle is connected to the inner aisle by two levels of crosswise aisle beams. The main one is placed on the head of the pillar at the outermost row and mortised into the inner aisle pillar at the height of 1.25 m. The second outer aisle beam is carried by a *tang mai*s. Both of them are mortised to the aisle pillar without an interruption of a flanking pillar.

There is a question posted from time to time, if the structure of outer aisle had been extended afterwards or if it had been erected simultaneously with the overall structure? My analysis suggests to closely inspect the joints employed by the carpenter in order to find out whether there exists any coherence in idea or not. The aisle beam of the inner aisle is connected to the nave pillar by a tenon with dovetailed bottom, while the outer aisle beam connect to the pillar at the inner row by a tenon showing a vertical (!) T-shape. Such a configuration does not have any effect in fact. So probably for this reason the carpenter strengthened the inserted tenon by introducing a wedge above it. The result of this very weak treatment can be seen at many places where the beam slipped out of the pillar's mortised hole (as inspected in 2012 – 2013). Whereas the inner aisle beam still does its job, although displaying some traces of deterioration due to rain water leakage. Our careful inspection revealed different jointing method executed at two different structural details that are supposed to be treated equally. As this detail is outstanding structural importance, we suspect two different times of execution and most probably different carpenters.

The carpenter adopted the same strategic arrangement to disassociate the span of nave pillar and nave roof structure similarly to the viharn of Nam Tame and viharn Luang. According to our observation the purlins are assembled into their seats on the horizontal crosswise beams using

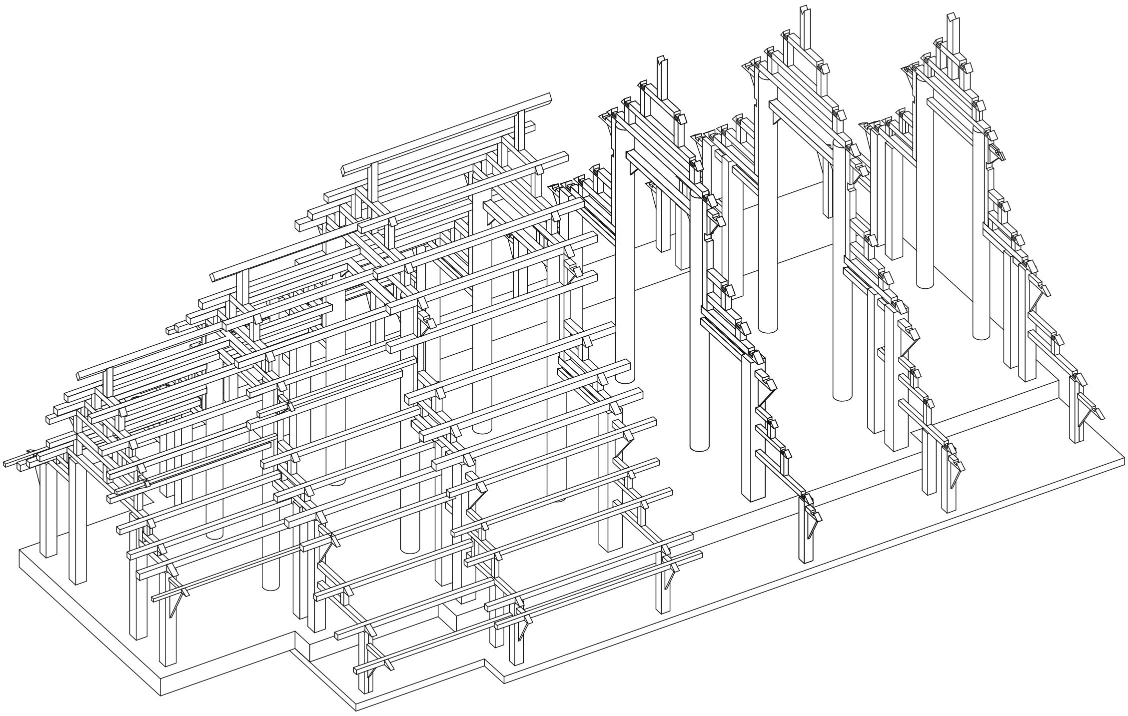


Fig. 3.25 Axonometric view of viharn of Wieng Thoen

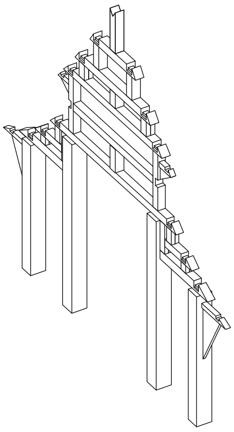


Fig. 3.26 First transverse frame

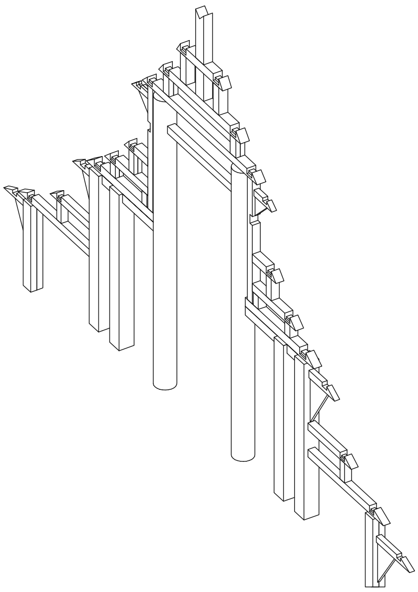


Fig. 3.27 Second Transverse frame

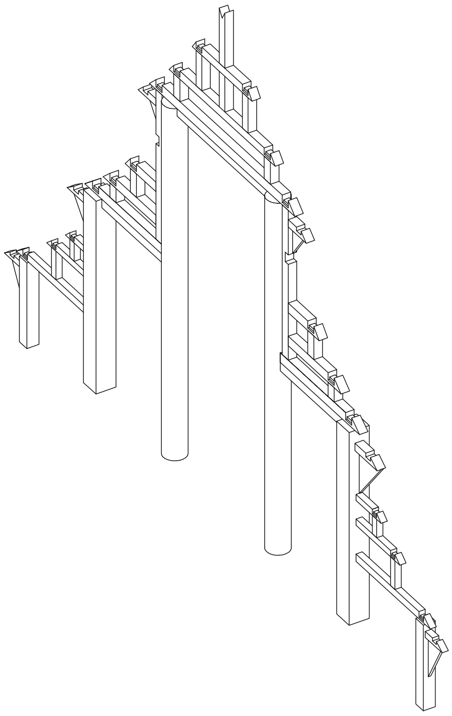


Fig. 3.28 Fourth transverse frame

halved joints recessed on both sides. But the positions for the footing and tenon head of the *tang mai* were not accessible for close inspection. The gap between the flanking pillar and the main nave pillar is significantly wider in this building showing a distance of around 5-6 cm.

The carpenter combined purlins from the smaller transverse frame to the larger on the following order. The main aisle purlin is held by an additional pillar. The second aisle purlin is connected to a horizontal member inserted in between nave pillar and additional pillar 5 cm below the inner main aisle beam (see Fig 3.31). The jointing point is defined by tenon held in place by a wedge alongside the tenon. The carpenter had to insert another vertical element in between the inner main aisle beam and inner second aisle beam placed directly adjacent to the flanking pillar in order to attach the third aisle purlin. This is done by tenon recessed on all sides. The second nave purlin is attached to a horizontal member inserted parallel beneath the main crosswise beam just for this reason (see Fig. 3.30). The third nave purlin is attached to the main crosswise beam. In both cases the purlins end in a tenon and are secured by a wedge. The main purlin of the nave structure is attached to the nave pillar. We could not investigate the jointing technique. The ridge purlin is adjoined to the additional component that is assembled in between the second and the third crosswise beam of the larger frame.

Fig. 3.29 Viharn of Wieng Thoen

Fig. 3.30 Purlins from the second bay meeting the third transverse frame in nave roof

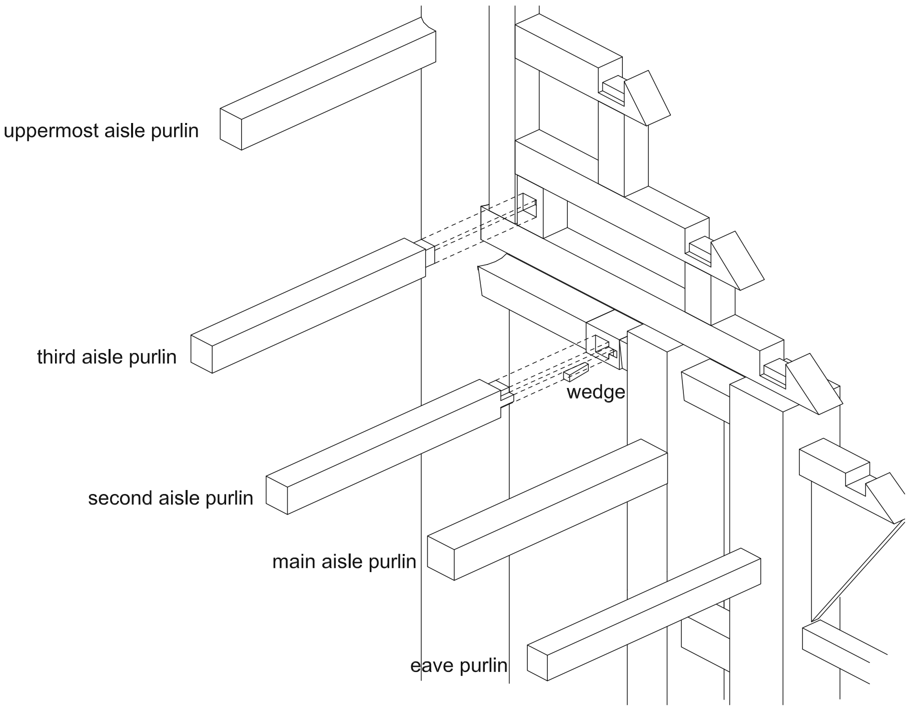


Fig. 3.31 Purlins from the first bay meeting the second transverse frame in aisle roof

Viharn of Lai Hin Luang Monastery, Lampang Province

The inscription on a wooden panel installed at the viharn of Lai Hin monastery indicates an erection date of the building in the year 1683 (2226) (Boonyasurat 2001b, p. 164). The local folktale additionally attributes a background to this erection narrating a story that the viharn was supported by the Buddhist people from Chiang Tung, Burma. There is an episode that the abbot of Lai Hin Luang monastery had travelled to Chiang Tung where he impressed by a local. Afterwards the Chiang Tung people visited him in Lampang and learned about the poor circumstances there. The viharn did not exist at the time, thus they decided to put their effort to erect it (Siriwetchaphan 2003, p. 47).

The overall structure of the viharn of Lai Hin Luang monastery is comprised of six transverse frames, creating five bays. The viharn has open sides with only exception of the rearmost bay. The carpenter had built up a brick wall encircling it creating a backdrop for the principal Buddha image. The principal hall is comprised of three transverse frames, but the arrangement of its structural components in each frame is not identical and significantly different from the previous cases. My analysis shall begin with the third transverse frame (see Fig. 3.35). I choose this frame to offer exemplary the carpenter's approach in this viharn.

A crosswise beam is placed along the whole axis of transverse frame at the height of 3.15 m. The beam is supported by a row of four equally high pillars. The beam's span measures 6.15 m. The carpenter put two pairs of standing pillar on top of the crosswise beam. The inner standing pillar's inner side is in line with the nave pillar's innermost limit. The outer standing pillar's inside is defined by thought line slightly beyond the nave pillar's outer limit. These four standing pillars on top of the main crosswise beam again all of the same height carry a horizontal beam that defines the dimension of the principal nave roof. The arrangement of the structural components inside this nave roof is the same as in the previous cases. For each side of the aisle roof structure, the carpenter assembled two levels of aisle beams by fixed a side to outer standing pillar and used the smaller standing pillar to carry the beam on other side. The seat for purlin is prepared at the intersected alignment between the horizontal beam and the small standing pillar. The uppermost aisle purlin is assembled to the outer side of outer standing pillar, while the lower position of purlin (main aisle purlin) is rested on a seat above the outer aisle pillar.

The combination of the transverse frames number three to six constitutes the principal part of the roof. At the fourth transverse frame, the carpenter omitted the two nave pillars. Thus the crosswise beam has to cover the wide span. The trace of a mortise for diagonal bracing under this crosswise beam can still be observed (see Fig. 3.36). Presumably a diagonal bracing was inserted to prevent the beam from being sagging. In the fifth transverse frame the main crosswise beam was omitted entirely to provide an unrestricted view of the principal Buddha Image (see Fig. 3.37). Referring to the third, fourth, and sixth frame the continuous main beam was restricted here to two main aisle beams. While the height of roof ridge connecting second and third frame is lowered, the length of the main crosswise beam is maintained in the second frame. Also the alignment of all four pillars standing on the ground floor is adjusted to those of the third frame. The pillar's height has

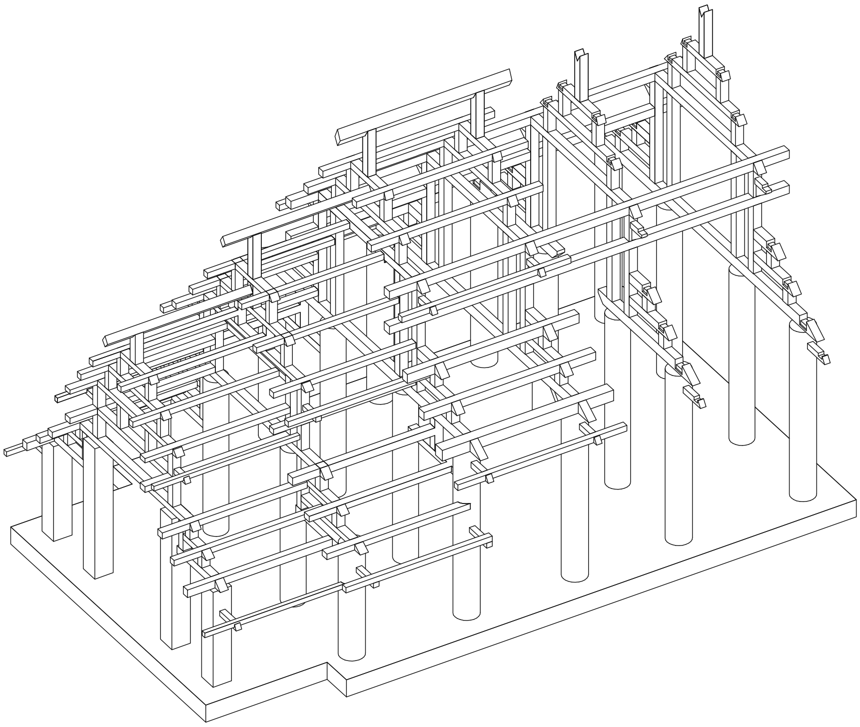


Fig. 3.32 Axonometric view of the viharn of Lai Hin

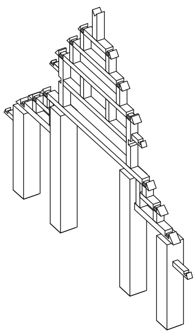


Fig. 3.33 First transverse frame

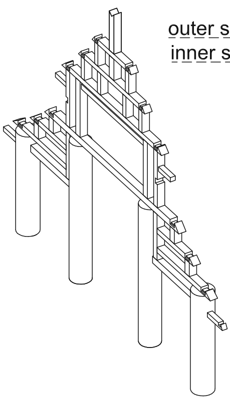


Fig. 3.34 second transverse frame

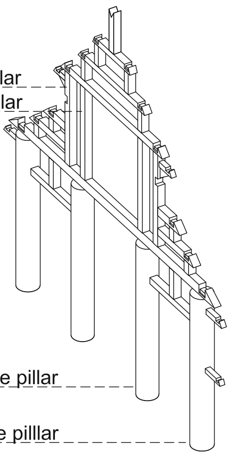


Fig. 3.35 Third transverse frame

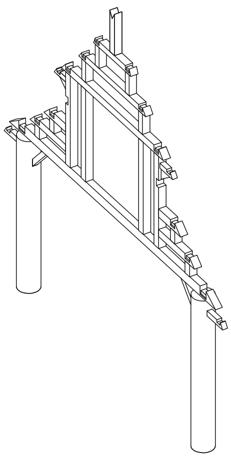


Fig. 3.36 Fourth Transverse Frame

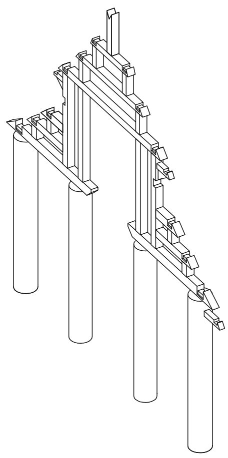


Fig. 3.37 Fifth Transverse Frame

changed. The nave pillars were reduced by 0.3 m, the aisle pillar 1.10 m. So to say, the third aisle beam appears to be placed on the nave pillar and takes the whole length of the transverse frame. As a result, the arrangement of this transverse frame can be compared to the frontal transverse frame of the viharn of Nam Tame and the first two transverse frames of the viharn Luang. The carpenter had no difficulties to connect the purlin leaving the second transverse frame to the third frame since both frame's pillars stand aligned. He created tenons relying on dovetailed shape and T-shape in order to handle the pulling strength between transverse frames.

From the second to the frontal transverse frame, carpenter reduced the dimension of roof structure in both span and height. He took the distance of the two inner standing pillars above the central nave of second transverse frame and transferred it as the span of main crosswise beam of the frontal frame. The ridge purlin is leveled down approximately 1.10 m. The purlins from the frontal transverse frame cannot be attached to the standing pillars of the second transverse frames as easily as in the other frames. Their positions are on different alignment. The systematic arrangement that the carpenter used to connect the purlins can be described as follow (see Fig. 3.40). The frontal frame's main aisle purlin is fixed at the horizontal beam installed beneath the second frame's main aisle beam by ordinary tenon. The carpenter introduced this beam to offer the main aisle purlin a connection point. Careful investigation observed a small standing pillar positioned in the same alignment as the purlin as well as a mortise underneath this lower beam. Despite the deterioration of the joinery at this place, one can speculate that the footing of this standing pillar has secured the tenon of the purlin against pulling strength. The second aisle purlin is connected to the aisle beam with a notched ending secured by a recessed dovetail hidden at the bottom side. The third aisle purlin is forked to the second aisle beam. The uppermost aisle purlins as well as the main purlins of the nave structure situated directly above each other are mortised into the inner standing pillar of the second transverse frame. The second nave purlin is mortised into the additionally inserted beam directly beneath the main crosswise beam. The carpenter introduced another structural vertical element to connect the third nave purlin as well as the ridge purlin. They are mortised again into this standing pillar.

For the general method of assembling, the carpenter fixed a standing pillar on the horizontal beam beneath by the footing. The standing pillar keeps the upper horizontal beam in place by a tenon. At their intersection, the carpenter created a seat for the purlin by creating a recessed halve joint.

Fig. 3.38 Viharn of Lai Hin Luang monastery

Fig. 3.39 Transverse frames of the viharn

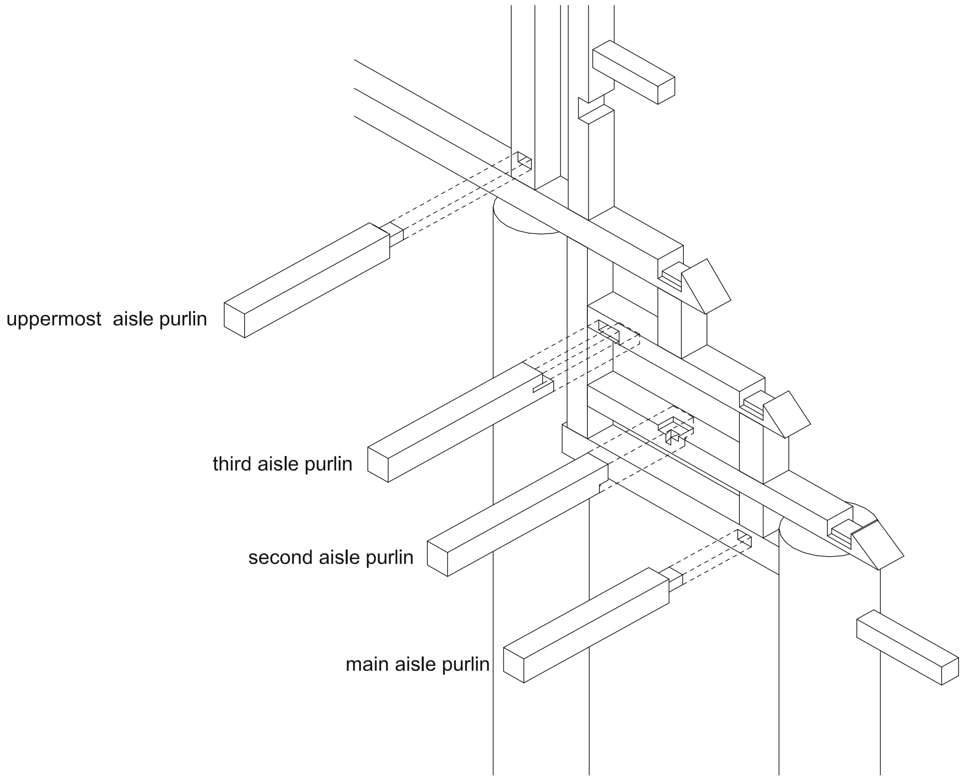


Fig. 3.40 Purlins from the first bay meeting the second transverse frame in aisle roof structure

Viharn of Pong Yang Kok Monastery, Lampang Province

Art and architectural historians have no clear evidence when the viharn of Pong Yang Kok monastery was erected. They suppose that the erection period should fall in between 1732-1759 (2275-2302) (e.g. Boonyasurat 2001b, p. 144). the main reason given as explanation is the reign of an important ruler of Lampang who originated from Pong Yang Kok area and ruled this region (Temiyabandha1975, reprinted 2014 p. 78). The monastery's elaborate craftwork and artistic execution is remarkable and noteworthy considering its remote site. Several scholars published an article on this building (e.g. Temiyabandha1975)

The structure of the viharn of Pong Yang Kok comprises six transverse frames connecting five bays. The three largest transverse frames in the centre constitute the principal hall. The observer sees a viharn with open sides. Only the final bay presents brick walls, very low enclosing the furthest bay but filling the largest part of the final transverse frames and thus supporting the upper timber structure of the nave defining space (see Fig. 3.41). Related to the principal hall the transverse frame's dimensions are reduced twice towards the front side and once towards the rear side (see Fig. 3.41). The carpenter reduced the length of the crosswise beam in relation to the lowering of the respective ridge purlins. The arrangement of structural components in the frame is comparable to the case of viharn of Nam Tame. It displays three levels of crosswise beams in the nave structure; the upper two beams are carried by a pair of *tang mai* in each case (see Fig. 3.43-3.44). For the aisle roof structure, the carpenter inserted the inner end of the main aisle beam into the nave pillar by using a tenon and fixed the outer side by putting it on a tenon on top of the aisle pillars. Likewise the second and third aisle beams are connected to the flanking pillar inside and supported by and fixed to a *tang mai*s outside respectively. The flanking pillar is detached from the main nave pillar at a distance of 3 cm.

The transverse frame of the frontal façade presents a different method of structural arrangement (see Fig. 3.42). The carpenter had erected the pair of nave pillars up to the level of the main crosswise beam. He defined the dimension of nave roof by preparing the seats for the main purlins following the axis of the nave pillars. Second and third crosswise beam are arranged logically in the simplest possible way in accordance with the intended roof incline. The ridge purlin is carried by a central pillar on top of the third crosswise beam. Three levels of aisle beams are jointed via a tenon directly to nave pillar strikingly there is no flanking pillar! The uppermost aisle purlin situates directly beneath the main purlin in certain height. This aisle purlin is mortised entirely in a respective hole. The neck part ("*korgeeb*") is formed at the spacing in between the two purlins.

The adjustment of purlins connecting two adjacent frames of different size is managed astonishingly consistent in this viharn. Similar to the previous cases, the occurring load is pulling stress. The carpenter used two types of secured tenons to deal with it: horizontal tenon and vertical tenon. The securing nail is of rectangular section. The connections of the purlins from the first transverse to the second can be described as following (see Fig 3.47-3.48). The main aisle purlin is connected to and held by an additional aisle pillar. The carpenter applied vertical tenon at this

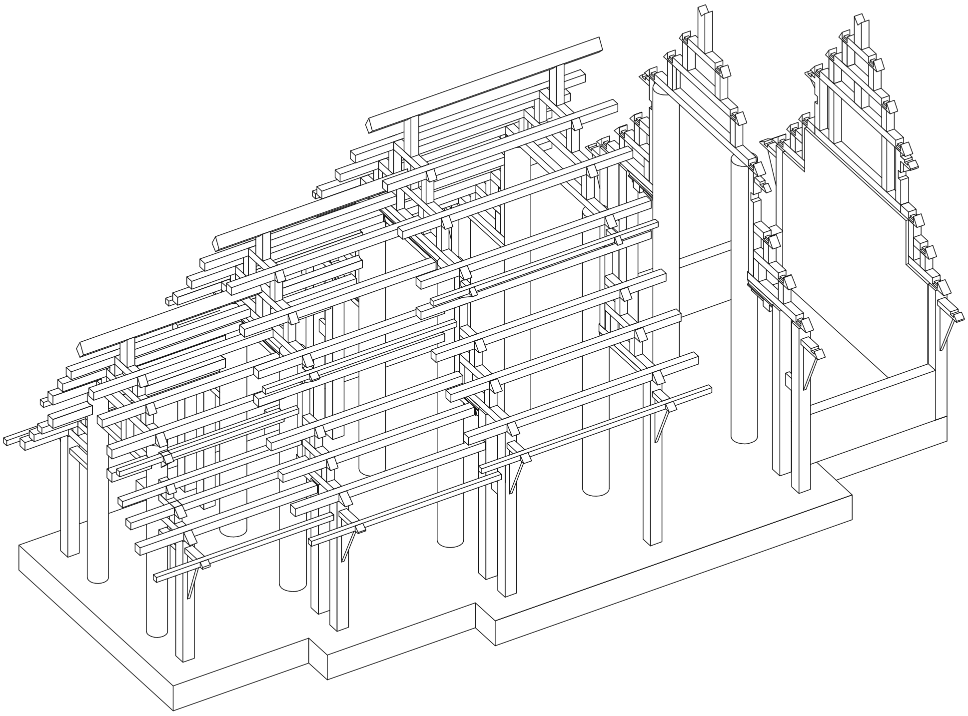


Fig. 3.41 Axonometric view of the viharn of Pong Yang Kok monastery

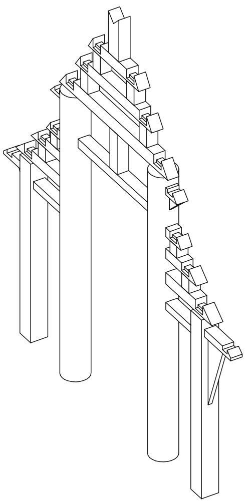


Fig. 3.42 First transverse frame

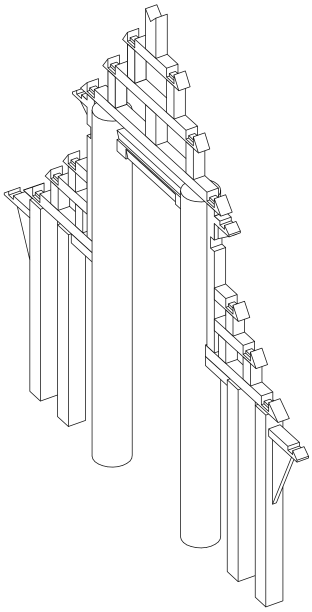


Fig. 3.43 Second transverse frame

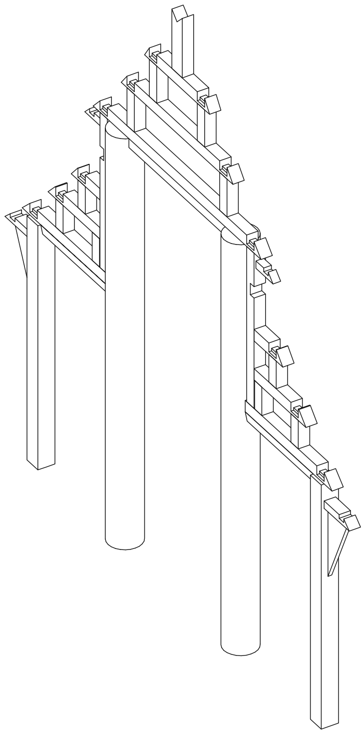


Fig. 3.44 Fourth transverse Frame

position. The second aisle purlin is mortised into an additional beam in between nave pillar and inner aisle pillar directly underneath the main aisle beam and fixed via a vertical nail. The third aisle purlin is mortised into the flanking pillar using a vertical tenon. The uppermost aisle purlin and the main nave purlin are mortised into nave pillar. The second nave purlin is mortised into an additional horizontal beam beneath the main beam. The third nave purlin as well as the ridge purlin are mortised into added standing pillars. The connections of the purlins from the second to the third transverse present consistency, apart from the third aisle purlin. This one is connected in between the franking pillar and the additional standing pillar.

Fig. 3.45 First transverse frame at the frontal facade; we can observe that the second and thrid aisles beams mortised directly to the nave pillars

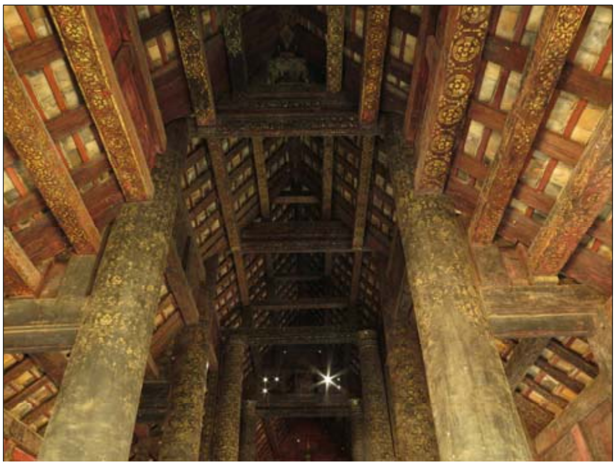


Fig. 3.46 Purlins from the first bay meeting the second transverse frame

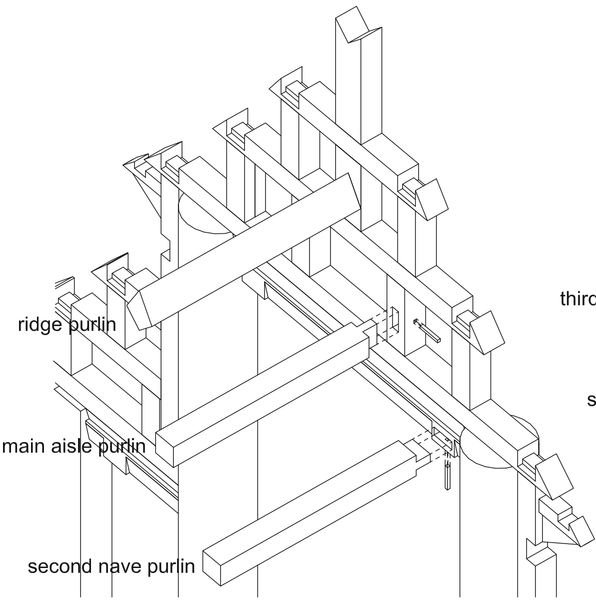


Fig. 3.47 Purlins from the first bay meeting the second transverse frame in nave roof

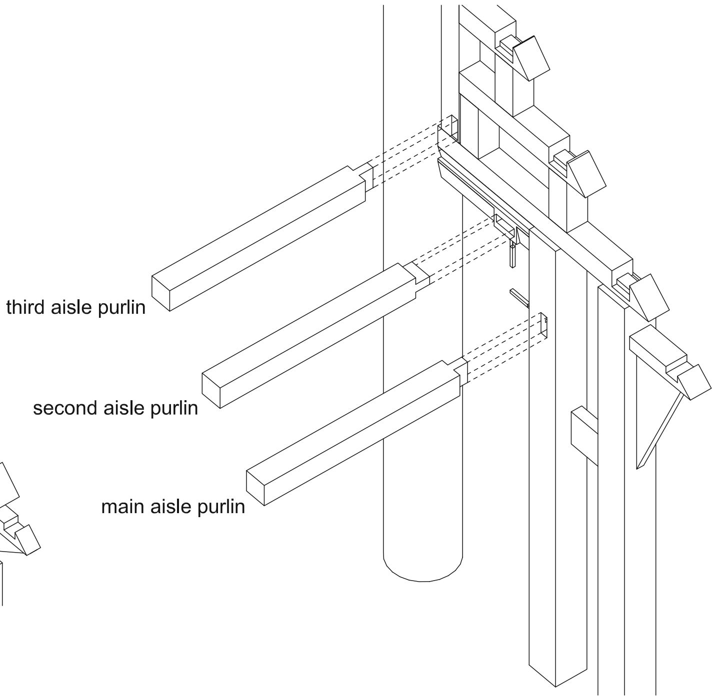


Fig. 3.48 Purlins from the first bay meeting the second transverse frame in aisle roof

3.4 Chiang Mai Region

Viharn of Ton Kwen monastery, Hang Dong district, Chiang Mai province

The monastery of Ton Kwen was built in 1856 (2399) during the Lan Na revival period in the reign of King Kawilorot (rule: 1856-1870). According to the local history, the abbot of monastery at the time was Phruba Inn. He was known as a skillful carpenter. He erected the monastery's viharn in approximately 1858 (2401) (Charoenmuang 2009, p. 105).

The viharn was made as a timber structure. The carpenter built up the brick wall in between all outer aisle pillars to enclose the building. The base foundation of the viharn is elevated 1.35 m above the surrounding ground. The structure of the viharn is comprised of six transverse frames, divided into five bays. The space in between third and fifth transverse frames constitutes the principal hall. The dimensions of the transverse frames are reduced twice to the front and once to the rear side (Fig 3.49). The transverse frame's composition consists of nave part in the centre and aisles to the left and right sides. The nave pillars are round, while the outer aisle pillars are of rectangular shape.

The nave roof structure seems to be steeper than the previous viharns in Lampang province. In the principal hall, the main crosswise beam is placed above the pair of nave pillars at a height of 7.00 m. Its length is approximately 4.00 m. A pair of *tang mai*s is placed above the main crosswise beam carrying the upper level crosswise beams. My investigation observed that the carpenter assembled additional standing pillars in the middle of the frame in order to prevent the second crosswise beam from sagging. The third crosswise beam carrying the ridge supporting pillar is assembled above the second beam following the same principle. The main aisle beam is jointed to the nave pillar on one side by tenon and fixed on top of the aisle pillar via the recessed tenon on other side. The joinery at this position is hidden. There cannot be found any trace that would allow to assume a simple tenon, a dovetailed tenon or whatever. A gap due to an loosened joinery would have helpful but that doesn't exist. The flanking pillar is assembled on top of the main aisle beam attached to the nave pillar with almost no space in between. The second and third aisle beams are fixed on the flanking pillar by a tenon on the inner side and carried by *tang mai* on the outer side (Fig 3,51-3.52). The frontal transverse frame looks very similar to the other frames. The pair of the central nave pillars present an eye-catching difference. They are of octagonal section (Fig 3.50).

The methods employed by the carpenter for combining the purlins from smaller to larger transverse frame displays a framework following an entirely different structural rational compared to cases in Lampang province. The carpenters rely on keyed tenons in all cases. Some keys are wedges, some keys nails. For the connection from the first to second transverse frame (see Fig. 3.55), the main aisle purlin is mortised to the additional aisle pillar that the carpenter combined into the aisle part. The tenon is secured by horizontal wooden nail. The second aisle purlin is held by the additional horizontal element; the carpenter notched the purlin at the lower side and nailed to the element in vertical direction. The third aisle purlin is attached to the main aisle beam, it is notched at the upper side and the carpenter nailed to the aisle beam in vertical direction as well. The uppermost

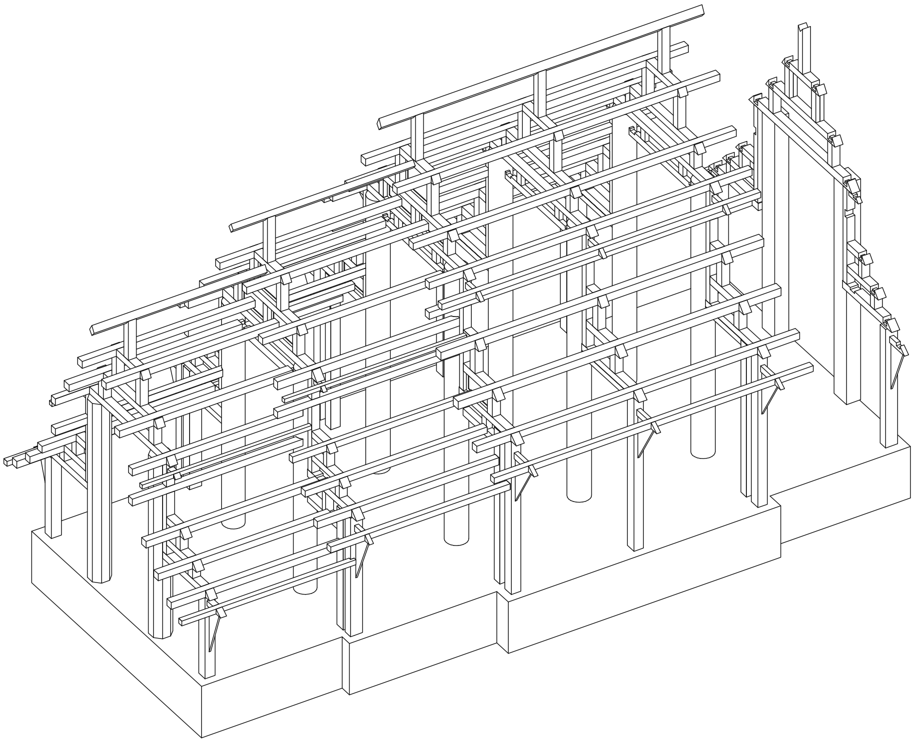
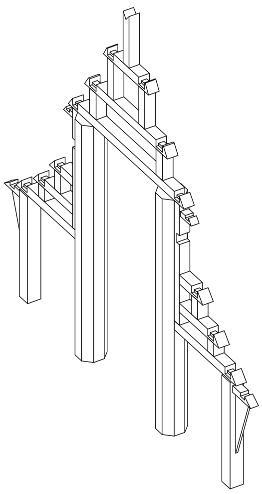
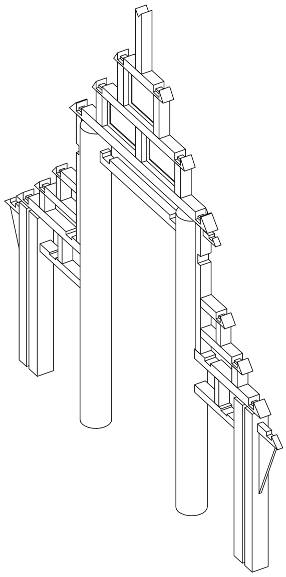


Fig. 3.49 Axonometric view of viharn of Ton Kwean monastery.





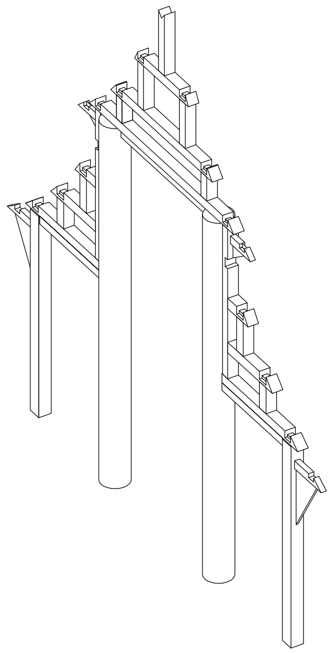


Fig. 3.50 First transverse frame

Fig. 3.51 Second transverse frame

Fig. 3.52 Fourth transverse Frame

purlin of aisle roof and the main purlin of the nave structure are tenon to the nave pillar. The second nave purlin is notched on additional horizontal element; the carpenter secured the connection using vertical key nail. The third and the ridge purlin are tenon to the in filled wooden panel inside the frame between standing pillar and horizontal beam. They are secured by key horizontal wedge. My investigation observed that a purlin is placed on its seat by double recessed halved joint.

Fig. 3.53 First transverse frame at frontal facade

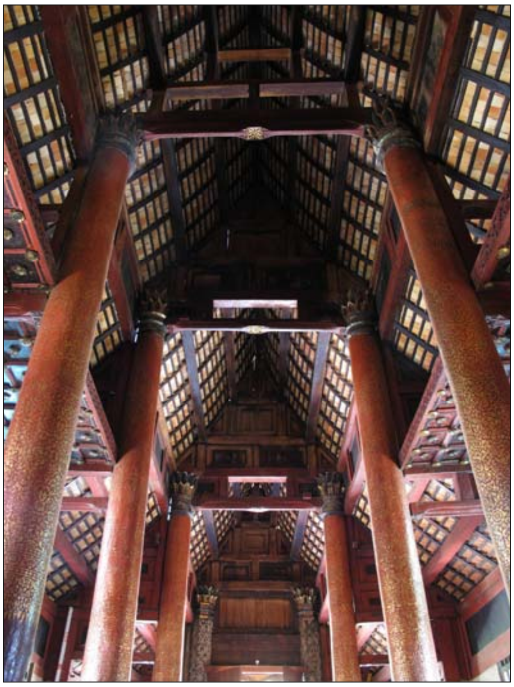


Fig. 3.54 A view from principal hall towards the first transverse frame presenting the roof structure

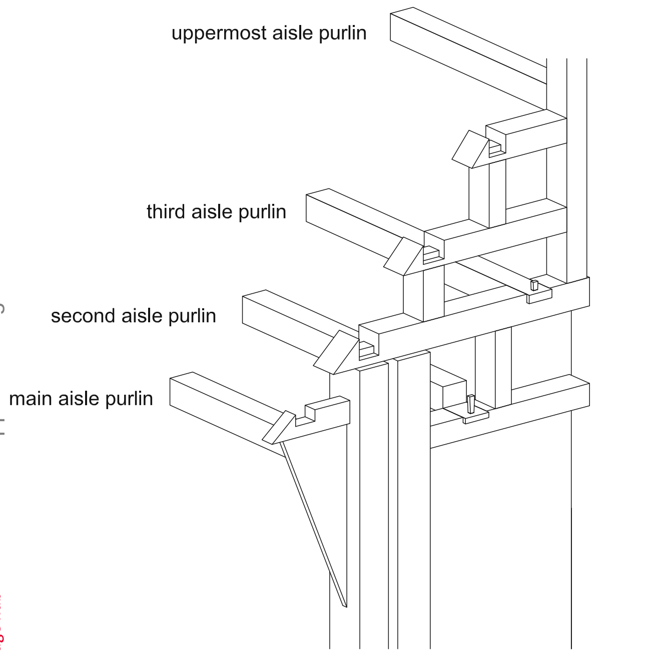


Fig. 3.55 Purlins from the first bay meeting the second transverse frame in aisle roof

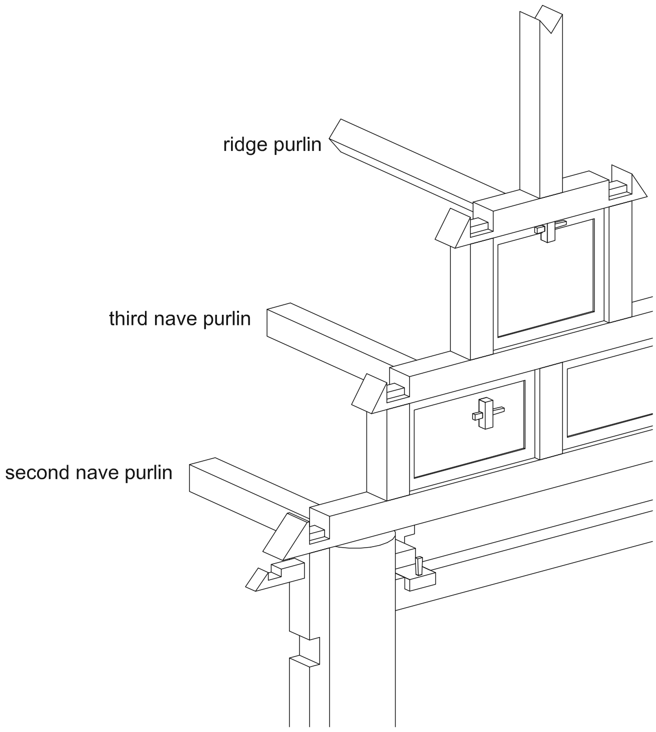


Fig. 3.56 Purlins from the first bay meeting the second transverse frame in nave roof

Viharn of Tung Aor monastery, Hang Dong district, Chiang Mai province

We do not have historical information of Tung Aor monastery (Malai 1997, p. 141). Some study assumes that the monastery was founded around (1807) 2350 and the viharn probably was erected during 1857-1907 (2400-2450) (Boonyasurat 1992, p. 110). The building was made as a timber structure, situated on a foundation base at a height of 1.45 m above the surrounding ground. The carpenter built up brick walls in some parts to enclose the area. In total, the viharn's structure comprises seven transverse frames, thus divided into six bays. The first bay is intended as the porch area, it is enclosed by a brick wall 0.75 m high. The second bay is enclosed partly with brick wall at the height of approximately 1 m. The carpenter inserted a wooden grill in the central third of the wall above the brick wall and enclosed the uppermost space by vertical wooden boards. The area in between third and fifth bay comprises the principal hall. The walls defined by the corresponding outer aisle pillars are closed by brick walls at the bottom part and wood panels above. The principal Buddha image is enshrined in the final bay closed to its rear side by a brick wall to full height. The inner nave pillars show a round section with only exception of the frontal's pillar. They present an octagonal section. All aisle pillars are rectangular.

Taking the principal hall as reference dimension the transverse frames are reduced twice toward the frontal façade and once to the rear side following the main crosswise beams that are becoming shorter step by step (see Fig. 3.57). The main beam in the principal hall measure 2.90 m. The carpenter placed it above the pair of nave pillars at the height of 4.95 m. The aisle beam is 1.50 m in length assembled above the outer aisle pillar at the height of 3.11 m. The arrangement in this principal hall attributes to the comparatively narrow dimension of nave and aisle compared to the other examples. At the connection point of aisle beam to nave pillar one can observe the nail securing tenon there. Regarding the assembling of the aisle roof structure, we observe that the second and third aisle beams are mortised to flanking pillar on one side secured by round wooden nails, while on the other side are carried by *tang mai*s and fixed on their top ends by tenons. The carpenter assembled the purlin a top the intersection of the aisle beams and supporting pillars using double recessed halved joints. The assembling of the nave roof structure had been carried out following the same principle. Generally speaking the flanking pillar are attached directly to the main nave pillars. Only the second transverse frame stands out (Fig. 3.59). There the flanking pillar stands apart from the nave pillar in a distance of 8 cm.

For the attachment of the purlin connecting smaller transverse frame and the following larger one the carpenter introduced a jointing technique appearing strikingly expressive. He used through tenons that were keyed by a wedge. The tenon-head extruded beyond the fixing point up to 25 cm. The arrangement in longitudinal direction can be described in the following order (see Fig. 3.63), starting from the lower purlin to the upper one. The main aisle purlin is mortised into to the additional pillar secured by a horizontal wedge. The second aisle purlin's end is recessed to a long horizontal beam. This tenon is clamped in between to inserted beams beneath the main aisle beam. It is keyed by a vertical wedge. The third aisle purlin penetrates an in filled panel via its recessed tenon. This one's secured horizontally. The uppermost aisle purlin and the main nave purlin are recessed to

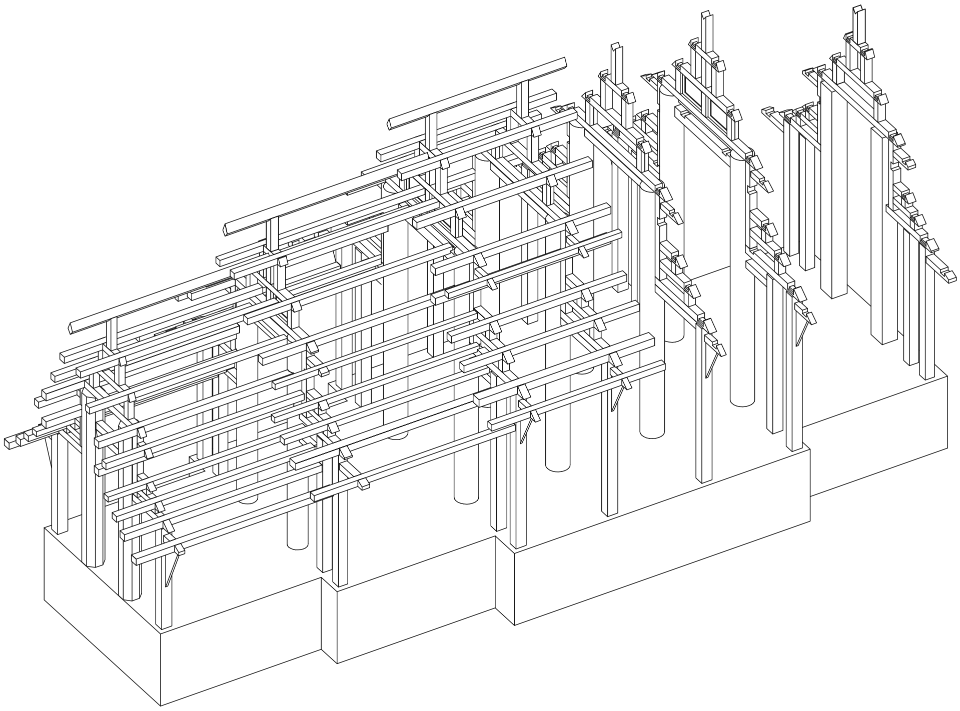


Fig. 3.57 Axonometric view of the viharn of Tung Aor monastery

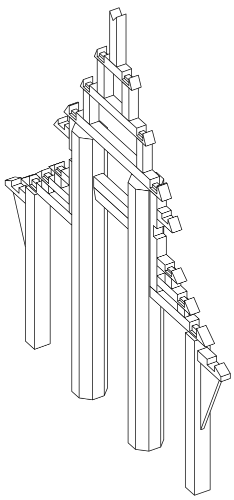


Fig. 3.58 First transverse frame

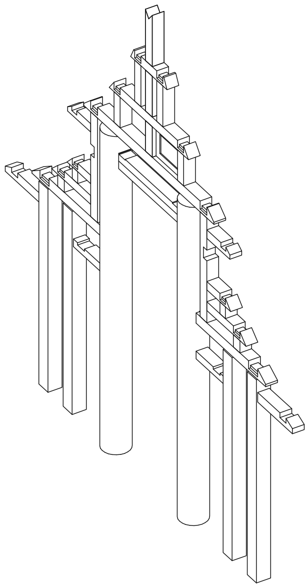


Fig. 3.59 Second transverse frame

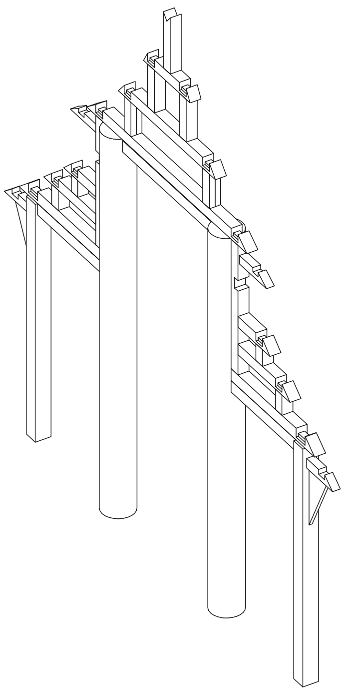


Fig. 3.60 Fourth transverse Frame

tenons alike. There tenons penetrate the nave pillar directly above each other. They are secured horizontally. Considering their important task in the erection process –these purlins are principle locking devices in longitudinal direction– and their vulnerability due to the tiny connecting surface of round pillar and wedge, the carpenter refined the contact surface by enlarging it. Thus he cut a horizontal groove into the pillar to support the wedge's back. All pulling stress is distributed to this enlarged surface in contrary to otherwise just two points. The second nave purlin is notched on top of an inserted horizontal beam beneath the main crosswise beam, secured by a vertical key wedge. The third purlin and ridge purlin penetrate an in filled panel and the additional standing pillar respectively, both of them are secured by horizontal key wedge.

Fig. 3.61 Purlins from the first bay meeting the second transverse frame in aisle roof

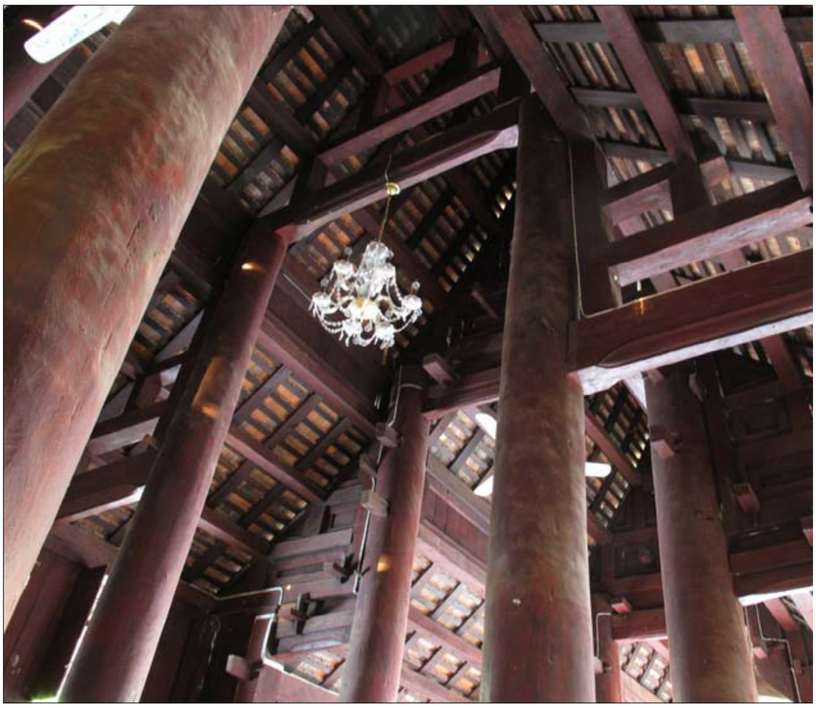


Fig. 3.62 Purlins from the second bay meeting the principal hall

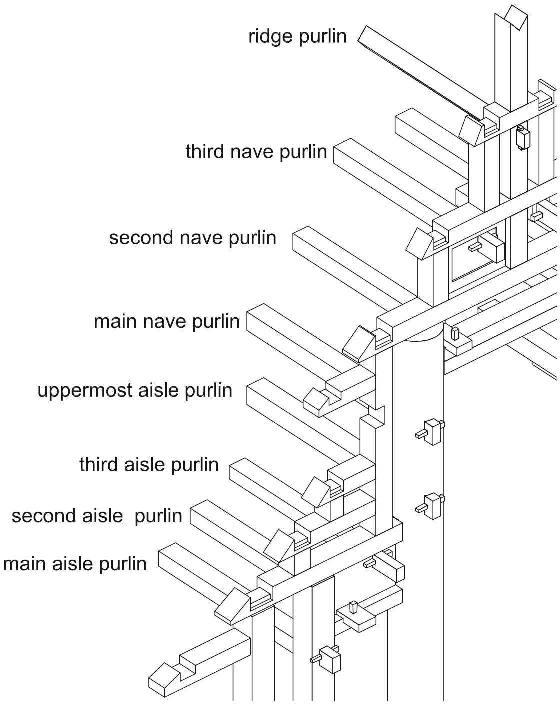


Fig. 3.63 Purlins from the first bay meeting the second transverse frame

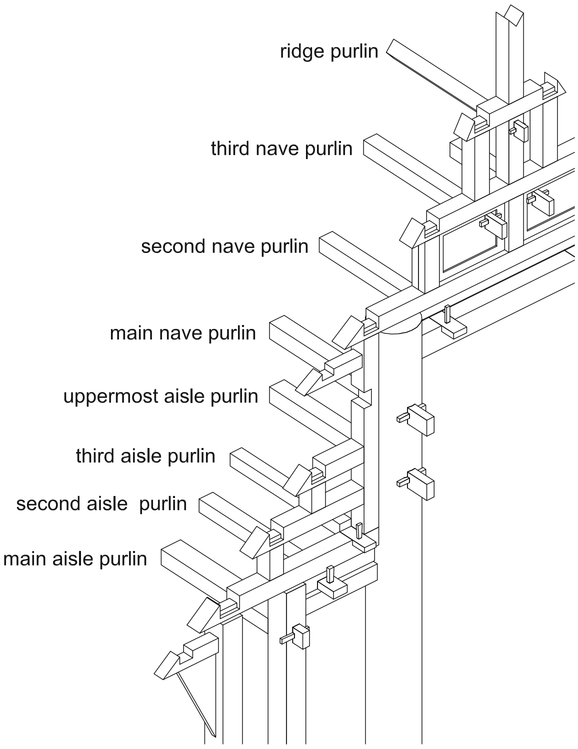


Fig. 3.64 Purlins from the second bay meeting the third transverse frame

Viharn of Prasat monastery, Mueang district, Chiang Mai province

Prasat Monastery was founded in approximately 2035. The viharn of the monastery was erected in combination with a stupa approximately during the years 1841-1843 (2384-2386) (Boonyasurat 2001b, p. 206-207). The main structure of the building is made of timber situated on elevated basement at a height of 0.9 m above the surrounding ground.

The timber structure is comprised of seven transverse frames, creating six bays. At this viharn, we meet a brick wall closing nearly all open space left between the pillars defining the outline. The first bay is closed to both sides by the wall reaching the level of the main aisle purlin. From the second to the fifth bay the brick wall reaches only a height of 1.25 m. Above the solid wall the space is closed by wooden frames filled with wood panels. The carpenter built up brick wall at the final bay leaving an open access to the stupa where the main principal Buddha Image is enshrined. The section of the pillar varies. Apart from the frontal facade's octagonal section, all nave pillars are round. The aisle pillars are all cut rectangularly. Third, fourth, and fifth bay comprise the principal part covered by the highest roof of this building.

The ground floor plan and the arrangement of the roof structure in this viharn are comparable to the viharn of Ton Kwean monastery. The dimensions of the transverse frame are reduced twice toward the frontal façade and once to the stupa side (see Fig. 3.64). At the principal hall, the transverse frame displays a proportion appearing rather steep. The main crosswise beam is 4.95 m long and placed above the nave pillar's pair at the height of 8.00 m. The aisle beam is 2.90 m. long and situated at the height of 4.75 m. The cross section of aisle beam is 21 cm. This is larger than the comparable beams in Ton Kwean and Tung Aor monastery. The aisle beam is mortised into the nave pillar. The carpenters secured the tenon by using rectangular wooden nail. Generally the joinery in this building relies on tenon joints keyed by wooden nails. These nails are left uncut and can be seen therefore protruding the surface of pillars and flanking pillar alike. Purlins and horizontal beams are connected via halved joints using double recesses.

Regarding the longitudinal connection the carpenters used tenon joints and notched joints secured by wedges and nails to fix the purlins arriving from a smaller frame at the larger one (see Fig. 3.71). The main aisle purlin is mortised into an added pillar keyed again by wooden nail. The second aisle purlin is notched to a horizontal beam inserted underneath the main aisle beam for this purpose. The securing wedge is mounted vertically. The third aisle purlin meets a panel filling the structural frame of aisle beams and related pillars in appropriate height. The third aisle purlin's protruding tenon is keyed horizontally. The uppermost aisle purlin and the main purlin of the nave roof are tenon to nave pillar. The carpenter used wooden nails to secure the connection. The second nave purlin is mortised into the related horizontal beam beneath the main transverse beam, and fixed by a vertical nail. The third and the ridge purlin are mortised into infilled wooden panels closing the structural frames. They are secured by horizontal wedge.

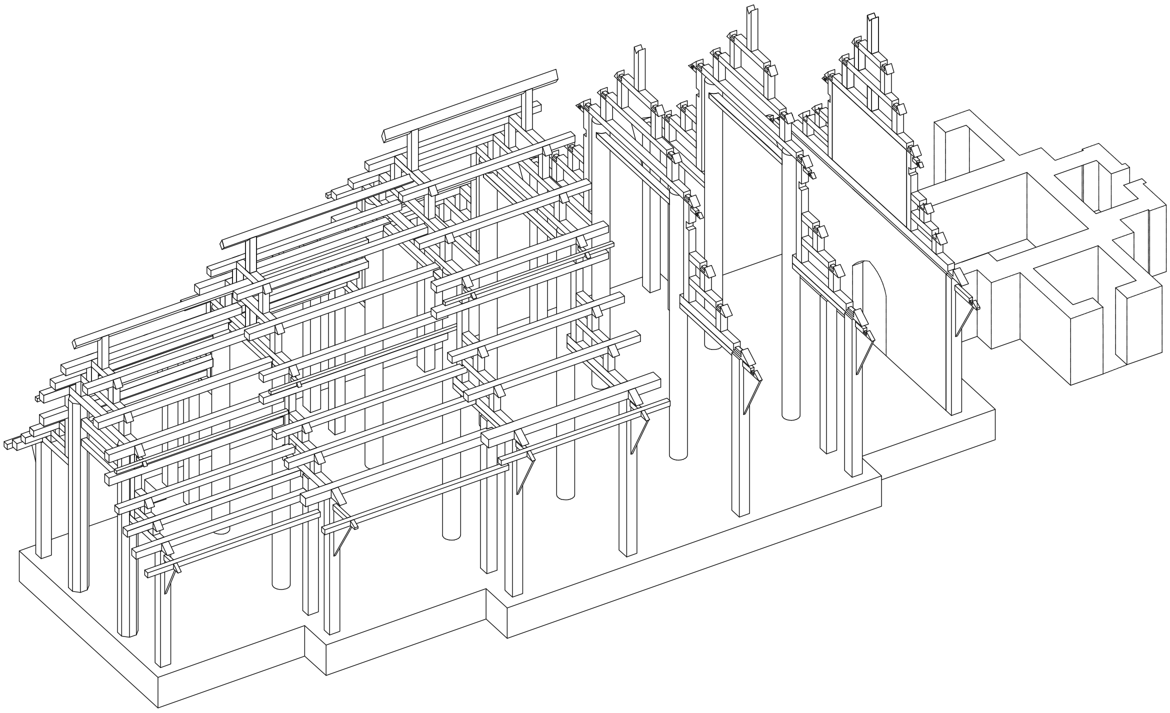


Fig. 3.65 Axonometric view of the viharn of Phrasat monastery.

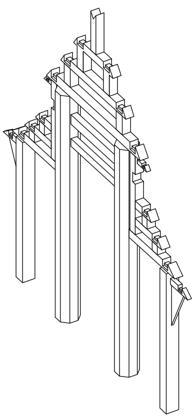


Fig. 3.66 First transverse frame

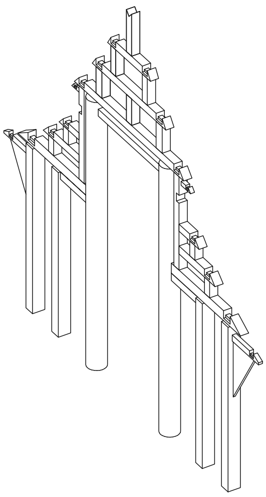


Fig. 3.67 Second transverse frame

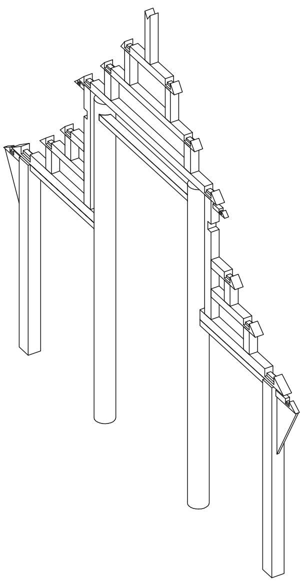


Fig. 3.68 Fourth transverse Frame

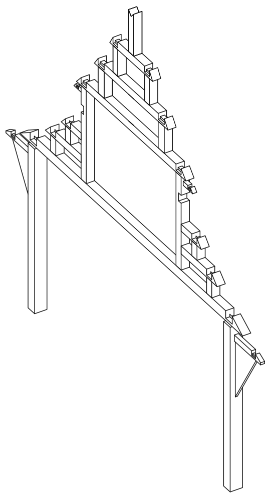


Fig. 3.69 Seventh transverse Frame

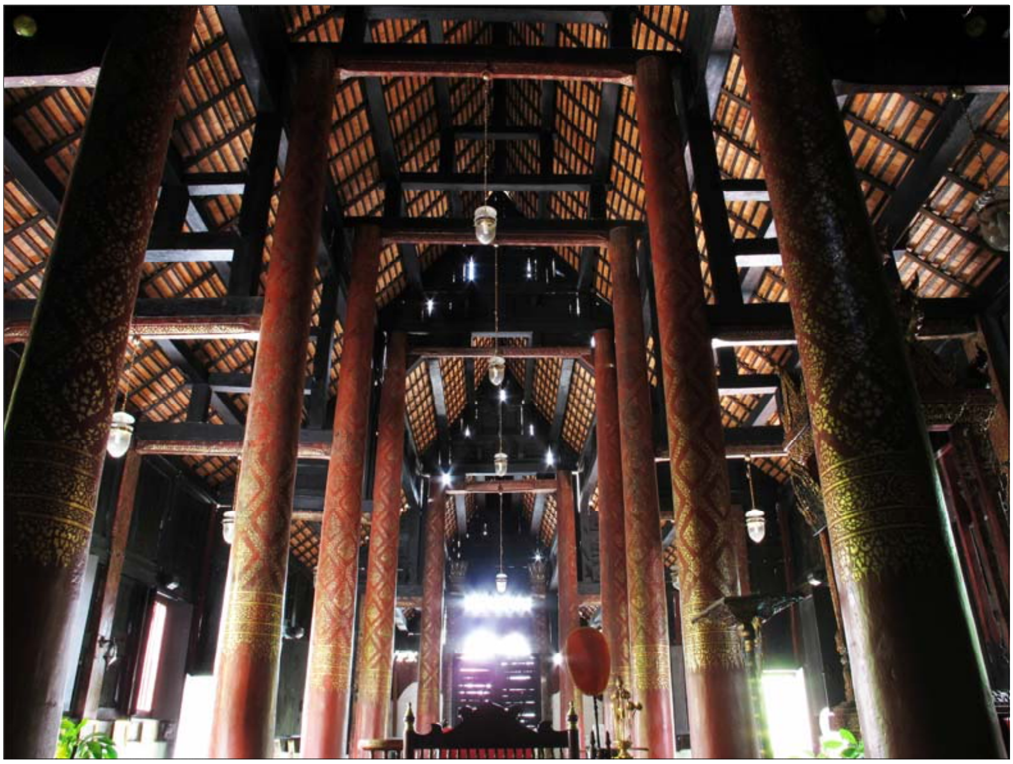


Fig. 3.70 Roof structure of the viharn of Phrasat monastery; seeing from the principal hall toward the first transverse frame at the frontal facade

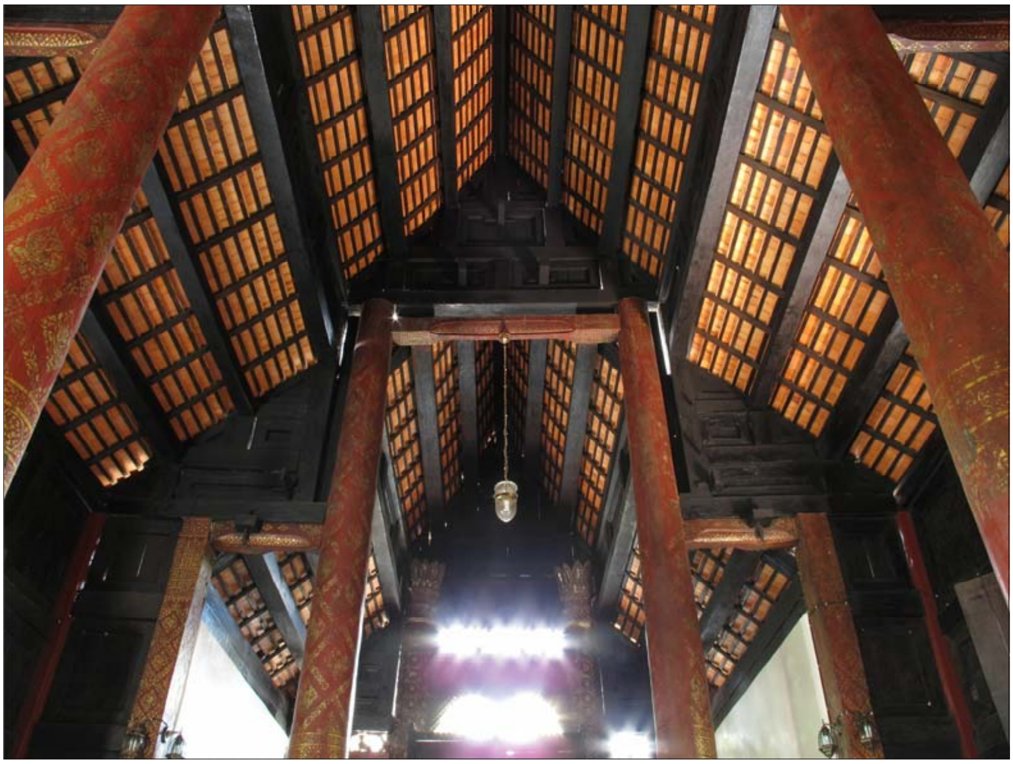


Fig. 3.71 Connection of purlin from the first bay meeting the second transverse frame

3.5 Other Regions

Viharn of Hong Ngaer monastery, Pua district, Nan province

The viharn of Hong Ngaer monastery was erected on a foundation platform height 0.3 m above the surrounding ground. The main structure is made of timber and comprises of nine transverse frames, defining eight bays (see Fig. 3.72). The first bay indicates the porch area having no enclosing wall. The carpenter closed the outsides from second to seventh bay at half height with a brick wall. Above the brick wall he closed the open space with a wooden grill filled and wood panel. The final bay is closed entirely in crosswise direction providing backdrop for the principal Buddha images. The space in between fifth and seventh transverse frame makes up the building's principal part. The dimension of the transverse frame is reduced only in height twice toward to frontal and once to the rear side, while all spans are maintained. The nave pillar is round and the aisle pillar is rectangular.

The composition of a transverse frame consists of a central nave and aisles on both side as in previous cases, but the arrangement and the assembly had been carried out following a different method. The nave roof structure consists of four levels of crosswise beams including the main one in contrary to the cases in Lampang and in Chiang Mai regions that display only three (see Fig. 3.76). In the principal hall the main crosswise beam is placed on top of the nave pillar pair at a height of approximately 4.9 m. Measurement of the beam presents a length of 4.6 m. The second, third, and fourth crosswise beam measure in length 2.92, 1.70, and 0.75 m. respectively. They carried by pairs of *tang mai*s 0.8 to 0.85 high. Although the purlin is similarly positioned at the alignment between the intersected point of beam and pillar, it was not connected only to the beam as in previous cases (e.g. halved to the beam). Three components meet at a junction (see Fig.3. 85-4). The carpenter started to prepare the junction by cutting the upper edge of *tang mai* into cross shape, then recessed both cheeks of the beam corresponding to the opening of the previous cut *tang mai*. He assembled the beam to the *tang mai* in crosswise direction flushing its upper edge. In order to assemble the purlin, he had to recess again both cheeks of the purlin following the given opening of *tang mai* in lengthwise direction. The previously recessed part of purlin and beam are again halved inside the cross shape opening (see Fig.3. 78). The carpenter used this method to connect pillar, beam, and purlin beside the connection of main crosswise beam and main purlin where the carpenter only halved them. Interestingly, the carpenter cut the inner edge of aisle beam connecting to nave pillar into doubled tenon tightening by wedge. Flanking pillar is fixed on the aisle beam using double footings as well. The second and third aisle beams are connected to flanked pillar by tenon joint, secured with wooden nail.

Regarding the longitudinal connection the carpenter's task was comparatively comfortable. Since all pillars stand in line, all purlins starting at a lower frame can easily be connected to the corresponding pillars of higher frame. The mortised tenons are secured against pulling strength by wooden nails. In addition, the carpenter assembled a longitudinal element with the cross section of 9 cm. x 9 cm, fixed as a through tenon along the whole length of the building from the second

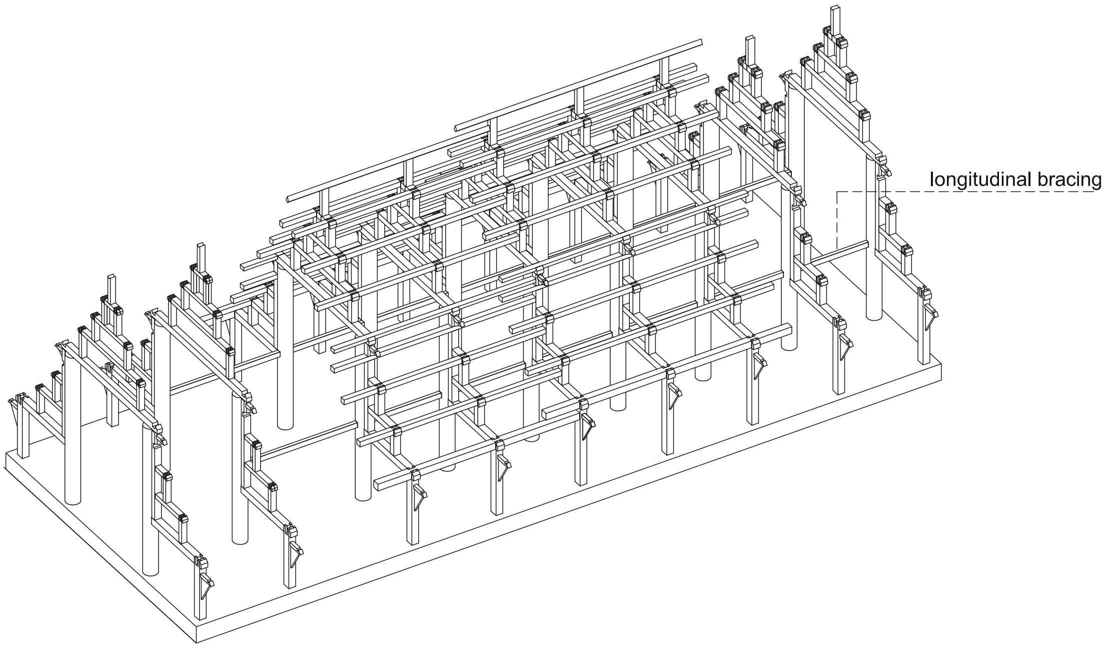


Fig. 3.72 Axonometric view of the viharn of Hong Ngaer monastery

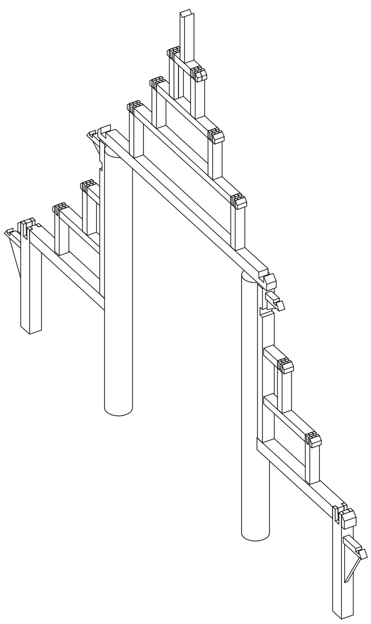


Fig. 3.3 First transverse frame

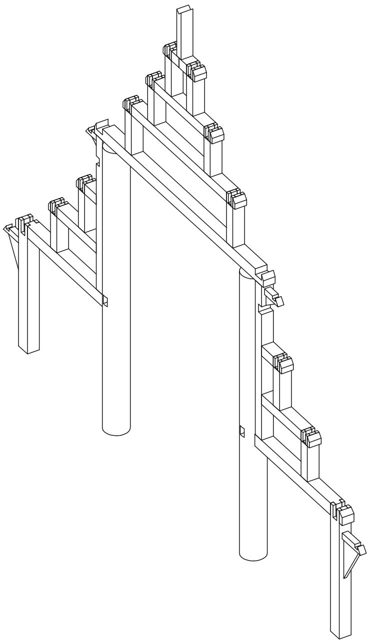


Fig. 3.74 Third transverse Frame

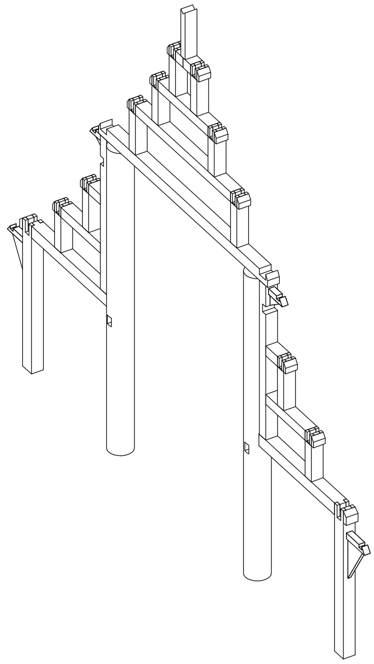


Fig. 3.75 Fifth transverse Frame

Fig. 3.76 Nave roof structure consists of four levels of crosswise beam

Fig. 3.77 Carpenter inserted longitudinal bracing along nave pillars

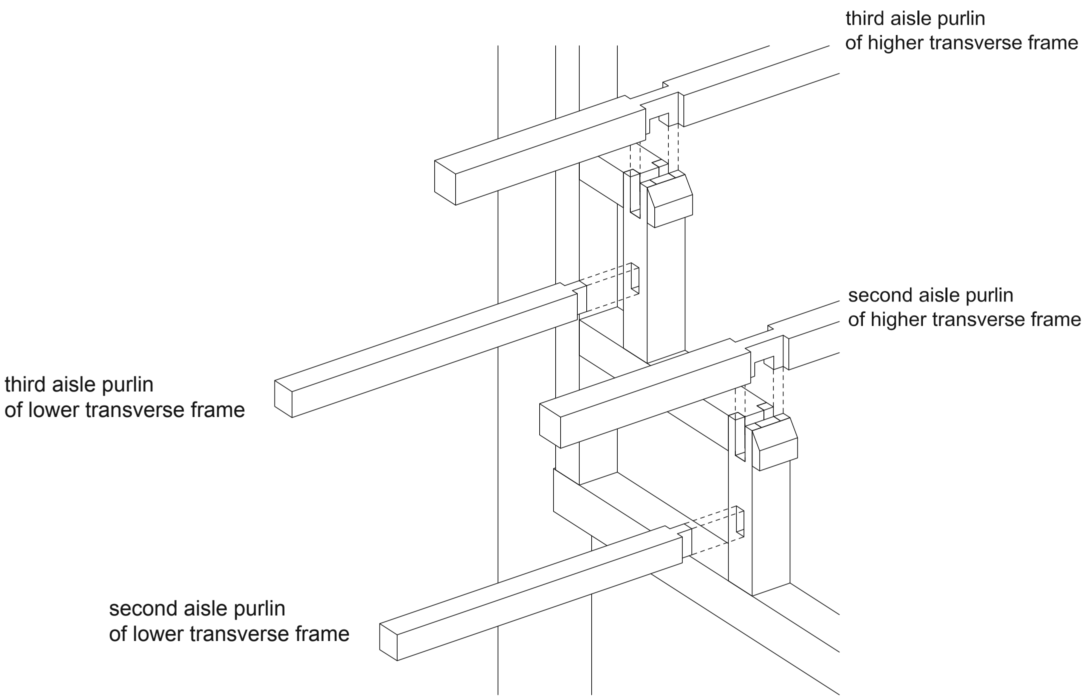


Fig. 3.78 Purlins from the first bay meeting the second transverse frame in aisle roof

transverse frame to the final. The reason for this assembling can be seen as the improvement of longitudinal stability (see Fig. 3.72).

Viharn of Chiang Khong, currently in Samutprakarn province

The viharn is open to all sides. The overall structure of the viharn is comprised of eight transverse frames and thus divided into seven bays. The building as shown in the open-air museum of Ancient City near Bangkok was re erected on a base foundation about 50 cm high. The history of this building is ambiguous. We only know that the building was originally located in Chiang Khong district, Chiang Rai province. Hence, the museum names it the viharn of Chiang Khong.

The central nave pillars are round, while the outer pillars are rectangular. The principal part is constituted from transverse frames defining third to sixth bay (Fig. 3.79). There is a striking different detail in assembling the structural components of this viharn's transverse frames and the main purlin. This purlin is fixed disassociated from the flanking pillar. The main crosswise beam is held in place by a double height tenon on top of the nave pillars. At this fixation point, the seat for main nave purlin is prepared as the tenon head of nave pillar is extended through the main crosswise beam to secure the purlin in to its place. The assembling of upper crosswise beam and supporting *tang mai*s also follows this way of fixation. The nave structure is comprised of three levels of crosswise beams including the main one as well as the horizontal beams in the aisle structure. Second and third aisle beams are mortised into the flanking pillar secured by wooden nails. In my investigation I realized that the flanking pillar is placed next to the nave pillar only fixed at its bottom and top end. Its foot end is mortised into the main aisle beam, its top end into a bracket arm carrying the uppermost aisle purlin (Fig. 3.81). The bracket arm itself is mortised into the nave pillar as a cantilevering element. The restriction of the flanking pillar to this short height is exceptional. A consequence of this structural decision is uncommon. The flanking pillar and the nave purlin are not aligned above each other. Thus the neck part cannot be formed. The carpenter only placed the wooden board grooved at its lower part to the upper most aisle purlin.

The purlins from lower transverse frames can be connected to the pillars of the higher frame since all alignments of pillars are consistent. The carpenter applied the through tenon with securing wedge for fixing them. In addition the carpenter integrated transverse and longitudinal bracing for stabilizing the whole structure. For the longitudinal bracing, it is fixed at the nave pillar beneath the aisle beam running from the first until the final transverse frame, the connection point is tightening by wedge.

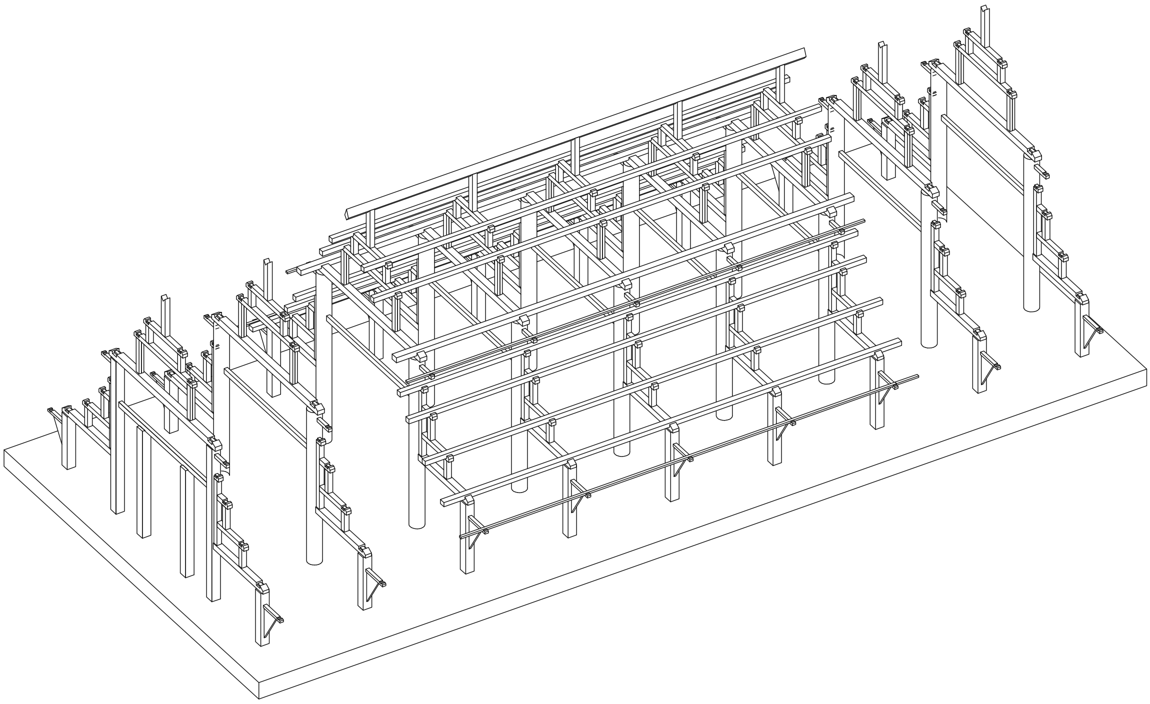


Fig. 3.79 Axonometric view of the viharn of Chiang Khong monastery

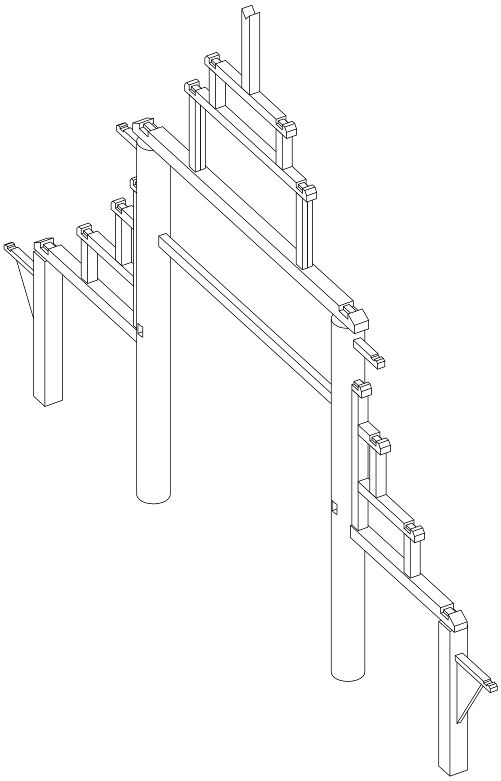


Fig. 3.80 Fourth transverse frame

Fig. 3.81 Flanking pillar reaches until the bracket arm supporting uppermost aisle purlin; it is disassociated from the main crosswise beam

3.6 Structural Aspects in *Tang Mai* System

3.6.1 Curved roof plane and longitudinal connection

The higher or lesser degree of roof inclination is a result of the ratio between purlins' distance and supporting pillar. the curved roof as we have seen at viharn roofs is a result summing up the increasing ratio of the distance of purlins from lower to upper levels in relation to the height of *tang mai* growing from outside to inside. A prevailing concept of the "school of carpentry" categorizes the building according to their formal expression of the roof. The two options are a significantly curved roof surface or a flatter surface. The first group of steep curved roofs is attributed to the Chiang Mai school of carpentry and connoted to an analogy of "female" appearance. The latter group of flatter roofs is of the Lampang school of carpentry and connoted to "male" appearance (Khampuanbutra 2001, p. 70; Siriwetchaphan in Boonyasurat 2001a, p. 58; Boonyasurat 2001b, pp. 57-60).

Not all viharns belonging to the Chiang Mai group follow the generalized assumption of showing a steeper curvature. For instance, the measurement from field investigation obtained at the viharn of Phasat monastery presents a rather gentle raise of the nave roof's curvature (see Fig. 3.83 and 3.84). As with Chiang Mai group's viharns we must not believe that all Lampang representative fit into the assert scheme. My measures of Wieng Thoen monastery's viharn prove this statement. Nevertheless, my disagreement does not imply that we shall reject completely the concept of school of carpentry. The viharns do show significant building technique unique and therefore representative in regions. But the implication to roof shape alone is too superficial, thus not acceptable.

The methods that carpenters employed to combine different transverse frames display the coherency in idea and consistency in method within the group of Lampang and Chiang Mai. According to my analysis, all the examples that have been categorized to Lampang group need to be discussed under more characteristics and technical means than the above mentioned roof shape. In stark contrast, I present three viharns from Chiang Mai region selected for my analysis. There the carpenter connected the purlins departing a smaller transverse frame to a wooden panel filling the open space inside a framing of structural components determined more or less randomly by purlin's position.

The arrangement of structural components to form the curved roof plane and the longitudinal connection of purlins are in fact interrelated aspects. We could even say they are mutually dependent. The main purlin and the second purlin are connected on the nave pillar and the added beam beneath. The significant difference starts at the connection point of the third nave purlin. For Lampang cases the carpenters connected the third purlin either on second crosswise beam or an additional component, while the Chiang Mai carpenters connected it in an infilled wooden panel. It shall be observed that the ratio of the set-back measurement of the purlin and the height of the *tang mai* begins to shift at this position as the curved plane of the roof starts to increase its steepness. Thus, it would not be easy to arrange the connection point on the structural component. Additionally the introduction of added structural elements seems to have been unfamiliar to them.

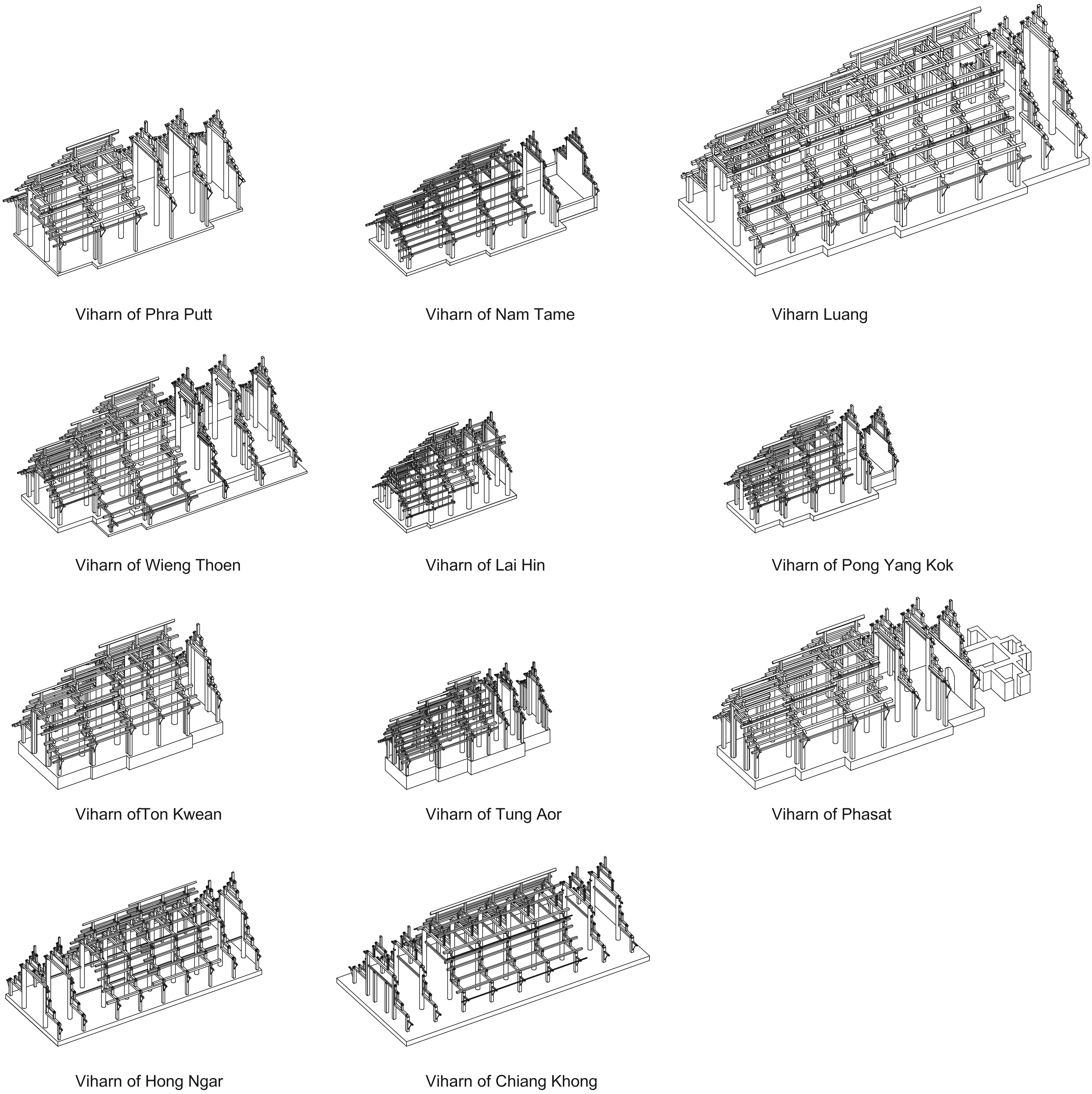


Fig. 3.82 Structural typology of viharns reflecting their sizes in the same scale

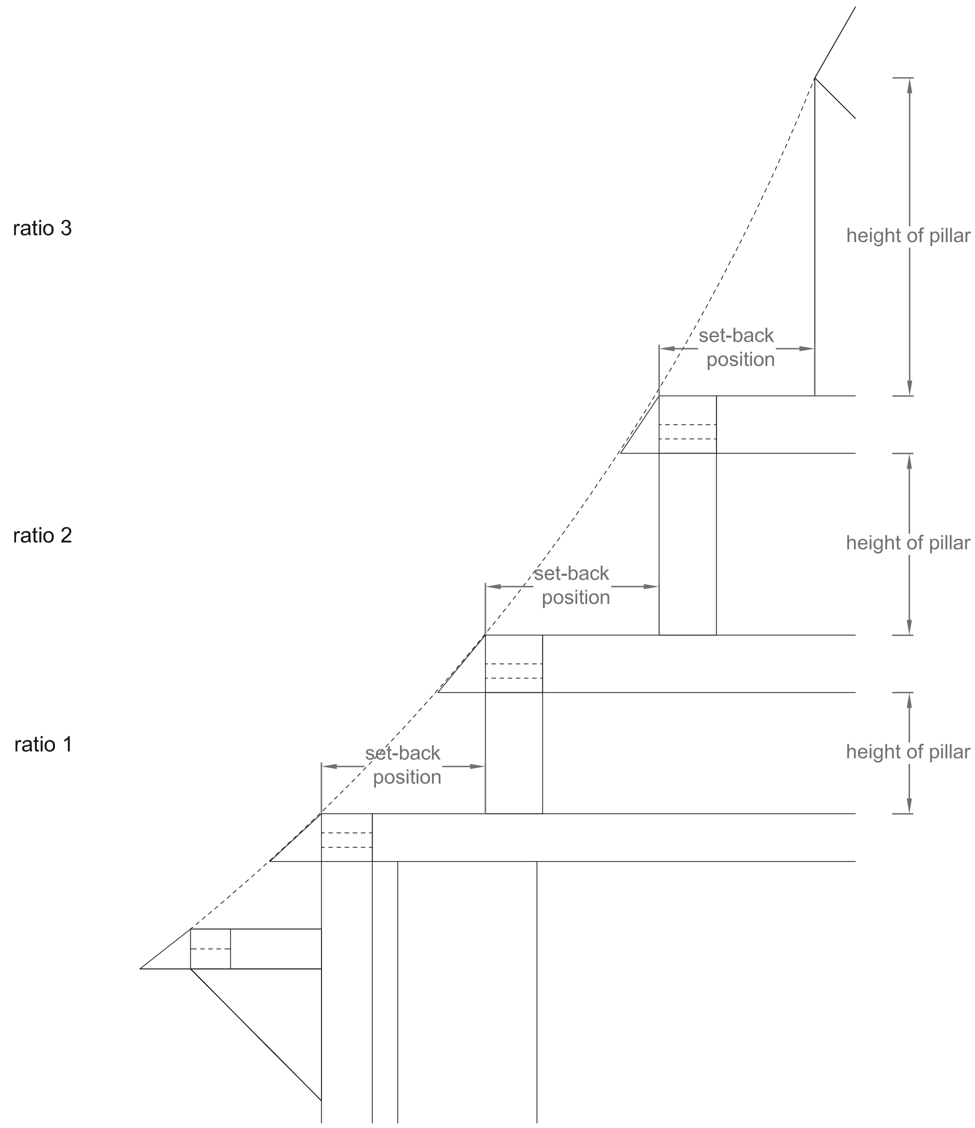


Fig. 3.83 Ratio: height of pillar / set-back position

	main crosswise beam	second crosswise beam	third crosswise beam	first level of staning pillar	second level of staning pillar	ridge standing pillar	Heigth (ridge standing pillar)	Overall Ratio	Ratio 1	Ratio 2	Ratio 3
Lampang											
viharn Phra Putt	4.600	3.040	1.560	0.620	0.750	1.140	2.700	0.587	0.795	1.014	1.462
viharn Nam Tame	3.700	2.320	1.350	0.670	0.510	0.820	2.100	0.568	0.971	1.052	1.215
viharn Luang	6.700	4.300	2.510	0.900	0.850	1.740	3.700	0.552	0.750	0.950	1.386
viharn Wieng m.	3.350	2.300	1.230	0.380	0.570	0.990	2.180	0.651	0.724	1.065	1.610
viharn of Lai Hin m.	2.960	1.900	1.100	0.440	0.450	0.810	1.850	0.625	0.830	1.125	1.473
viharn of Pong Yang Kok m.	3.260	2.110	1.170	0.510	0.500	0.800	2.020	0.620	0.887	1.064	1.368
Chiang Mai											
viharn of Ton Kwean m.	4.000	2.560	1.430	0.460	0.860	1.170	2.700	0.675	0.639	1.522	1.636
viharn of Tung Aor m.	2.900	1.740	0.780	0.450	0.560	0.730	1.940	0.669	0.776	1.167	1.872
viharn of Prasat m.	4.950	3.360	1.790	0.640	0.780	1.230	2.900	0.586	0.805	0.994	1.374
Diverse Region											
viharn of Hong Ngaer m.	4.420	2.920	1.690	0.700	0.610		3.220	0.729	0.933	0.992	
viharn of Chiang Khong m.	4.700	2.700		1.030			3.100	0.660	1.030		
viharn of Doi Yuak m.	4.100						2.900	0.707			
viharn of Suchada m.	5.550	4.090	2.460	0.420	0.630	1.480	2.730	0.492	0.575	0.773	1.203
viharn of Sob Lee m.	4.160	2.320	1.120	0.810	0.640	0.910	2.590	0.623	0.880	1.067	1.625

Ratio: height of pillar/ set-back position

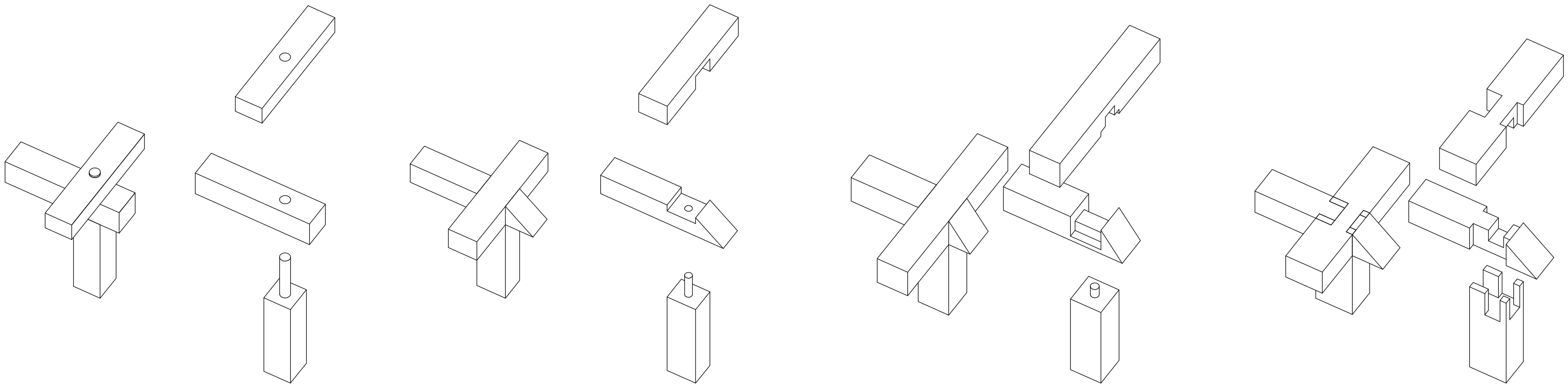
Fig. 3.84 Table presents dimensions of roof structural components and its ratio contributed to the steepness of the curved roof plane

3.6.2 Principle of dovetail and tenon

The method of handling pulling strength either in transverse or in longitudinal axis by developing a refined tenon adding a hidden dovetail can only be found in Lampang region, although not in all cases. For instance, the carpenter employed a recessed tenon at the viharn of Pong Yang Kok monastery. The use of a partly dovetailed tenon contrasts the widespread and much more generally applicable keyed tenon. The mentioned dovetailed tenon is hidden inside the pillar. Nobody can easily realize its execution method by just looking at the pillar. We can only consider whether there existed a group of carpenter (might be comparable to a guild) who transmitted their secret within their closed circle. However we must state that this kind of execution ensured a smooth surface on the pillar enhancing the exceptional furnishing of a viharn's interior.

3.6.3 Assembling detail

The junction between purlin, transverse beam, and *tang mai* is one of the most crucial tasks carpenter had to solve (see Fig. 3.85). The developed results offer a broad spectrum of ideas. Regarding all examples in Lan Na region my analysis can outline two different basic ideas: a) the horizontal elements transverse beam and purlin respectively are put on top of the *tang mai*; b) all three structural elements are intersected. The core characteristic of the first group is the separated treatment of horizontal and vertical elements. The *tang mai*'s sole function is to provide a supportive surface at a given height. There appear three different executions distinguishable by their complexity. The simplest execution puts the transverse beam on top of the pillar and acts as support for the purlin. The two horizontal elements are held in place by a circular tenon recessed on top of *tang mai*. This tenon is long enough to pierce transverse beam and purlin. None of these elements is secured against lateral rotation (Fig. 3.85 -1). An improved execution connected the horizontal elements by a halved joint (Fig. 3.85 -2). Thus these two elements are firmly secured against rotating between each other. The recessed tenon on top of the pillar is housed in the lower beam. The rectangular section provides more résistance against rotation of the pillar out of intended alignment. A further improvement was reached by recessing the neck of halved beam. The tenon head beam left slightly longer(Fig. 3.85 -3). In fact the joint's execution had become a little bit more time consuming but the function improvement stayed. Only with the second group we can speak of a sophisticated solution(Fig. 3.85 -4). The overlapped halved beams were additionally recessed to fit into the crosswise forked top end of the *tang mai*. The horizontal structural elements had been held in place anyway. They were fixed in their position via jointing of their second top end. The forked pillar left no space for any twisting and thus supported the reinforcement of the whole structure.



1. purlin placed on the beam fixed through the tenon

2. purlin halved to the beam

3. purlin halved to the beam with double recesses

4. purlin halved to the beam and secured by crosswise forked pillar

Fig. 3.85 Assembling Techniques: purlin, crosswise beam, and pillar found in Lan Na region

Chapter 4

Tang Yo: Inclined Member System

4.1 Background

Most eye catching, and therefore highly relevant as optical characteristic feature is the roof's shape. This shape is determined for its part by several specifications: primarily the angle of inclination, the curvature and the staggered roof structure in lengthwise as well as crosswise direction. I have explained how Lan Na carpenter managed to create the curved roof shape and the staggered appearance relying on the arrangement of beams and standing pillars in chapter 3. In this chapter I explain the Lan Na specific structural methods of producing the intended angle of roof inclination, its structural inclination, and the way how carpenter managed to provide the huge roof with such an elegant curvature in roof plane. Rafter is the most widely used term in literature we should have in our mind's eye. However I refrain from using the term in this context, not the least due to its inconsistency in English terminology

Chapter 4 is a revision of my article *On Tang Yo: a Historic Structure System of Roof in Lan Na*, published in *Najua* (2015). This chapter cannot begin with the formulation of analytical framework as in chapter 3, since the background study of this system shall be outlined before. The current state of the arts concerning the inclined member or *tang yo* system has failed to provide clear definition and presented inconsistency in the usage of terms. A matter of fact is that the *tang yo* system received much less recognition compare to the description related to *tang mai* or standing pillar system that has been established profoundly in treatises and stimulated attention from the academic.

The term *tang* in *tang yo* is corresponding to the term *tang* in *tang mai* in chapter 3. A dictionary, *The Northern Thai Dictionary of Palm-Leaf Manuscripts*, provides three possible meanings for this term: 1) to appoint, 2) to carry, 3) to lift up (Wichienkeeo 1996, p. 283). The usage of this term in old Lan Na building technique corresponds to the second meaning: to carry. This structural component, *tang yo* has to support roofing member put above. For the term *yo* the aforementioned dictionary does not provide a specific meaning for it. Nevertheless, the term *yo* appears consistently in Tai speaking regions: *tang yo* or just *yo* in Lan Na, *kha yo* in Chiang Tung, *si yua* in Laos. According to discussions with the carpenters in these regions the *term yo* reflects the geometry of inclination. Thus the term *tang yo* characterizes a specific detail of roof structure expressing its functional use and position simultaneously. Prior to 2015, there is no scientific work addressed exclusively on this subject.

A sample of imaginary curved roof can elucidate how importance the roof expression played in Lan Na culture. In the ritual text composed by Yanna Rangsri, the author elaborated an erection process of Lan Na house that involves to a belief of good fortunate. The architectural historian, Vivat Temiyabandha has quoted and annotated this text in his important study *Rituals in House-Building.* The relevant sentences dealing with roof construction and their meaning are worth to be quoted here "assembling the set of lower component and the set of upper component that named a large umbrella [concave shape]. It appears so representative embracing the prosperity and joyfully inviting a visitor" (Temiyabandha 1996, p. 52). The "upper component" in this text refers to a set of structural roof elements possibly including an inclined component, while the portraying of the "large umbrella" reflects a form that create an image of welcoming good fortune.

In Temiyabandha's work, when he referred to the assembling of a house elsewhere, he quoted a text from different source, narrating "…raising up the wall panel, placing the crosswise beam, erecting the jan tan, (the Siamese term for inclined roof member), assembling the purlin to jan tan, laying the roofing material" (Temiyabandha 1996, p. 42). In this case, the Siamese term is clearly adopted to address the inclined member in Lan Na roof. It is believed that the usage of Siamese term *jan tan* (rafter) is interchangeable with *tang yo* of Lan Na. *The Encyclopedia of Northern Thai* defines the meaning of *tang yo* as: "[the term] *tang yo* corresponds to the Siamese term jan tan (rafter). The term refers to the roof structure component that is comprised of 2 members. The cross section of the component is approximately 5 x 20 cm. they are assembled to form the sides of roof triangle. The upper end is mortised to the kingpost and the lower end is placed on the crosswise beam or occasionally cut into tenon shape, then assembled to a mortise on the crosswise beam for transmitting the roof load to the beam similar to the pediment [structural frame]. *Tang yo* is used as a substitution of pediment [frame]. Therefore, *tang yo* could only be found in area that does not have pediment," (Foundation of SCB 1995, p.243). My study shall make a note immediately that the final sentence referring to pediment frame and inclined member frame is not necessity true for all cases; there exist cases that consist both pediment frame in combination with the inclined member frame (for example, see the central pediment of the mandapa of Ton Kwen monastery).

Another research report investigating at the core region of a building culture that displays distinct features of inclined member system resulting into the publication *Tai Lue Viharn in Nan Province* by Samart Siriwetchaphan (1987). This publication still addresses the inclined component by using the term jan tan. The term "*khue*" or crosswise beam is referred as the "bracing component," or "*mai kham*" in Thai (Siriwetchaphan 1987, p. 78). The preference of Siamese terminology occurred regularly in the studies upon describing Lan Na historic roof structure.

The priority of my concern is in fact not merely an adoption of Siamese terminology in substitution to the one of Lan Na. I want to emphasize the intrinsic meaning deriving from the term to prevent confusion and bring order into continuous ambiguous terminology. In contemporary use, Thais tend to address a diagonal component that is hanging from a ridge purlin and over a head beam by using the term *jan tan*. But, the structural behavior of this contemporary *ja tan*, is significantly different from the traditional *tang yo*. In historic Lan Na the inclined member in the system is not hanging, it is standing on a crosswise beam or a purlin. The load transfer to the crosswise beam is entirely different. *Jan tan* and *tang yo* work diametrically opposed. *Jan tan* burden the crosswise beam with compression, *tang yo* with tension. In first case, the compressed beam holds the *jan tan*'s foot ends apart, in the latter case the crosswise beam pulls the *tang yo*'s foot ends inwards. Carpenters are fully aware of this difference as they had to design entirely different joints. Improper use of the terms creates confusion or neglects the importance of structural differences. Exception does not facilitate our perception; they rather corrupt our attempt of categorization. Yet, for the sake of accuracy and actually to confirm our endeavor enabling a discussion without verbal vagueness, we actively point at this exceptional case. The roof structure of traditional Siamese house resembles the inclined roof member in the same way as in Lan Na culture. The lower end of *jan tan* was fixed immovably to the crosswise beam and the upper end to the ridge supporting pillar similarly to *tang yo* of Lan Na. It seems the Thai had adopted the word *jan tan* from their traditional usage and applied to modern context regardless of the difference in its structural trait. Whereas the Lan Na carpenter seemed to be well aware of such difference, the awareness of the difference between *tang yo* and *jan tan* became evident during the early phase of transformation from the *tang yo* to the completed rafter. (See section 4.5: Transition from inclined member system to modern rafter).

4.2 Analytical Framework

The principle of *tang yo* system is based on the formation of an angle-stable triangle. Pairwise inclined components are connected with a crosswise beam to a rigid frame. A special case can be found at the aisle roof structure where the closed triangle is formed by using a single inclined component assembled in combination with a flanking pillar and the aisle beam. There were two method to produce a curved roof. The first (see chapter 3) relied on the appropriate lay-out of the supporting beams and standing pillar. The making of a curved roof plane in the *tang yo* system requires additional means. The force diagram in the crosswise beam of standing pillar and inclined member system displays an opposite direction. The first is attributed to compression resulting from the distribution of load from standing pillar elements, in contrary to the latter that displays tension as the crosswise beam receives diagonal force from the inclined component.

The development of technical aspects in *tang yo* system shall be seen through the carpenter's eye. I am going to discuss the improvement of joinery that resulted in diverse solutions. I investigated the role of inclined member *tang yo* in the development from traditional inclined member to an early start of modern rafter. The major development in the system evolved along the transverse axis and allows us to outline the considerations of carpenters. Nevertheless, the development along transverse axis does not imply that there was no invention along longitudinal axis. In specific cases, the carpenters had demonstrated how to apply *tang yo* in very complex tasks.

"Transverse" consideration

- How did the carpenter form a curved roof plane based on application of *tang yo*? In all cases, the *tang yo* was made of a single wooden component. Nevertheless, it must constitute to curved plane and contribute to Lan Na belief e.g. in handling down the image of a "large umbrella."
- How the *tang yo* is assembled with the crosswise beam? Essentially, the *tang yo* stands on the crosswise beam and in many cases it has to hold a ridge standing pillar/ kingpost.

Considerations on joinery had played a crucial role. The intention is a categorization of the connecting points.

"Longitudinal" consideration

- How were different transverse frames combined; especially in case the frames had different sizes?

4.3 Scope of Case Studies

The *tang yo* system is used in religious and domestic building throughout the old Lan Na region. A selection of case studies shall present such diverse usages. I investigate a group of Tai Lue building in Nan and Phayao provinces. The buildings from these regions represent one of the oldest applications of *tang yo* system dating from 1550 onwards (from 22nd Buddhist century). My research suggests not to separate the carpentries of Tai Lue and Tai Yuan from each other, since they coexisted and continually exchanged their cultural elements throughout history. The anthropologist Michael Moerman is even convinced that Tai Lue and Tai Yuan are indifferent referring to their intrinsic culture. The different ethnic names should be considered as an ethnic label constitution self-identification and should express own historical background (Moerman 1965). Buildings from Lampang province are dated to around 24th-25th Buddhist Century that is from 1850. They present the application of *tang yo* system in combination with the usage of modern tools attempting to advance their building technique in the system. The selected cases from Chiang Mai province (dated from 24th Buddhist century) displays a more refined and labor intensive method. The cases include a house, a viharn, and a mandapa (open pavilion).

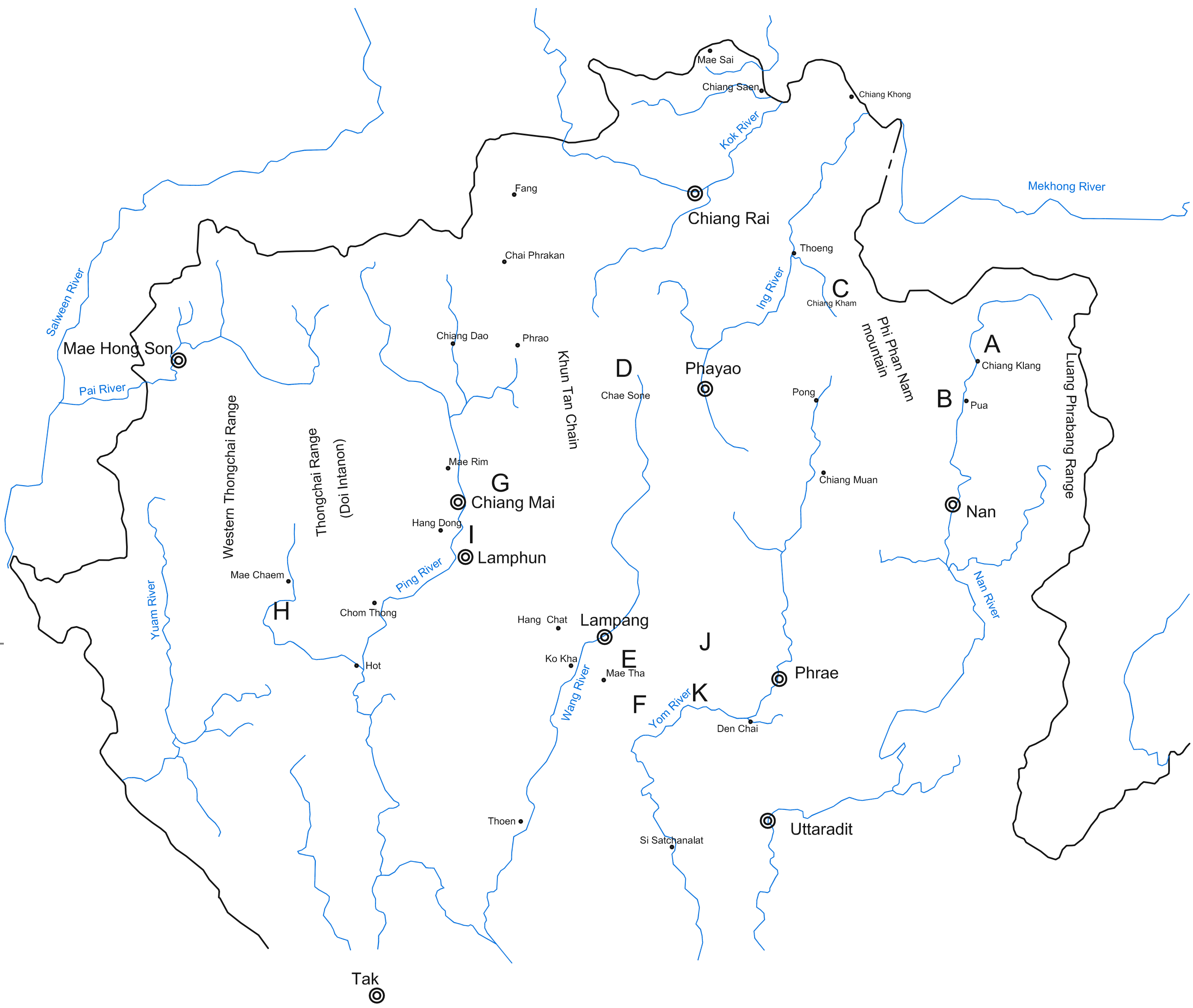


Fig. 4.1 Map of Case Studies

A. Viharn of Nong Daeng monastery

B. Viharn of Ton Leang monastery

C. Tai Lue House

D. Rice Granary

E. Ubosot of Sri Auan monastery

F. Ubosot of Phra Bath Mae Thai monastery

G. Phaya Wong House

H. Viharn of Klong Kak monastery

I. Mandapa of Ton Kwean monastery

J. Colonnade at Mae Tha Luang monastery

K. Monk residence at Baan Luk monastery

4.4 Traditional *Tang Yo* System

Viharn of Nong Daeng monastery, Nan Province

The viharn of Nong Daeng monastery is believed to be erected approximately 1787 (2330) by a group of Tai Lue carpenters (Siriwetchaphan 1987, p. 18). According to an investigation on the building during the year 2012- 2013, the roof compound of the viharn consisted of three parts: the curved gable on the top of the nave structure, the hipped roof of the aisle structure, and lean-to of porch area extending from the hipped part. The stage of building during my survey showed the inner timber structure and a surrounding outer brick wall. However, according to the information from locals, the outer wall was previously made of wood. It was restored replacing all wooden walls with a brick wall during the year 1952-1957 (2495-2500). The monastery was provided a funding for celebrating the year 2500 BE. The mortise hole for a tenon head of outer pillar can be generally observed on the perimeter purlin (beam) resting on top of current brick wall.

The structure of the viharn is comprised of five transverse frames. The measurements of the span between a pair of nave pillars and an aisle part measuring to the outer wall are approximate 4.55 m. and 2.25 m respectively. The upper curved gable was inaccessible due to the installed ceiling at the level of main crosswise beam. However, one can still observe from the pediment at frontal façade and recognize a pair of *tang yo* leaning against each other carrying two purlins that were assembled on each member (see Fig. 4.2). The arrangement of structural components can be examined much easier at the aisle part. The inner side of the aisle beam was fixed to the nave pillar by using a tenon secured with a wooden nail. The outer side was laid on top of the brick wall. I suppose that the outer beam end was fixed on the tenon, that was cut at the top end of the aisle pillar. The carpenter assembled the *tang yo* into a traverse frame by fixing its lower end on the aisle beam and its upper side to the nave pillar without interruption of a flanking pillar. The straight components form a closed triangle. Strikingly the *tang yo* is straight, but the roof component supported by it appears curved. How then did the carpenter transform the straight element to a significantly bent?

The carpenter prepared five purlins as support for a curved board (see Fig. 4.4). The topmost is fixed outside of the nave pillar directly above the *tang yo*. This purlin is laid vertically (1). The next purlin underneath is notched to the *tang yo*, laid perpendicularly according to the *tang yo*'s angle on top of it (2). Both members are recessed one third of their depths and secured by a wooden nail. A third purlin is seated likewise but only recessed about one quarter of their depths (3). Apart from these three purlins with direct contact to *tang yo,* there were applied two more. The forth purlin was jointed to the outer end of the aisle beam (4). The fifth purlin finally rested on eaves arm (5). The demanding for the carpenter was the appropriate determination of the purlins' upper side to create a smoothly bent curve. This curve was needed visibly by laying a thin wooden board to the purlins. I call it therefore, roof/ curved shaping element, or in Tai Yuan language of Lan Na "*gon*."

Fig. 4.2 Pediment of the viharn of Nong Daeng; we can observe a pair of *tang yo* assembled on each side

Fig. 4.3 *Tang yo* in aisle roof structure assembled to the aisle beam and to the nave pillar.

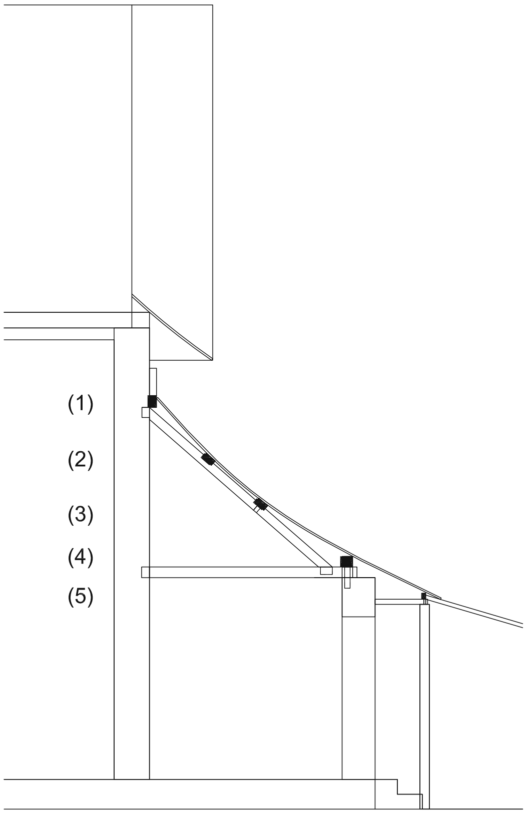


Fig. 4.4 Cross section of the aisle roof structure presenting five levels of purlin

The roof structure above the porch had been executed in an entirely different way (see Fig. 4.4). The construction resembles a common pent roof. The carpenter fixed the upper end of the angle defining inclined component at the fascia of the just discussed roof segment. This inclined component rests on its upper end on the beam that carried the fifth purlin. The lower end is supported by the pillar's top beam marking the entrance of the porch. These inclined components can be called rafter not the least as they were erected much later. In is worth to mention here that this porch was completely restored in the year 2014. The roof shaping boards have been elongated until its present extension at this time, as it was possible to combine the two roofs. The restoration work has erased important historical evidence showing the development of this viharn.

Viharn of Ton Leang monastery, Nan Province

An oral history indicated the erection period of the viharn of Ton Leang monastery during the year 1578 (2121) (Siriwetchaphan 1987, p.3). The building's roof structure is more complex in comparison to the viharn of Nong Daeng monastery. The roof is doubled hipped and gabled. Therefore we have to examine three structural parts: the curved gable roof on the top and an upper and lower hipped roof. The top most curved gable and the upper hipped roof belong to the nave roof structure, while the lower one attributes to the aisle roof. The overall structure consists of six transverse frames (see Fig 4.5 and 4.6). The assembling of structural components at the first and the last transverse frame display arrangements different to the inner four frames, as the carpenter had to handle the hip's direction of the eaves' and gable sides. The approximate crosswise measurement of the nave span between pair of pillars is 5.05 m. The aisle part between pillar and outer wall measures 2.25 m.

For a typical arrangement of structural components at the central four transverse frames, the carpenter divided the measurement of main crosswise beam into three parts and put a pair of standing pillars on the top of it (see Fig. 4.9). They create a central part with distance in between 2.8 m. They are connected on top by an upper beam parallel to the main crosswise beam. In between these two standing pillars, a kingpost rises upwards penetrating the upper beam in order to support the ridge purlin. On each side of the kingpost, the carpenter assembled an inclined member mortised to the kingpost on its upper end and to the crosswise beam on its lower end. This pair of struts secured the kingpost and offered the support of the roof shaping boards as purlin at the same time. The carpenter provided three positions of supporting purlins. The ridge purlin was topmost. An intermediate purlin was notched to *tang yo* and secured by a wooden nail. The lowest was notched to the upper beam above the head of standing pillars.

The upper hipped roof is formed using a similar method as the uppermost curved gable. The carpenter fixed the *tang yo* to standing pillar and to the main crosswise beam. The drawing shows that he secured the upper tenon by applying a wedge. Again the carpenter used three purlins to create the slope of the curved roof. The upper one is situated above the wedge. The intermediate one is notched to *tang yo*, and the lowest one is on top of the cantilevered part of the main crosswise beam.

Executing the hipped roof at the frontal and rear side of the viharn requires throughout three dimensional considerations (see position A in Fig 4.6). In longitudinal direction perpendicularly to the pair of *standing pillar*, the carpenter connected the crosswise beams of the first transverse frame at the second transverse frame's junction of the crosswise beam and standing pillar. He repeated the same measurement for producing and assembling the inclined members along the axis of this bridging beam. The carpenter assembled one *tang yo* on each of the face bridging beams strictly following the axis of pillar standing on the face of inner crosswise beams. Their position is chosen according to the inclination of the upper hipped roof parallel to the ridge. The gable sided inclination shall be equal. The same amount of purlin is assembled in the same length with exception of the intermediate purlin. The gable-sided intermediate purlin is fixed to the standing pillar slightly higher to

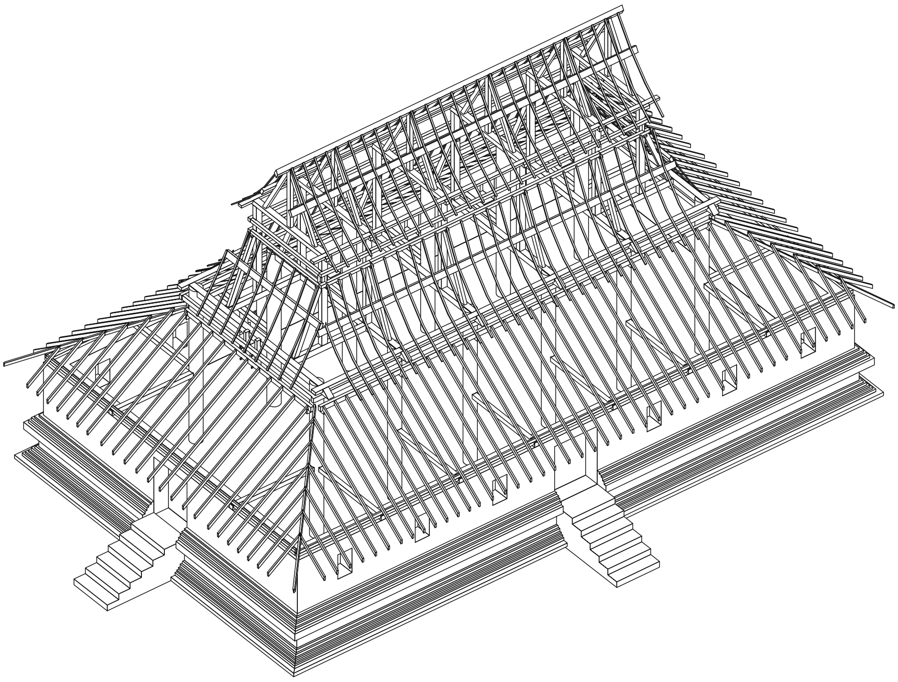


Fig. 4.5 Axonometric view of the viharn of Ton Leang monastery
showing roofshaping member

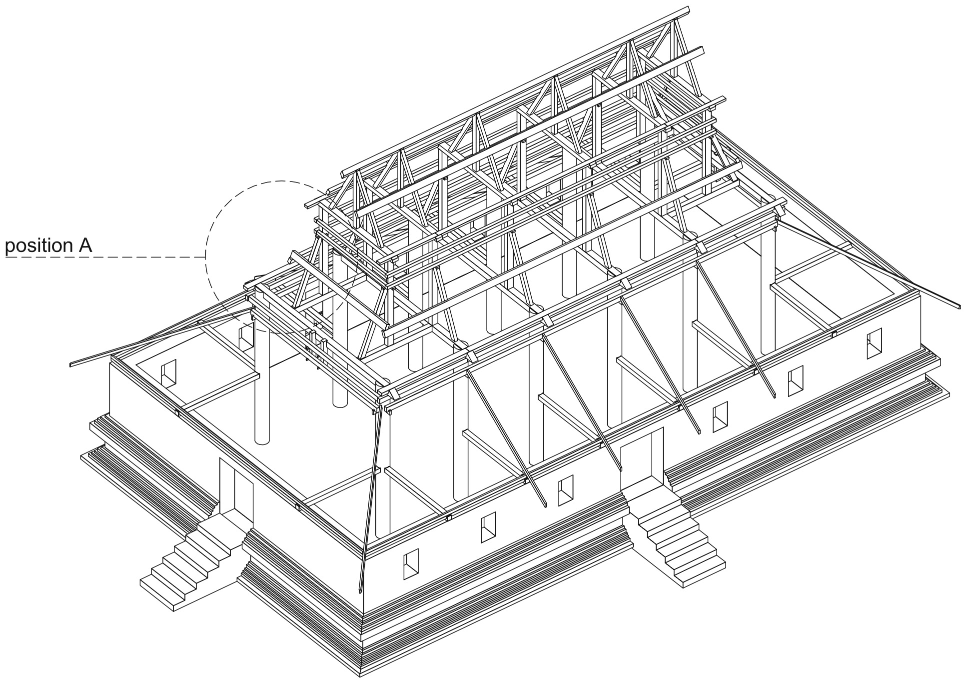


Fig. 4.6 Axonometric view of the viharn of Ton Leang monastery
without roof shaping member

rest with their lower side on top of those fixed in longitudinal direction. The hip rafter is supported by cantilevering the intermediate purlins from both directions; the crosswise met on top of the lengthwise, thus providing the place for hip rafter.

Currently, the structure of the lower hipped roof covering the aisle part was modified and executed based on rafter system, not the stable triangle anymore. The restoration work had been carried out during the years 1952 - 1957 (2495 - 2500) at the same occasion as the viharn of Nong Daeng monastery. As we can still observe the traces of mortise holes on the lowest purlin and presuppose to the previous connection of the inclined members. The use of ordinary rafter in the lower hipped roof is incapable to give the roof plane a curved shape. Even my drawing reveals the unpleasant appearance of the viharn's roof seen as a whole. Local people expressed their dissatisfaction after the restoration: The lower roof looks too "hard" in contrary to the "softer" appearance of the upper parts.

Fig. 4.7 Frontal facade of the viharn presents uppermost curved gable, upper-lower hipped roof

Fig. 4.8 Roof structure of the viharn; the carpenter connected first and second transverse frames by bridging beams

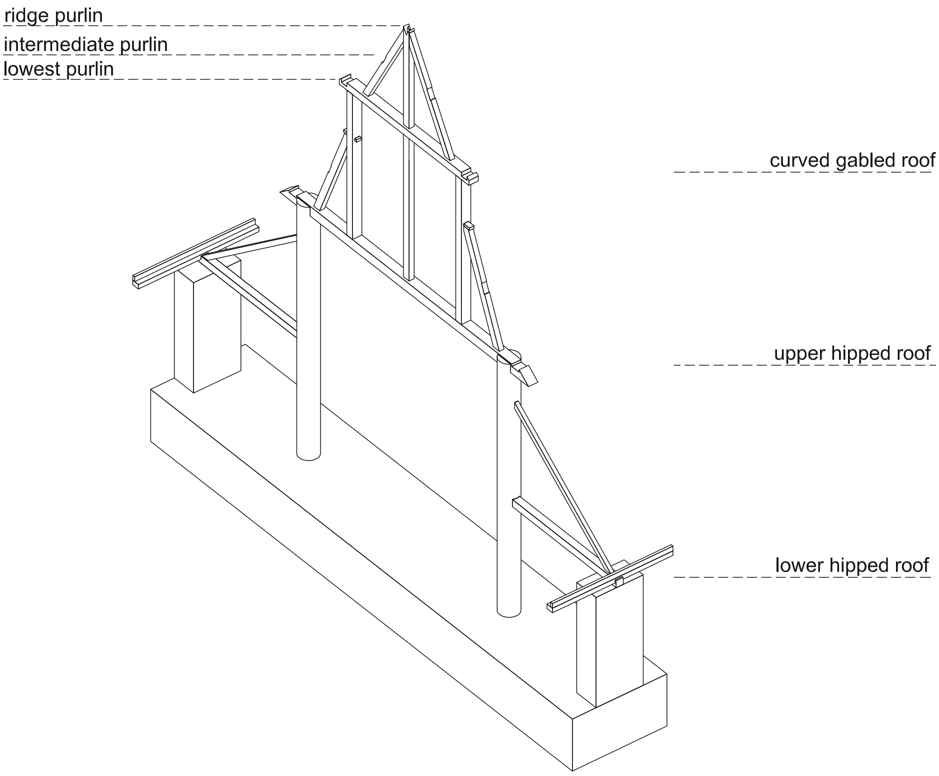


Fig. 4.9 Transverse frame

Tai Lue house, Chiang Kham province

An old house in Chiang Kham district, Phayao province, represents one of the very last domestic timber structure still standing in situ. According to an interview with the owner, the building had been erected around the year 1950-1955, when the owner, Mrs. Sangda Samrith was 15 years old (interview date September 2014). The house is comprised of three building units: 1) the main bed room, 2) the (old) kitchen, and 3) the rice storage in combination with a new kitchen. All of them are erected on stilts approximately 2.3 m above the ground. The eaves ending of the main bed room, and the (old) kitchen shared one common rain gutter drainage and protected the terrace. The rice storage building connects to these two with an open terrace. A carpenter erected the roof structure of all three buildings using the principle of closed triangle system. My study opted to discuss the structural arrangement of main bedroom and kitchen unit, since they presented rather large scale structure and complicated adjoining eaves end technique.

The main skeleton structure in a transversal frame is defined by a pair of round pillars. The carpenter reduced the head of the pillars to tenon shape for fixing a crosswise beam. The beam presents a cross section profile of 6 x 25 cm and has been assembled face upside. A pair of inclined members leans against each other. Their forked top ends are fixed scissor crossing serving to support the ridge purlin. Their lower ends find hold with recessed tenons mortised into the crosswise beam. In order to strengthen the frame of this closed triangle, the carpenter assembled a horizontal bracing component in between the pair of *tang yo*.

The *tang yo*s support the purlins. We can count four on each side of a transversal frame. The uppermost is of ridge purlin. It is placed inside the crossed top ends of the two *tang yo*s. The intermediate purlin is notched in the middle of tang yo, slightly above the collar beam. The carpenter secured the connection by a wooden nail (square cross section). The next lower purlin rests on the outer edge of the crosswise beam above the pillar. The doubled-height tenon with four shoulders does not only penetrate and thus fix the crosswise beam but also the third purlin as well. It is noteworthy that the carpenter notched purlin and crosswise beam only recessing the crosswise beam. The upper surface of the purlin is 4 cm higher than the crosswise beam. Finally the eaves purlin is supported by a cantilevered arm firmly anchored in the pillar. Again a thin wooden board is bent more or less forcefully to follow the curve created by the purlins.

Let us return once more to the assembling of the eaves purlin’s supporting cantilevered arm. This arm penetrates the whole pillar like a through tenon. The inside protruding end is keyed by a vertical wedge. The wedge is prepared into rectangular shape, chamfered on its edges. The combination of eaves arm and the wedge forms a T-shaped configuration resisting the moment load at eaves. At the corner pillar, where two eaves arms meet each other inside the pillar, the carpenter connected them via halved joints inside the pillar. The final analytical aspect relates both planning and technical means. There are four positions where the carpenter had cut the pillars in order to increase utilization of space. He connected two adjacent uncut pillars by inserting a horizontal beam 25 cm below the top ends and used this inserted beam as support for the cut suspended pillar. The

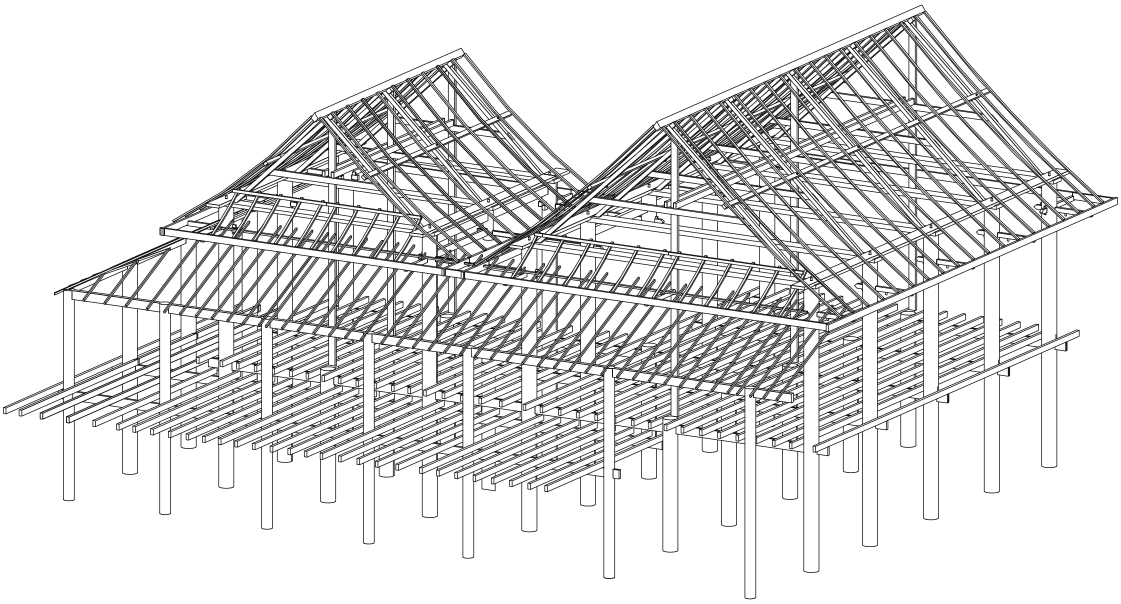


Fig. 4.10 Axonometric view of the Tai Lue house showing roofs shaping member

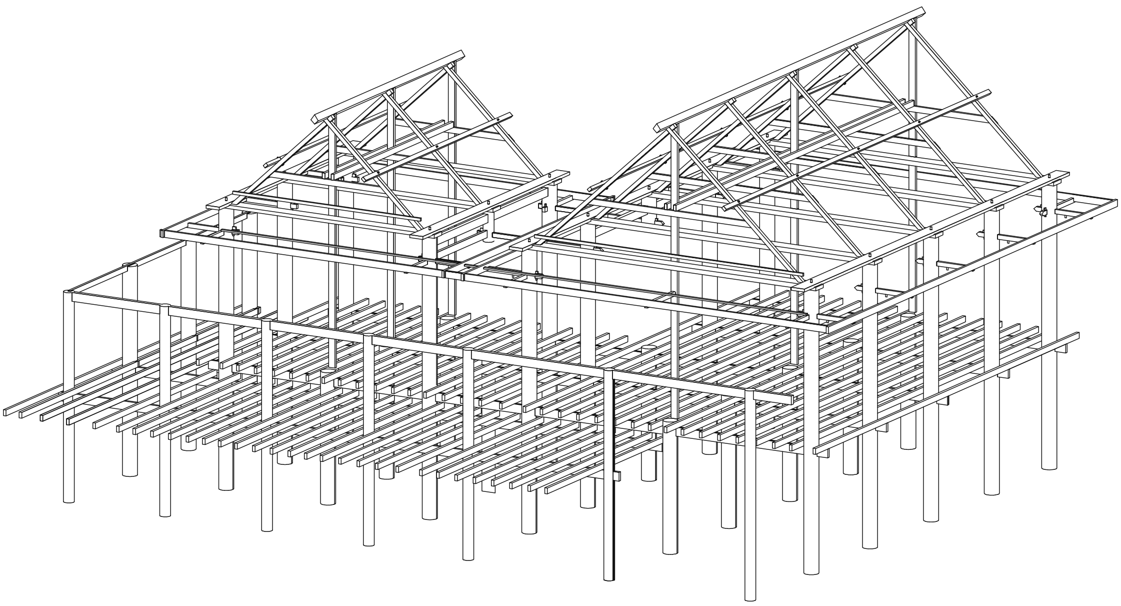


Fig. 4.11 Axonometric view of the Tai Lue house without roof shaping member

mentioned component is so called the “hanging post,” functioning to fix the crosswise beam and the main purlin through its tenon head.

Fig. 4.12 Current stage of an old Tai Lue house in Chiang Kham district, Phayao province; the house was erected approximately 1950; building on the right side is a rice granary, two connecting roofs on the left side are the living units.

Fig. 4.13 A collar beam braced tang yo frame

Fig. 4.14 Carpenter assembled crosswise beam and purlin face upside; they are carried by a hanging post

Rice granary of Phaya Ping in Cha Sone Luang district, Lampang province.

Granaries are another important building typology in old Lan Na culture. This building was closely related to people's agricultural life. Many of them were erected in a representative way, expressing the wealth and socio-economic situation of the owner. The granary of Phaya [local ruler] Ping is a large timber structure, erected on piles. It still offers evidence of its historical structural arrangement. The building is structurally divided horizontally. The lower part is defined by 24 imposting pillars that carry the granary in proper sense. This structural separation allows easy relocation. According to Izikowitz, this option can traced back to a former idea of granary (see Izikowitz 1979, pp. 41-42 and p. 51) . The total area of this granary on the upper floor covers approximate by 100 sqm, divided into 2 rice storage compartments that are surrounded by a walkway.

The structural compound of Phaya Ping's granary is comprised of eight transversal frames (see Fig. 4.15 and Fig. 4.16). Logs in a diameter of 40 - 45 cm are used to lift the granary to a height that allows walking and working underneath. Three piles support each frame of the granary; the two directly beneath the piles of the granary, one in the very centre (see Fig. 4.19). They stand in distance of about 1.5m. Concerning the outer two pillars, the carpenter notched seats on their heads in order to hold the fork footing of the upper pillars, while for the middle one, the carpenter chopped its head into fork shape in order to fix transverse beam above it. A beam with the cross section of 15 x 40 cm connects every three supporting pillars aligned in transverse direction. The beam cantilevers beyond the head of outer pillar by 1.6 m. on each side.

The actual granary is housed within seven bays of similar transverse frame. A slightly broader central bay acts as a passage way and as a distribution hub separating two equal chambers. All transverse frames are defined by a pair of pillars closed to their top by a crosswise beam. The first, fourth, Fifth and eighth transversal frames –those enclosing the two chambers—are structurally subdivided to facilitate their closure of a wall.

The frame-defining pair of pillars is provided with double height tenon cut out of the pillar heads in order to secure the crosswise beam. Pairwise scissor- jointed *tang yo* are put on top of the crosswise beams. Their foot end's tenons follow the inclination angle of the *tang yo*. The scissor shaped contact area is intended to support the ridge purlin. Directly next to but separated from edge of *tang yo*, the carpenter added a vertical element very similar to a kingpost, yet structurally different. This pillars stands centrally directly beneath the ridge purlin. Its foot end is jointed to the crosswise beam with a key-wedged through tenon. The crosswise beam offers enough space to allow both supporting structural elements to position in a row.

The central pillars was equipped with a horizontal stick forming two shoulders in approximately half height in order to support a pair of longitudinal bracing elements. The walkways cover the distance in between outer pillar and the outermost edge of the beam separating granary and lifting pillars system. According to the beam's cantilever the walkway has a depth of 1.6 m. The walkway is bordered to the outside by pillars reaching a height of 1.35 up to 1.38 m. These pillars are

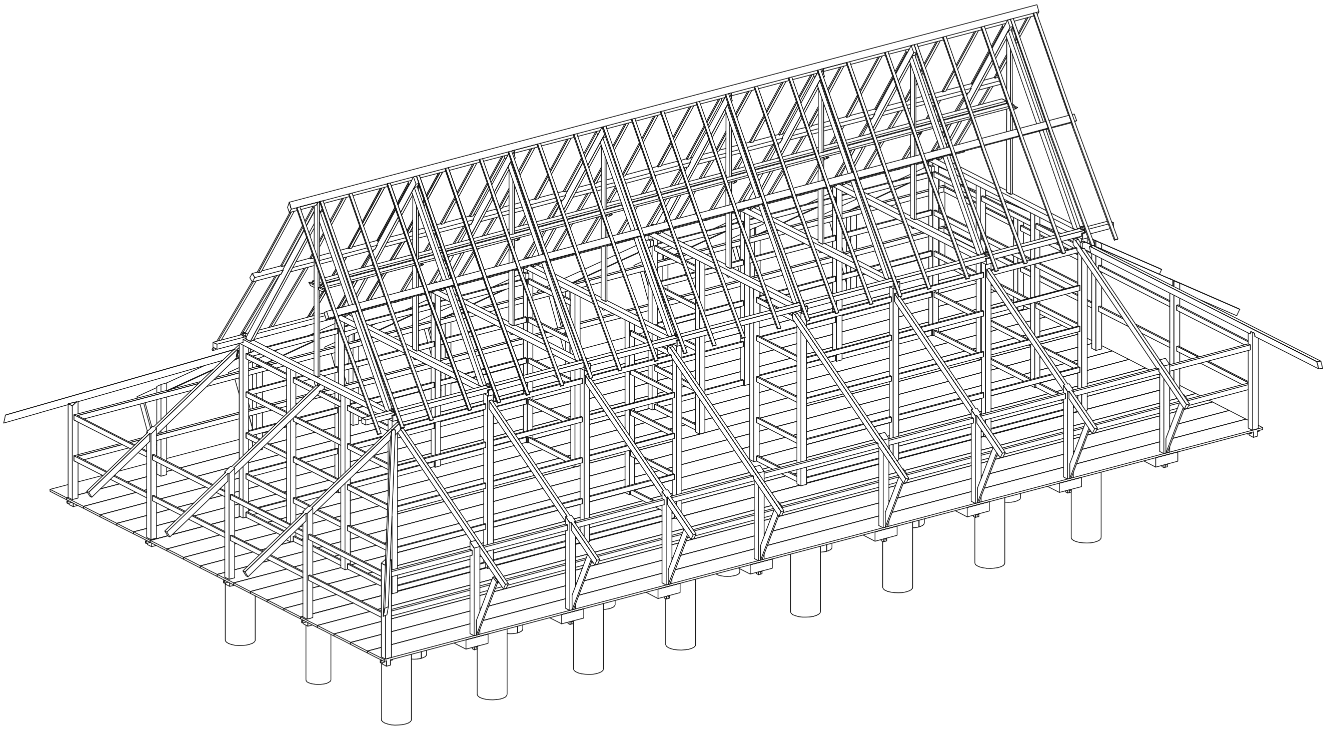


Fig. 4.15 Axonometric view of the rice granary of Phaya Ping showing roof shaping member

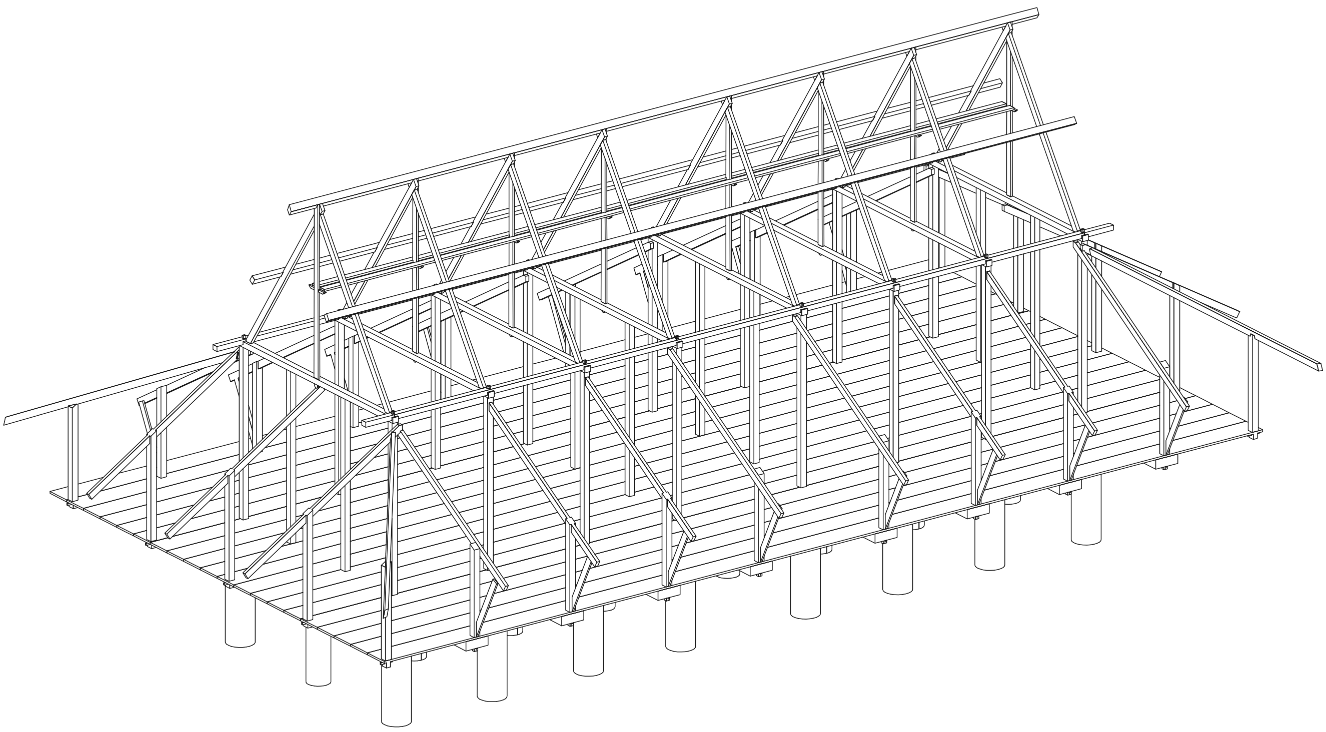


Fig. 4.16 Axonometric view of the rice granary of Phaya Ping without roof shaping member

secured via key-wedged through tenon to the floor supporting beams. Ordinary rafters cover this granary surrounding aisle. They are lap-jointed to the granary pillars at their top ends by means of iron nails. The rafter protrudes the outmost wall so far that their lower end needs to be supported by additional struts. The gable side covered walkways are assembled accordingly. The curvature of the upper part of the roof is determined by three purlins leading to a rather discreet curve.

Fig. 4.17 Phaya Ping rice granary was erected approximately 200 years ago

Fig. 4.18 The vertical element supporting the ridge purlin is detacthed from the pair of *tang yo*; therefore this element behave differently from a kingpost

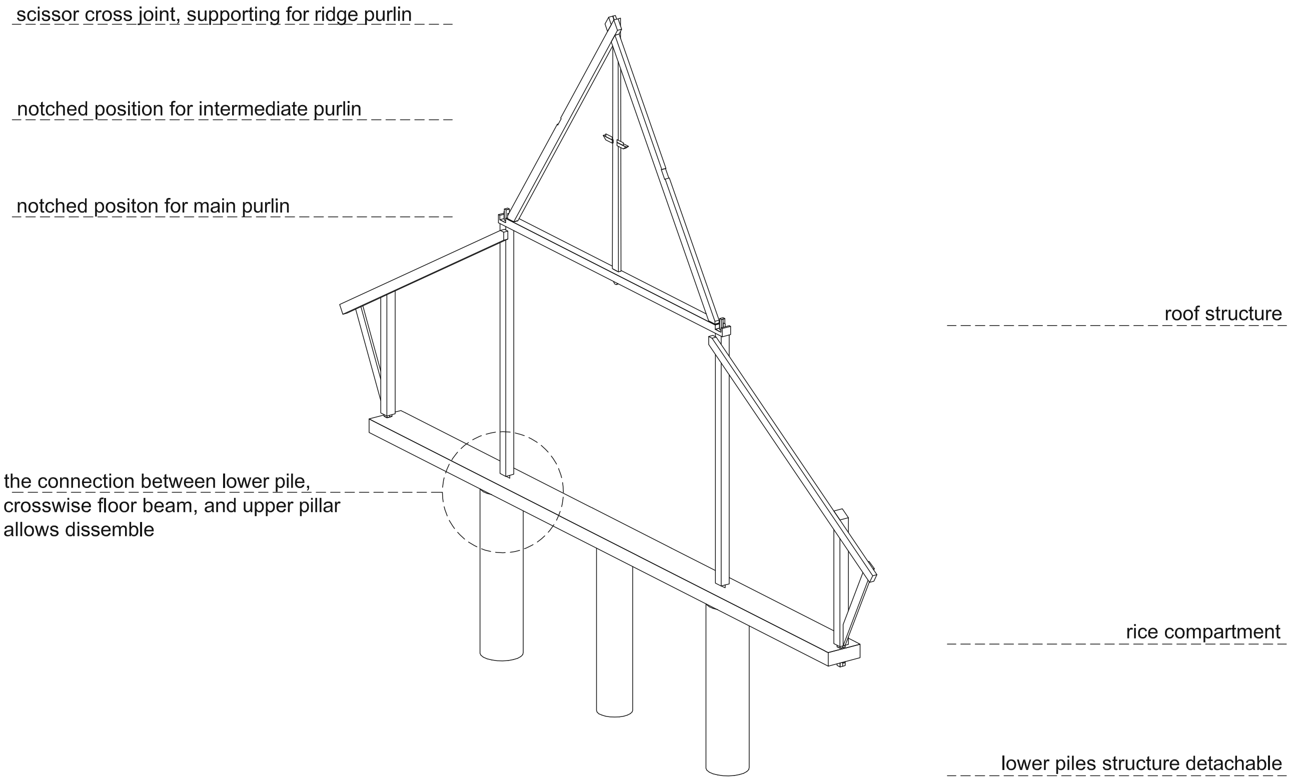


Fig. 4.19 The transverse frame of Phaya Ping rice granary

Old Ubosot of Sri Auan monastery, Mae Tha district, Lampang province

Ubosot is a small type of religious building serving mainly for monks performing Buddhist ceremony. The old ubosot of Sri Auan monastery was erected approximated 1905 (2450) (see history of the monastery in Sanyakiatikun 2008). During the course of my investigation in 2013, the building was abandoned in a really poor condition (Fig. 4.22). The ground floor of this building is rectangular. The measurements in crosswise and lengthwise are 5.1 m and 6.15 m respectively. The internal structure is made of timber. The visible enclosures are brick walls to all four sides. The main structure comprises from 4 transverse frames (Fig. 4.20). Only in the first and the last frame a pair of pillars showing on the floor separate nave from aisle. The carpenter intentionally omitted them in the second and third frame in order to maximize the area utilization serving ceremonial and religious practices.

The pair of nave pillars carries the main crosswise beam. The beam is held in place by the pillar's forked top ends. The beam's ends protrude far enough that the carpenter could put a flanking pillar at the distance of its width outside the nave pillar and still standing beneath the beam end. . A tenon on the flanking pillar's top end secures the pillar with the crosswise beam. The flanking pillar thus supports directly the purlin resting in the recessed crosswise beam outer end. A kingpost is placed in the middle of the crosswise beam (see Fig. 4.24). A wooden nail fixing the jointing of kingpost to beam shows us that the kingpost does not burden the beam but instead is intended to relieve the beam from its dead weight. The kingpost acts as a hanging pillar carried by pair of *tang yo*. A pair of *tang yo* leans to the kingpost secured by tenons. *Tang yo*'s lower ends show an interesting variation on jointing. A bird's mouth shape presses against the aforementioned purlin (Fig. 4.23). This purlin is notched to the crosswise beam exceeding beam top edge by 4 cm. Therefore a significant height difference between beam and purlin must be taken into account when shaping the *tang yo*'s joint. This bird's mouth joint rests without any tenon relying entirely on the roof weight The *tang yo* above aisles are assembled accordingly. Their top ends are fixed on the flanking pillars.

It was obviously a spatial consideration supported by the visual effect. The carpenter left the entire ground floor empty of obstructing pillars. In the second and third frame the carpenters resigns from nave pillar and assembles pairs of flanking pillars exclusively. It could be discussed whether they can still be termed flanking pillar without pillars to whom they are flanked. However, the structure of these two inner frames is a copy of the two outer frames simply omitting the nave pillars standing on the floor. Three plus one (including eaves) purlins support the upper gable roof. Four plus one (eaves) purlins support the lower pent roof above the aisle. The assembling of the purlins creates slightly curves.

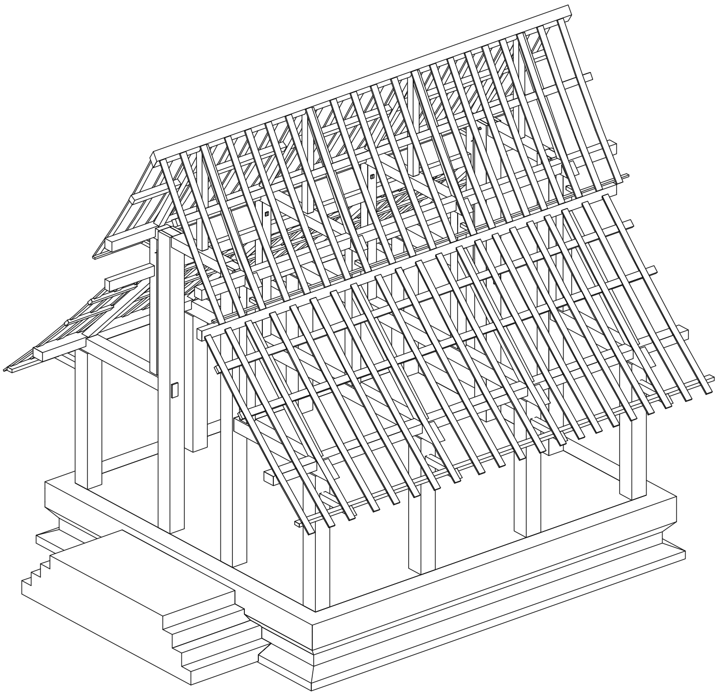


Fig. 4.20 Axonometric view of the ubosot of Sri Auan monastery showing roof shaping member

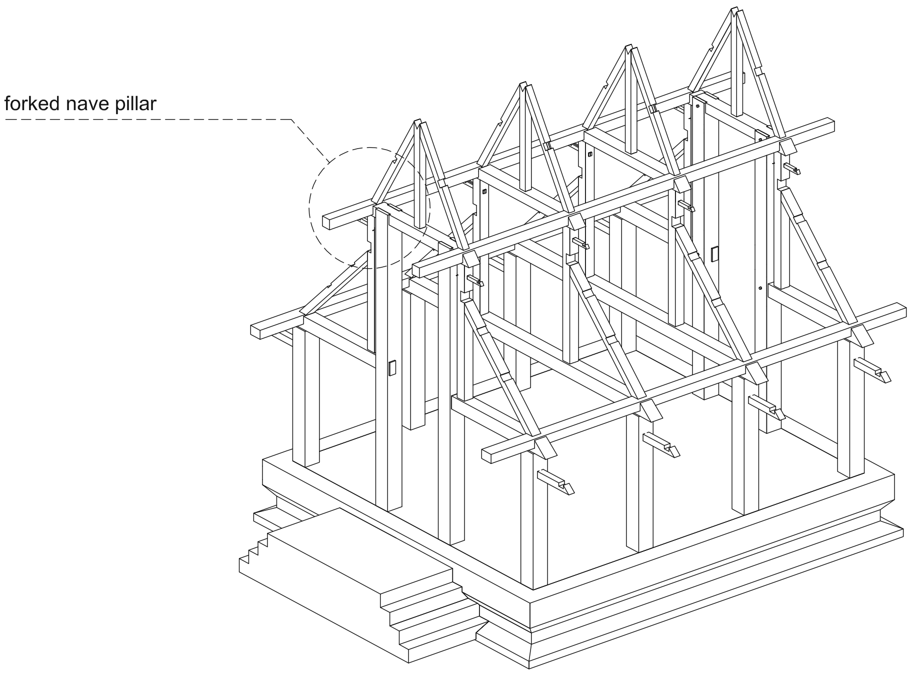


Fig. 4.21 Axonometric view of the ubosot of Sri Auan monastery; the standing pillars which are placed on the crosswise beam of the second and third transvers frame situating on the same alignment as the flanking pillar of the first and fourth transverse frame

Fig. 4.22 Nave roof structure of the ubosot of Sri Auan is in deteriorate stage (surveyed in 2013)

Fig. 4.23 The top edge of main purlin exceeds the surface of the main crosswise beam by 4 cm, it provides a place for bird's mouth connection of the *tang yo*'s lower end

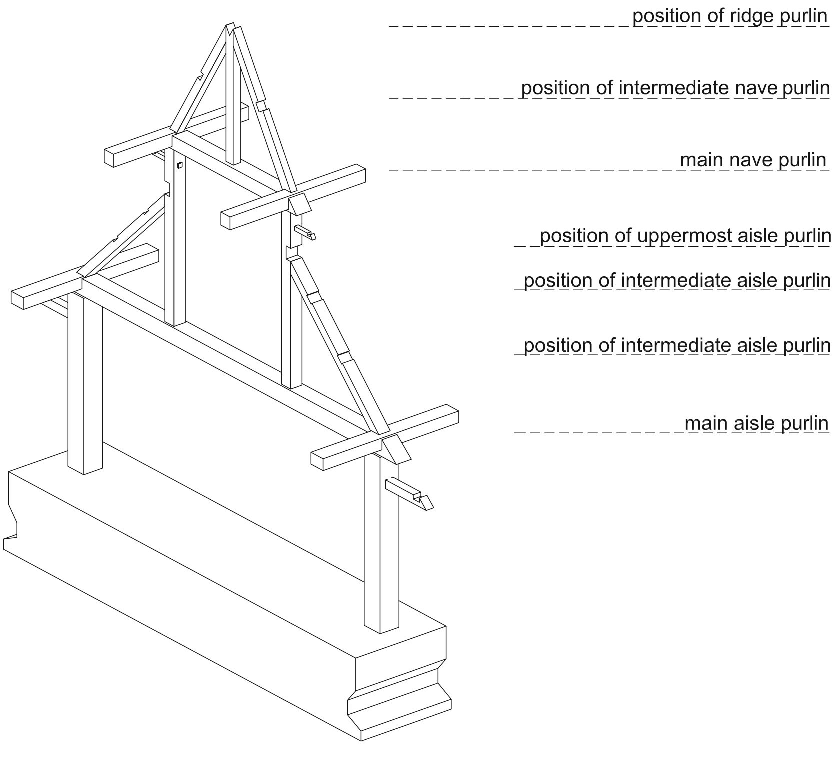


Fig. 4.24 Transverse frame of the ubosot of Sri Auan monastery

Ubosot of Phra Bath Mae Thai, Mae Tha district, Lampang province

The ubosot of Phra Baht Mah Thai is even smaller than the ubosot of Sri Auan monastery but presents a distinct structural feature. The building was erected in the middle of the pond reflecting to the belief of “*utokasima*,” or literally translated to “water ubosot” (see Fig. 4.25; Kruaraya 2017, p. A-31). The erection period is indicated on the building mentioning the year 2488 BE (1945) (Sanyakiatikun 2008, p. 318).

The ubosot’s ground floor is rectangular. The crosswise and lengthwise measurements are 4.0 x 6.0 m respectively. The overall structure and its enclosure are made of timber. The roof form is in gable shape with an elevated part in the middle creating a hierarchical appearance. When standing in front of the building one is astonished how the carpenter could have managed such a roof shape based an closed triangle frames. The building consists of four transverse frames. Visually, we recognize a nave roof flanked by two aisles. But structurally there are no pillars separating the used space above the ground floor (see Fig. 4.27). The whole roof load rests on pair of pillars defining ubosot’s walls. They are connected by large crosswise beams.

A flat wood ceiling has been installed inside the building. This ceiling provides the impression that the structures above, namely the crosswise beams, are assembled at the same height. In contrary to this assumption the two inner crosswise beams lie on higher pillars. My study concludes this measure as a design strategy of the carpenter. Remember the sample of Sri Auan monastery’s ubosot. There the carpenter increased the perception of the room’s size by leading the visitor through a narrowed gate into a room opening behind. In this case the carpenter has another tricky maneuver. He creates the impressing a larger room by laying the primarily visible horizontal beams in the inner frames. It is astonishing that this intention was ignored when installing the flat ceiling.

How did the carpenter connect the differently high frames? The two gable sided frames are assembled as expected. The main crosswise beam carried two standing pillars. These pillars are connected topside with another crosswise beam. A centered kingpost defines the height of the ridge purlin. The kingpost is secured by a deeper protruding through tenon on its lower end and by a pair of *tang yo*s on its top end. The footing of *tang yo* is prepared to bird’s mouth shape again. The created triangle provides seating for three purlins on each side. The lower aisle roof structure is assembled likewise. Three plus one (eaves) purlins provide the support for the roof shaping members.

The crucial task was to find a method how to connect the purlins of the lower frames to the higher frames inside the building. My study has discussed this aspect prior in chapter 3 with a bit difference. In the standing pillars system, the carpenter can fasten a purlin to a standing pillar. For the current case the carpenter developed a new idea. He installed additional inclined members beneath the “ordinary” in the second and third frame in order to receive purlins. I leave the lowest eaves purlin out of consideration. Then we can state that in both roof structures the topmost and the lowest purlin deriving from an outer (lower) frame can easily be jointed the inner (higher) frames as they meet a pillar. The purlin’s ends are reduced in section and fixed via key-wedged through tenon, thus ensuring

Fig. 4.25 Ubosot of Phra Bath Mae Thai was erected in the middle of the pond reflecting an idea of "water ubosot"

Fig. 4.26 roof structure of the ubosot

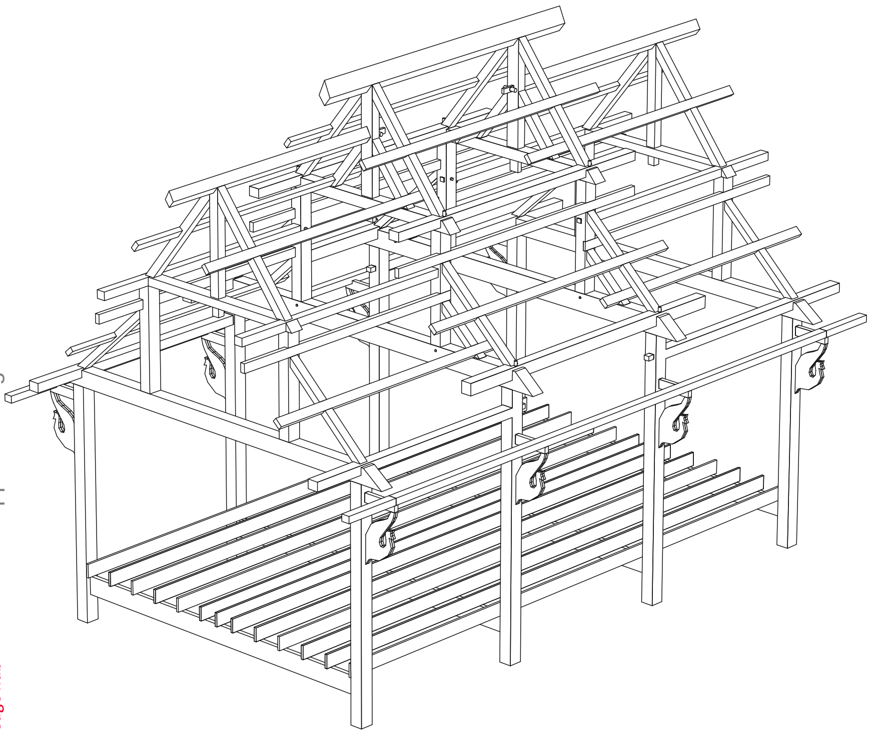


Fig. 4.27 Axonometric view of the ubosot of Phra Bath Mae Thai

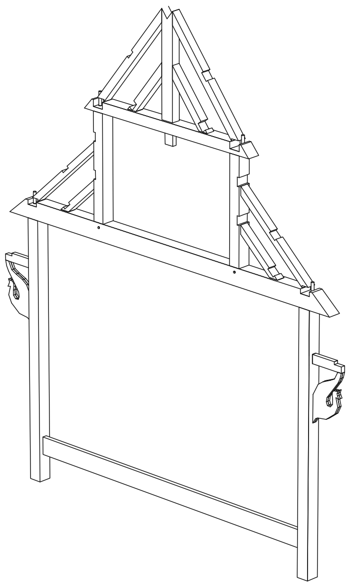


Fig. 4.28 second and third transverse frame; additional *tang yo*s are installed into ordinary triangle frame

pull resistance. Only the intermediate purlins had to be treated in alternative means. The additional short *tang yo*s were assembled to offer these purlins an adequate support (see Fig. 4.26 and Fig.4.28). The foot's end of short *tang yo* pierces to the beam and provide seat for purlin the same time. We shall observe that the levels of intermediate purlin of the first and fourth transverse frames are corresponded to the level of second and third's main crosswise beam.

Phaya Wong house, Open-Air museum in Chiang Mai

Phaya (local lord) Wong house presents an important typology of house in Old Lan Na, a so called *ka lae* house. The building technique and its construction of the *ka lae* type is considered as a “zenith point [of house] before accepting the external influence” (Temiyabandha 1993, p.73). Currently, the building is located in an open-air museum of The Center for the Promotion of Arts and Cultures in Chiang Mai University. The erection period of the building is estimated around the year 2440 (1897). Before the re-erection in this open air museum, the building was already relocated twice (Kruaraya 2014, pp. 65-66). Thus, the structural analysis and interpretation of this building must be carried out in the most careful way.

The cluster of Phaya Wong house consists of three building units which are connected through an open terrace. Two living units are facing the terrace while the extensive kitchen is located on the back side of the cluster. The numbers of transverse frames of the smaller and lager living unit are four and five respectively. Their eaves parts meet at a common fascia board. I omit the kitchen and discuss in detail just the two living units (see Fig. 4.29).

The crosswise measurements of the smaller and larger transverse frame are 3.70 and 4.75 m. For the smaller living unit, the heights from floor to crosswise beam and from crosswise beam to ridge purlin are equally 2.41 m. For the larger one, the figures present 2.61 and 3.12 m respectively. These measurements show quite similar ratio for the width and the height, thus the degree of inclination is almost the same. The arrangement of transverse frame has been carried out following the principle of closed triangle system. The rectangular crosswise beam (12 x 17 cm) is placed faced upside on the pair of pillars and fixed on their tenon heads at the positions where the seats for purlins are prepared. In the middle of this crosswise beam stands a kingpost. Especially for this *ka lae* typology, the kingpost is called *dang kwang* (“ดั้งแขวน”) or literally translated as “hanging ridge standing pillar.” In a sense the Lan Na term of this kingpost reflects the carpenter’s perception how he has understood the load transfer in the structural system. The two *tang yo*s hold the kingpost hanging in order to disburden the main crosswise beam and prevent it from sagging. The *tang yo*’s foot end is prepared to fit the connection point and to secure its position. It is partly forked into the beam, parly standing on the main purlin that is notched to the crosswise beam 2 cm deep (see detail in Fig.4.49).

There can be observed two different fixing methods of the *tang yo* to the kingpost. The first method uses the standard tenon head house in the forked kingpost. The second method applies a wooden stick inserted through the kingpost’s head in order to replace the tenons. During my investigation, I found traces of saw cut on the kingpost clearly related to the wooden stick. On the other hand there can be seen traces of an axe when inspecting the mortised version. I tend to interpret the saw traces as a result of restoration work as it was executed in different period of time.

The carpenter assembled three intermediate purlins on each side of *tang yo*. The curvature of the roof plane has been shaped in truly sophisticate way. If my observation was not distorted due to the relocation work of the building, the intermediate purlin in the middle is positioned lowest, halved to

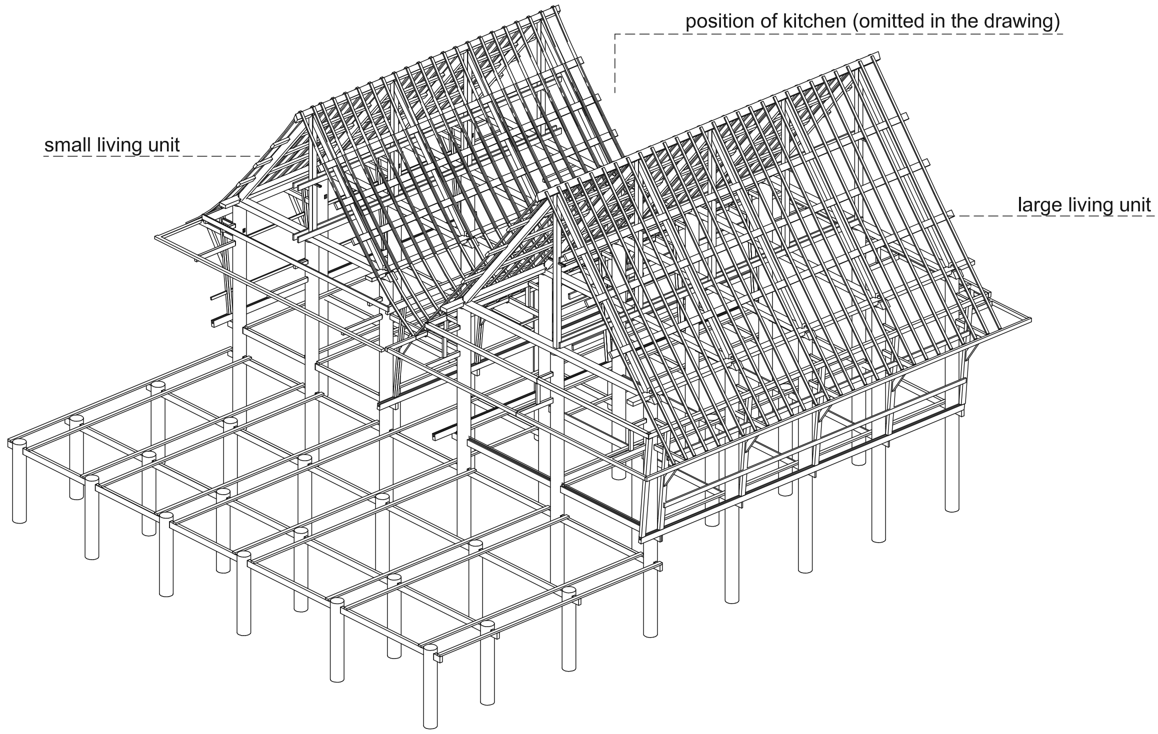


Fig. 4.29 Axonometric view of Phaya Wong house
showing roof shaping member

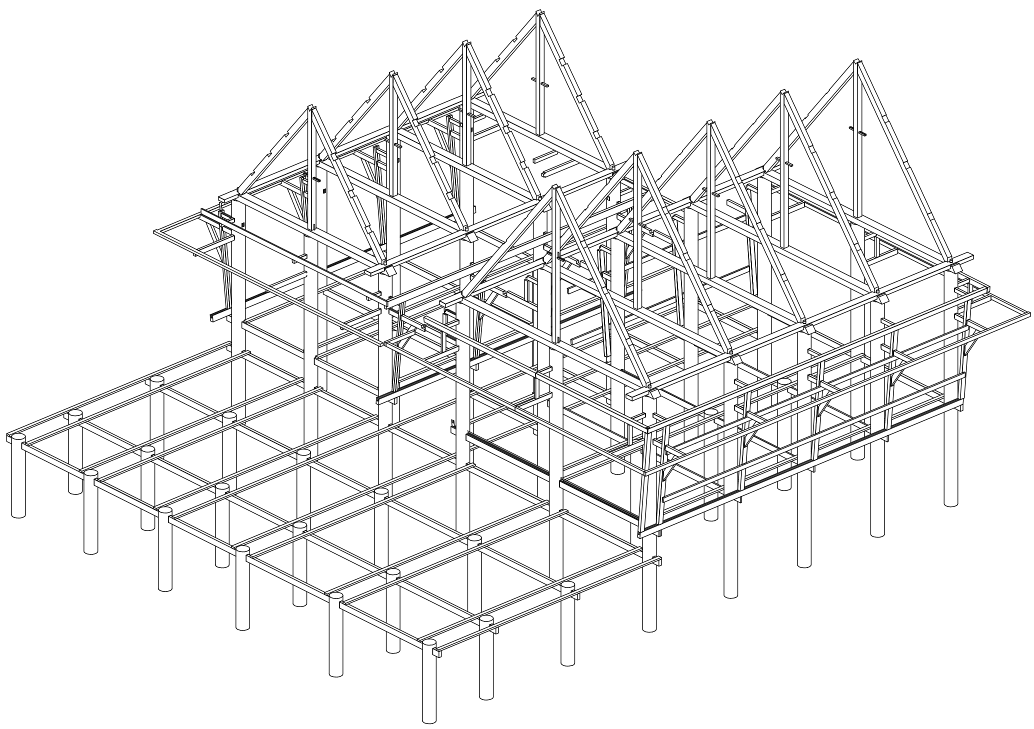


Fig. 4.30 Axonometric view of Phaya Ping house
without roof shaping member

the *tang yo*. The other two are notched less deep. The carpenter controlled the curve by watching the roof shaping member turning down gradually from the ridge purlin to the higher intermediate purlin until the middle one. Then it gradually rise to the lower intermediate purlin toward the main one above the pillar until reaching the eaves arm defining eaves ending position.

The carpenter integrated the slightly outward inclined wall system into the roof structural components. The structure of the eaves part consists of two levels of components: the upper level is defined by an intermediate purlin, the lower by the final fascia. The intermediate purlin is not only used for supporting the roof shaping member but also work as an upper closing beam in the wall frame. It is supported by inclined wall studs that held to the pillar by connecting horizontal strut (see position A in Fig. 4.33). The strut's outer end secures the upper closing beam by a keyed nail. The wall of this building presents an inclination of 5 degree leaned towards the outside. The sill beam stands on crosswise oriented floor beams. Considering the erection process, I assume that the whole wall was assembled lying on the floor. The boards served to close the frame. They were inserted in tongue and groove joinery to the frame elements.

Fig. 4.31 Phaya Wong house is currently situated at the Open-Air museum in Center for Promotion of Art and Culture, Chiang Mai University

Fig. 4.32 Roof structure of the larger living unit presenting three levels of intermediate purlins

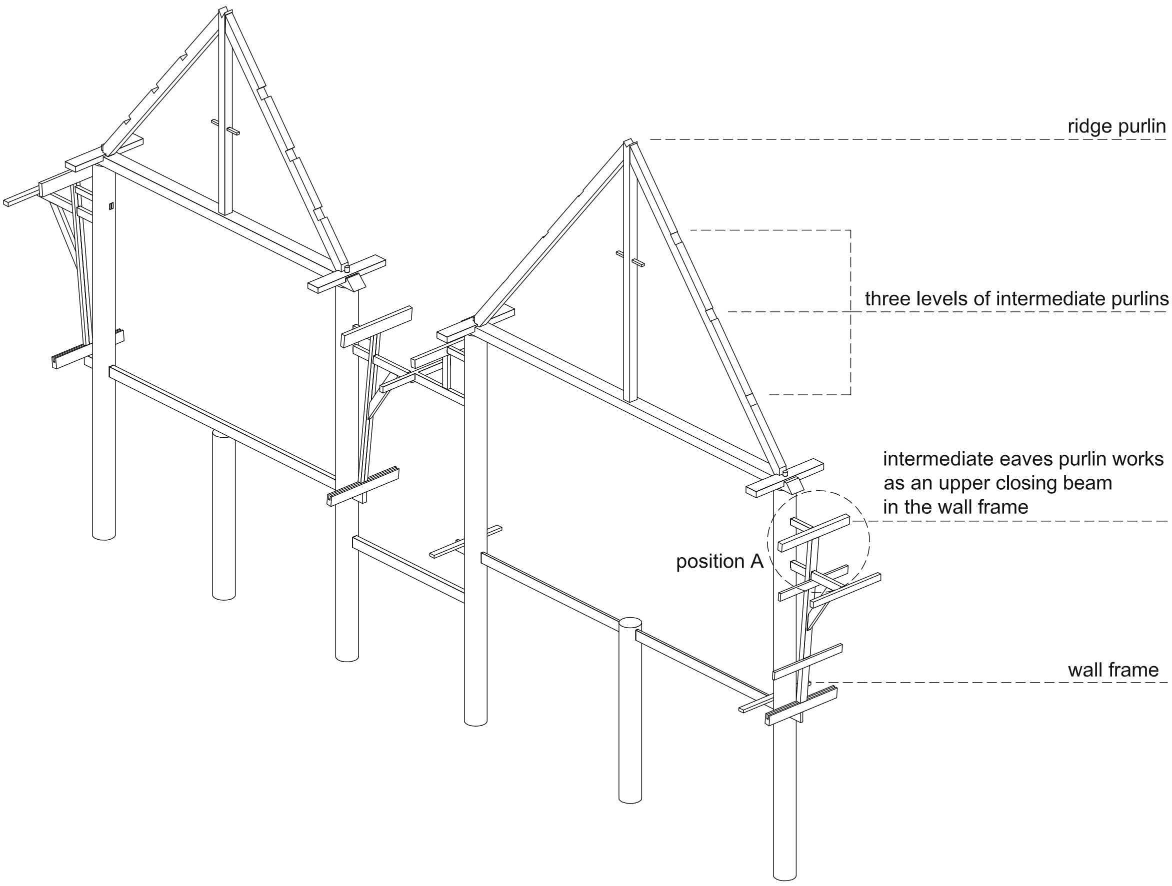


Fig. 4.33 transverse frames of Phaya Wong house present the integration of horizontal wall stud and the eaves purlin.

Viharn of Klong Kak monastery, Mae Cham district, Chiang Mai province

An art historian estimates the erection period of the viharn of Klong Kak monastery during the years 1887-1897 (2430 – 2440) following an inscribed date of the casting of principal Buddha image (Sooksawasdi 2005, p. 21). Those patrons supporting this erection came from Lampoon and Lampang provinces. More skillful carpenters and craftsmen from different regions were also invited participating in the erection process of this viharn (Somwatha 2010, p. 127). At the time of investigation, the building consists of two parts: the larger part constitutes the principal hall while the smaller part is the porch at the frontal facade. The roof constructions of these two parts have been done on different basis since the porch was added later on (Sooksawasdi 2005, p.15). The main structure of the viharn is made of wood. The carpenter enclosed the outer side of the building with a brick wall.

The principal hall of the viharn comprises six transverse frames. The crosswise measurement between a pair of nave pillars is 2.0 m while each side of aisle measured from nave pillar to outer pillar is 1.65 m. The carpenter applied a method to formulate the curved roof plane totally different from all previous discussed cases. The carpenter did not arrange the set of purlins on a straight inclined member for producing the supporting points of the curved shaping member. He had used the completed curved inclined member instead. A pair of curved *tang yo* is leaned against a kingpost in the middle. On the upper side, the curved *tang yo* is mortised to the kingpost, while on the lower side, the footing of the curved *tang yo* is partly mortised to the crosswise beam and partly stands on main purlin. In addition I found a small recessing of the depth of 3-5 mm deep on the main purlin to further secure the curved *tang yo* in its place. There are three intermediate purlins on each curved inclined member of nave and two each on the aisle parts.

There is another interesting difference to the former buildings. The main purlin is connected with the crosswise beam by means of a halved joint. It is not necessary to create an artificial step to ensure the intended curve in the roof plane. The construction on the aisle structure has been carried out following the same principle as in the nave part, but the curved member is fixed to the flanking pillar instead of kingpost. The general joinery that the carpenter employed in this building is the use of tenons with securing wooden nail, or sometimes including an extra wedge. For instance in the case of the aisle beam mortised to the nave pillar, the carpenter used a round wooden stick for fixing the joinery against pulling strength from the aisle structure.

How did the carpenter create the curved *tang yo*? Based on an observation on wood grain, it shows a straight pattern not a bended pattern in difference to the configuration of a curved element. Therefore, my analysis suggests that these *tang yo*s are cut into curved shape not bended. Behind such superficial simplicity of the structure, deep investigation eludes human's intensive works. The system required skillful carpenters' working for several hours to cut all members into consistent configuration.

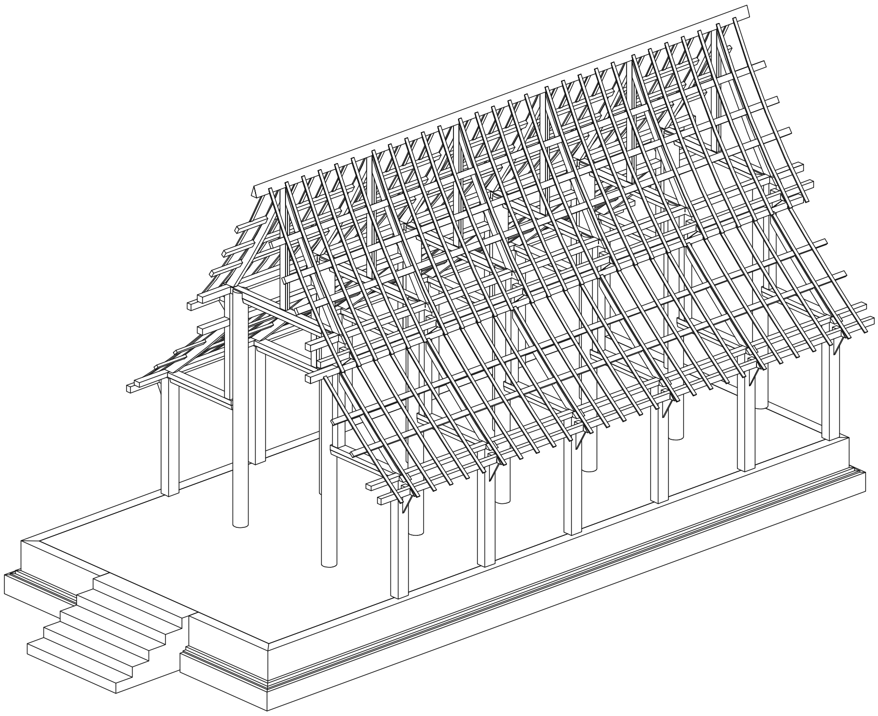


Fig. 4.34 Axonometric view of the viharn of Klong Kak monastery showing roof shaping member

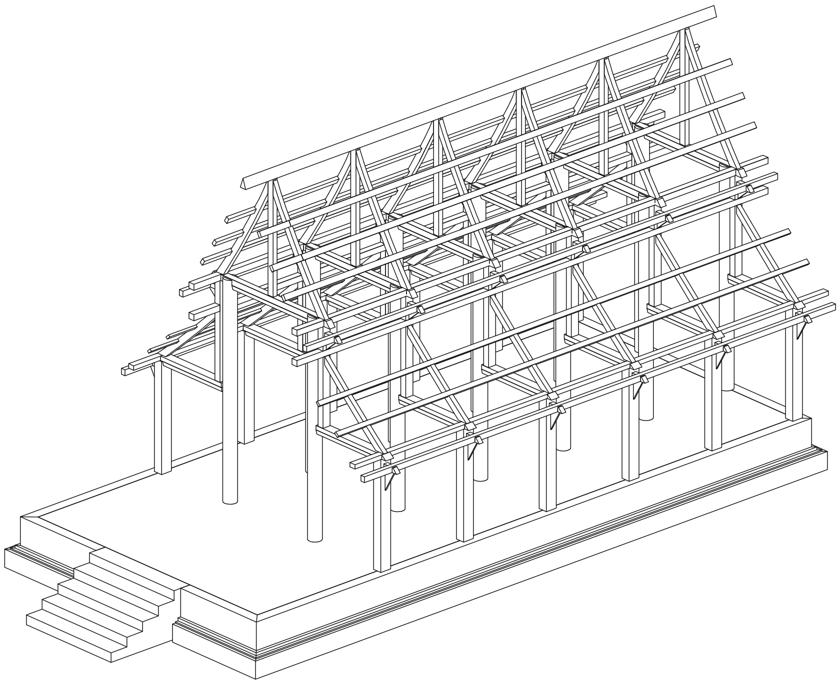


Fig. 4.35 Axonometric view of the viharn of Klong Kak monastery without roof shaping member

Fig. 4.36 Viharn of Klong Kak monastery; the structure of porch and principal hall are made of different structural principles

Fig. 4.37 curved *tang yo* at aisle roof rests partly on beam and partly on main purlin; the photogragh shows deterioration of the joinery

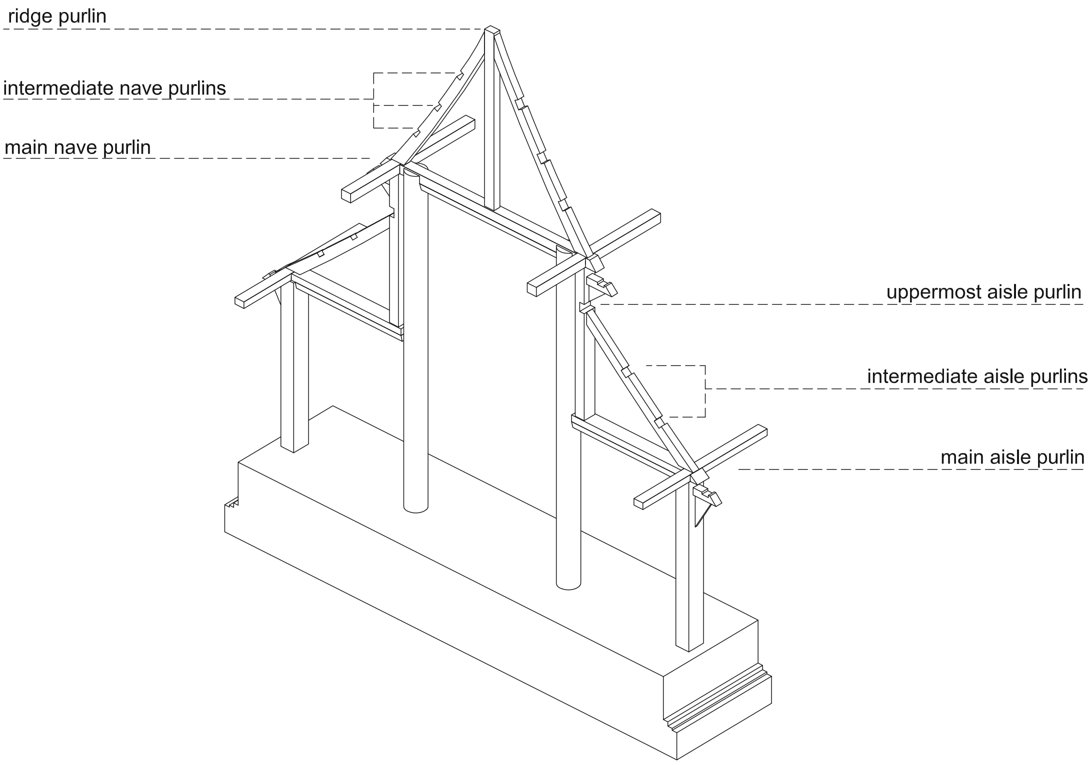


Fig. 4.38 transverse frames of the viharn of Klong Kak monastery presents curved *tang yo* member

Mandapa of Ton Kwen monastery, Hang Dong district, Chiang Mai province

The mandapa of Ton Kwean monastery presents the most complicated application of *tang yo* system known so far in Lan Na region. My dissertation discussed the viharn of this monastery already in chapter 3 (see chapter 3: viharn of Ton Kwen monastery). The background of this mandapa is given in chapter 2. Generally speaking, typology of mandapa is a square pavilion with four outlying porches Penth 1994, p. 230). The central part of the roof of square pavilion is often tiered and elevated in order to emphasize the hierarchy. Additional adorning is expressed by decoration (Wichienkeeo 2006, p. 36). Structurally for our specific case, we can consider and divide the roof complex of the mandapa of Ton Kwean monastery into three parts: an inner core structure with curved gable, a surrounding four sides curved hipped roof, and extended porches in four directions (see Fig. 4.39).

The ground floor of the inner core structure is in fact not in perfect square geometry. The reason can be explained with structural analysis. My analysis is going to discuss really interesting consideration of the carpenter. The perimeter of the central pavilion is defined by pillars put around the four core pillars at the distance of 1.75 m. Each central pillar is adjoined by two outer pillars placed in orthogonal direction. These eight pillars are complemented by four more pillars in the corners following diagonal alignment to the core pillars. The outer corner pillars measure 26.5 cm in diameter while all others have just 20 cm. The core pillar have a round section, all others are octagonal. Core pillars and adjoining beams in the main directions are connected at the height of the perimeter pillars. The inner core structure is laid out by four pillars approximately 5.45 m high; the distance of these pillars are 2.4 and 2.5 m. Despite the symmetrical four-sided layout, the "almost square" configuration created a distinctive direction of the building and provided carpenter orientation for his structural arrangement. The carpenter placed the pediment on the shorter side attributing the transverse axis, while the longer side formed the eaves part of gable roof reflecting to longitudinal direction. The clear distinct structural axis between transverse and longitudinal could facilitate carpenter to apply his prior knowledge and assembling process.

A core pillar pair was held in place by a crosswise beam put on their top ends. This crosswise beam protruded the pillars significantly in order to support an eaves purlin. As the eaves purlin has to carry a lot of weight, the carpenter added a flanking pillar outside the core pillar along the beam sides. The flanking pillar rests on the beam connecting core pillar and perimeter pillar. Crosswise beam and purlin connected by a halved joint, thus offering a flush surface. Again the carpenter protruded the purlin's ends significantly beyond the junction with the crosswise beam. His idea was to put the roof gable as far beyond the core structure as the eaves in order to protect the otherwise exposed structure between topping gabled roof and hipped roof beneath. A second consideration might have been the wish to preserve symmetry. The far protruded purlin offered the opportunity to add a second crosswise beam outside the existing. This outer crosswise beam was closed to the pediment by installing two strongly inclined *tang yo* structures. In fact, each *tang yo* structure consisted of an inner pair of inclined strut leaned against each other and an outer pair of inclined struts that clasped a short kingpost and enclosed a decorative strutting.

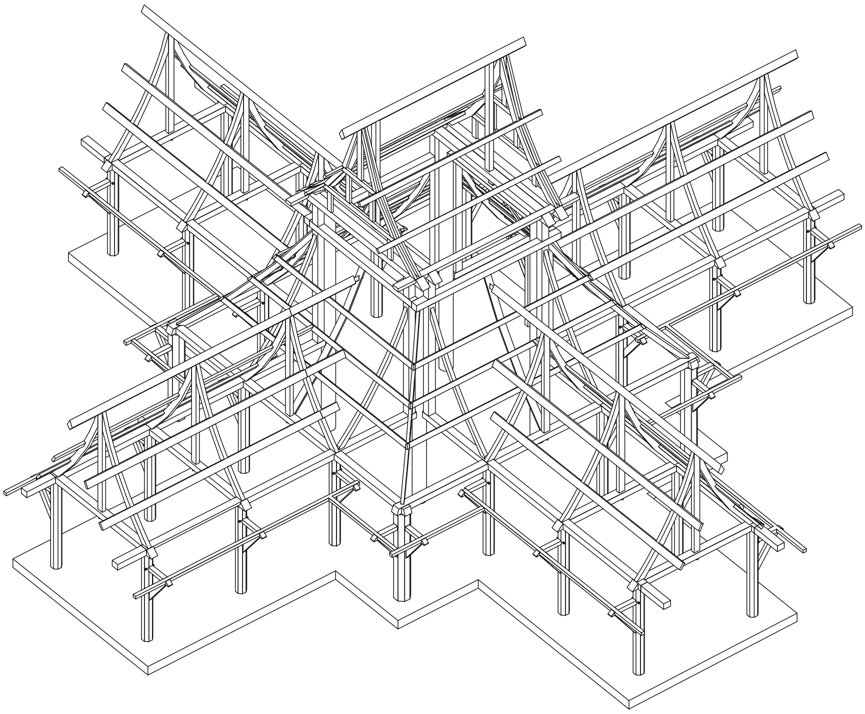


Fig. 4.39 Axonometric view of the madapa of Ton Kwen monastery reflecting to "a square pavilion with four outlying porches"

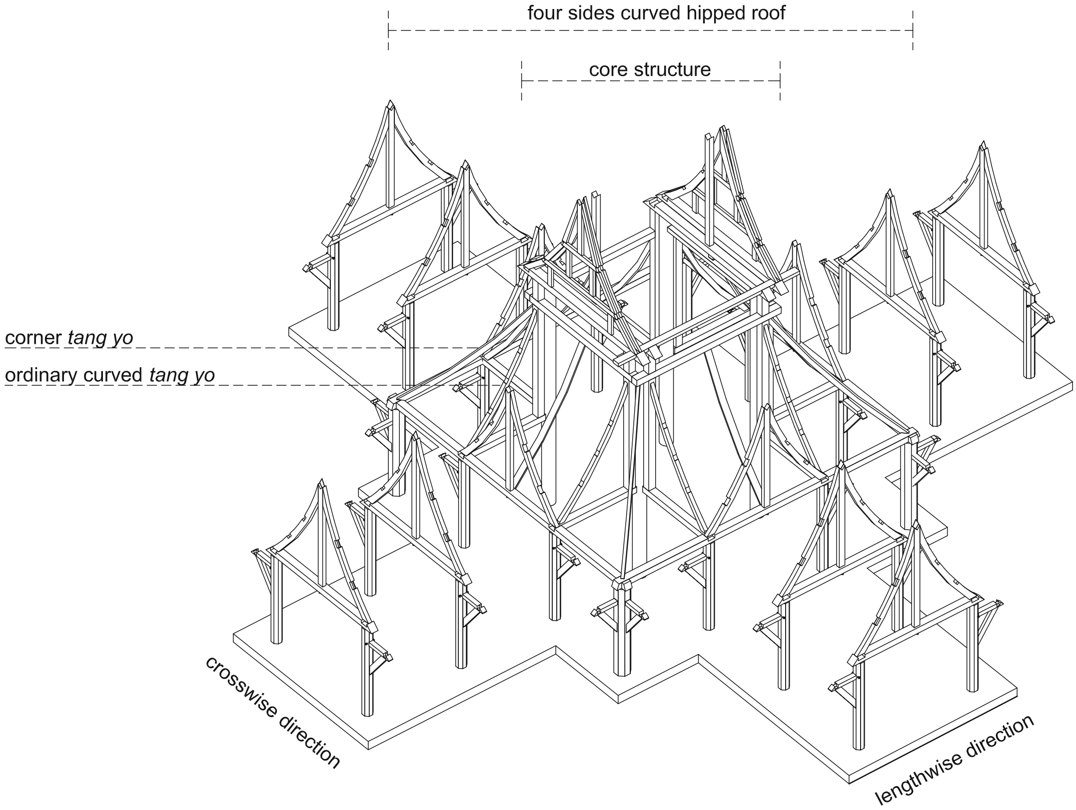


Fig. 4.40 Axonometric view of the madapa of Ton Kwen monastery

This construction made the gable really heavy. The carpenter used the same system he had applied along the eaves side. He added a flanking pillar directly beneath the junction of outer crossing beam and eaves purlin. The assembling of flanking pillars in longitudinal direction was no structural problem due to the symmetrical hipped roof structure. But also the inner crosswise beam got a duty, it had to carry a kingpost shortening the span of ridge purlin. In order to give this pillar a secured footing the carpenter inserted a horizontal beam between a pair of core pillars below the crosswise beam. These two beams were clearly set apart. The kingpost's footing was reduced on all four sides to a long tenon. This tenon was housed in both beams and thus strengthened stability against lateral movement significantly. Two intermediate purlins were installed to offer a supporting structure strong enough to resist the pressure of the strongly bent roof shaping members.

Let us turn to the hipped roof covering the central pavilion. The ground plan is outlined by twelve pillars enclosing the core pillar. The perimeter pillars are combined top side by four parameter beams connected on top of the corner pillars by halved joints. The horizontal beams bridging the distance from perimeter pillar to core pillar are mortised to the core pillar and halved to the perimeter beam. The structural triangle consisting of bridging beam, flanking pillar and a curved *tang yo* fixed with a tenon on both ends constitute size and inclination of the hipped roof. The accordingly curved corner-*tang yo* is a special case. Its upper end meets the core pillar, its lower end stands the junction of two perimeter beams. If we consider carefully the created roof plane's surface, we realize a curvature in two directions. The vertical curve is determined by the curved *tang yo*. A horizontal curve results from the footing of the eight regular *tang yo*s. They end reside the perimeter beam while the corner *tang yo* partly covers the perimeter beam. The uppermost purlin of the hipped roof is a horizontal beam assembled to the flanking pillars and thus defining the necked part of the pavilion. Three more intermediate purlins are notched to the *tang yo*.

Extending the bridging beams from four porches are attached wing-like to the pavilion (see Fig. 4.41). In strict alignment with core and perimeter pillars two pairs of pillars define the length of each porch. Each pair of pillars supports a crosswise beam that support for its part a kingpost and two *tang yo*s leaning to the kingpost. The connection of porch and pavilion is visually managed primarily by intersecting the two roofs. Structurally it happens along two adjacent inner perimeter pillars defined as a third of pillars carrying the gabled porch roof. It was impossible during my investigation to find any trance how the *tang yo*s were jointed to the beam. I can only provide two assumptions. 1) the curved *tang yo* was connected to the junction of purlin and beam by a kind of tenon. If so. it has been destroyed during the previous restoration process. 2) a tenon on top of pillar was cut long enough to penetrate not only beam and purlin but intrude the foot end of the curved *tang yo* as well.

The elongated bridging beam acts as the lowest structural purlin (see Fig. 4.41). In between this one and ridge purlin the carpenter provided two more intermediate purlins. All purlins were extended at their inner end in order to meet the roof surface of the hipped pavilion roof. There must be mentioned a joinery detail concerning the ridge purlin. The distance from the rearmost *tang yo* to the hipped roof's surface is quite long. The carpenter therefore decided to create a support for the inner ridge purlin's end. Based on the model of the *tang yo* defining the curve of the hipped pavilion

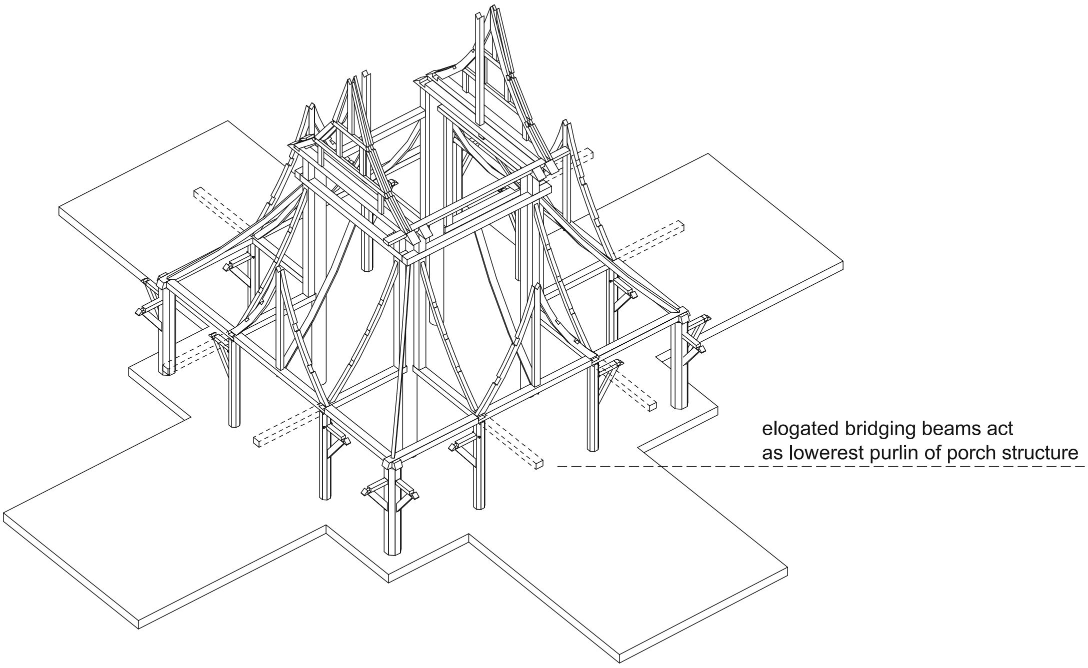


Fig. 4.41 Axonometric view of the madapa of Ton Kwen monastery present only inner core structure with curved gable and four sides curved hipped roof

Fig. 4.42 Mandapa of Ton Kwen monastery situated on the sand open filed

Fig. 4.43 Detail of inner ridge purlin end; the carpenter recessed ridged purlin into tenon, secured by key wedge

roof, he inserted a thin board in between the two *tang yo* combining core pillars and perimeter pillars. This board is 3 x 15 cm thick installing in alignment with the porches' kingpost. It is mortised into the topmost and lowest purlin. At the connecting point with the intermediate purlins, it is notched to the purlins for maintaining the tension. Finally, the porch's ridge purlin's end is fasten to this board via key wedged tenon for resist pulling strength of the center (see Fig. 4.43).

The carpenter erected a colonnade surrounding the main viharn. He applied the same proportion and arrangement of curved *tang yo* as in the porch structure of this mandapa. Before the year 2492, the colonnade consisted of 47 bays, but 11 of them were removed for erecting a new pavilion. Unfortunately, this new pavilion collapsed due to the thunder storm during the year 1966. The mentioning record is described on an information board inside the viharn of Ton Kwen. Currently, there are only 36 bays of colonnade left. According to the observation on the wood grain of all *tang yo*, the grain presents a pattern that allow to state that the curved elements are cut but curved and not bent.

4.5 Transition from *Tang Yo* to Modern Rafter

In this section, my study will analyze small structures and details in order to present the transition from former *tang yo* system to new rafter system. I interpret this change as a result of the introduction of a “modern” material: concrete roof tile; bolt and nut; and iron nail. These materials had significantly impact on load and load transfer. They demanded a rearrangement of structural components, and eventually redefined the understanding of carpentry.

Colonnade at Mae Tha Luang monastery, Mae Tha district, Lampang province

A record indicates the erection period of the viharn and surrounding colonnade of Mah Tha Luang monastery during the year 2486 (1943) (Sanyakiatikun 2008, p. 288). The colonnade here presents an interesting combination between the systems of modern rafter and *tang yo*. The colonnade’s structural roof components are made of timber covered by concrete roof tiles. At a first glance, we can observe that the carpenter laid a rafter from ridge purlin to longitudinal beam on top of the pillars. The cantilevering of the rafters form the colonnade’s eaves. This rafter is equipped with horizontal purlins that are distance corresponding to the size of concrete tiles.

The description above characterizes the contemporary roof structure. However, we can still observe a pair of *tang yo* that have been assembled along the axis of crosswise beam on top of the pillars. The lower end of *tang yo* is fixed on both ends of crosswise beam using iron nails. On *tang yo*’s upper end and its middle part, the carpenter cut notches, in order to house ridge and intermediate purlin respectively. A kingpost is nailed at the lateral side of the crosswise beam, to support the ridge purlin additionally (Fig. 4.44).

There might immediately arise the question why the carpenter still needs to assemble a pair of *tang yo* together with the intermediate purlin while using ordinary rafter. The colonnade of Mae Tha Luang monastery is covered with rafter of rather small cross section (2.5 x 4 cm), while the contemporary standard of rafter is 5 x 15 cm. The size of this small rafter remind us to the roof shaping member but base on significant different. The roof shaping member is assembled face upside, this rafter is edge upside. The roofing members would be ensemble in larger distance corresponding to the size of concrete roof tiles. The *tang yo* still fulfills the former task. Their support of the intermediate purlin prevents the rafter from sagging. My analysis suggests to consider this presented structural arrangement as an example of transitional period. We can read it as a carpenter’s pursuance to adapt his knowledge to materials and building techniques.

According to the principle of closed triangle roof in old Lan Na, *tang yo* system could not provide cantilevered eaves by itself. It was the roof shaping member’s task to create the structurally necessary overhang at the eaves. Concrete tiles are supposed to have come up during 1940 – 1960 when carpenters implemented them they had to deal with at least two constraints. First, he had to seek a solution to handle such heavy load as the traditional method of assembling structural components could not withstand. Secondly, the size of new concrete tiles is much larger compared to traditional wood shingle and clay tile. The bigger size did not allow to curve the roof plane as before.

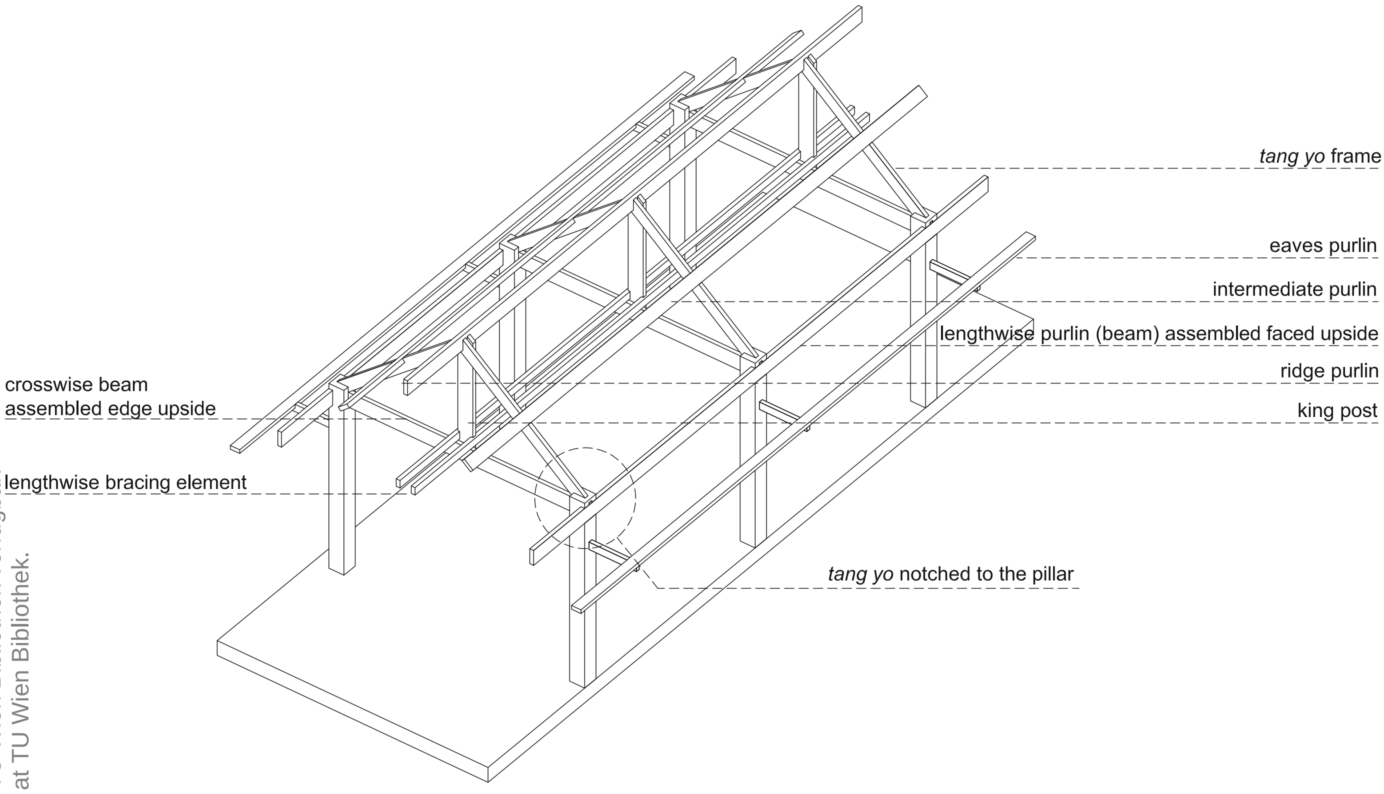


Fig. 4.44 *Tang yo* frames at the colonnade at Mae Tha Luang monastery

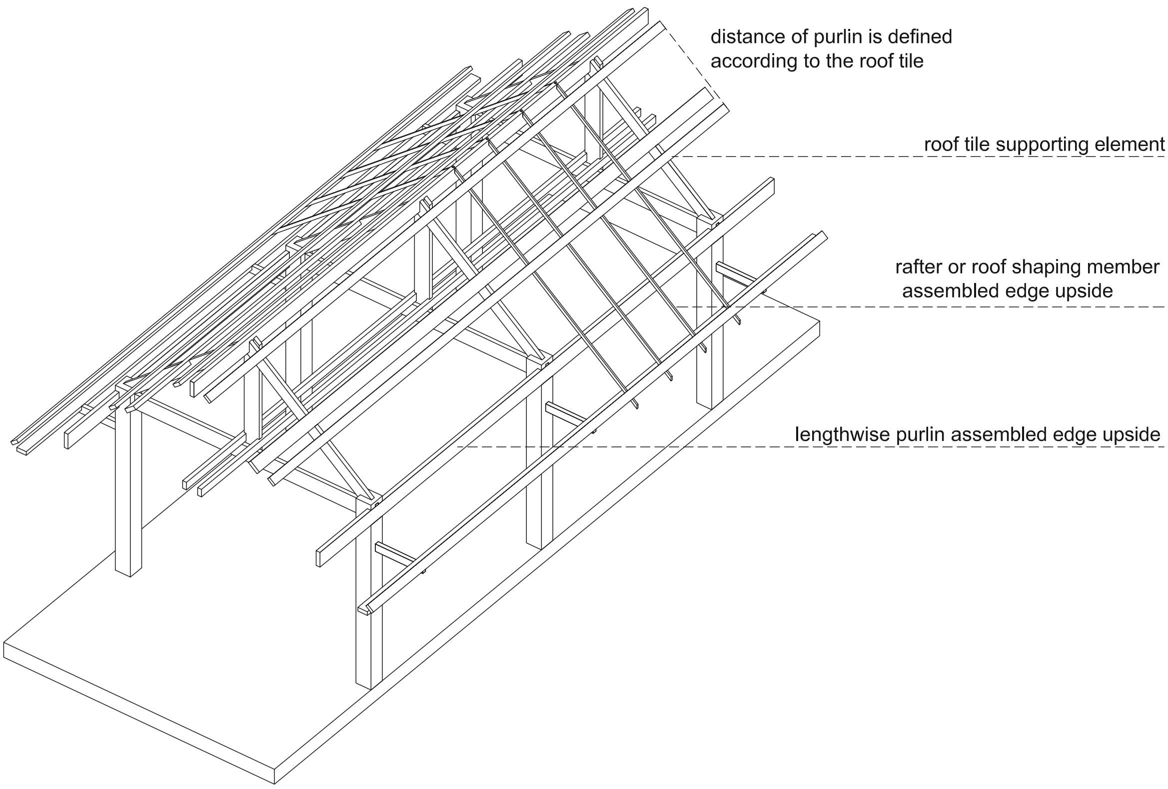


Fig. 4.45 *Tang yo* frame in combination with rafter

Therefore the carpenter had to redefine his common method working with *tang yo* system. He turned roof shaping member from face upside to edge upside in order to deal with the load of tiles and to create the eave part (Fig. 4.45).. Yet he had to give up the curved appearance. This redefinition leaded to the early appearance of rafter.

One might come up with another question related to the renewal of roofing material that resulted in a coexistence of *tang yo* and rafter simultaneously. Did this combination of closed triangle frame and rafter result the changing of roof tile after the period of construction? Is it possible that former wood shingles or clay tiles had been replaced by concreted tiles? Wooden joints could help to find an answer. If there cannot be found a trace of replacement the whole pillars. The roof structure as seen in situ should present the original stage of co-existence. In our current case, the carpenter assembled the crosswise beam and the longitudinal head beam edge upside in contrary to the traditional method that these components were face upside. The beam components are notched to the pillar head and connected to the column by bolt and nut. The change of this beam's execution should be recognized as an expression of carpenter understands of the fundamental structural change. The former load transfer from tension in close triangle system has been superseded by compression in rafter roofs.   The changing in direction of these beams should be seen in the light of the transformation of the carpenter understanding corresponding to the change of load transferring from tension in close triangle system to compression of rafter roof.

The structure of this colonnade represents an erection in a transition period in which the technical mean have been redefined following the adaptation of new material. The implementation of these new materials facilitates the construction work. Structural components can be fixed by iron nails thus open new possibilities of shaping the roof form as it does not rely on the close triangle anymore

Monk residential compound at Baan Luk monastery, Mae Tha district, Lampang province

A monk residence compound at Baan Luk monastery was erected around the year 2490 (1947). The building is built up on piles, elevated 2.20 m from the ground. The planning presents the living quarter surrounding a central courtyard. A staircase in the courtyard connects ground floor and upper floor. The transverse section of the building presents a gable roof resulting from the combination of *tang yo* with rafter. A distinct characteristic of the structural arrangement in a transverse frame of this building is the detachment of a pair of *tang yo* from the crosswise beam (Fig. 4.48). The carpenter cut the lower end of *tang yo* to bird’s mouth shape and let it stand on both outer sides of longitudinal beam leaning against each other. He had notched a seat for the ridge purlin at the intersection point. The ridge purlin again is carried by the kingpost standing upright on the crosswise beam. Both longitudinal and crosswise beams are assembled edge upsides. The carpenter strengthened the stability among different transverse frames by adding another beam. This longitudinal beam fastened all frames together (Fig. 4.46). The beam had been assembled at the base of the kingpost and secured by a pair of wooden pieces. A pair of rafters is connected together using scissor joints and hanging down from ridge purlin to longitudinal beam. The cantilevered part defining the eaves ending projects 60 cm. The roofing material is made from concrete tiles.

According to the building description above, the edge upside assembled components and the detachment of *tang yo* from the transverse frame represent the new concept of load transfer and the formation of new technical means. The carpenter cut the head of pillar, placed the crosswise beam above and then notched the longitudinal beam. The wooden joinery at the head of pillar seems to be a new invention in this period. The carpenter had to shift the pair of *tang yo* in order to provide sufficient working space at the pillar top end for joining crosswise and lengthwise components. As a result, *tang yo* only play a secondary role for carrying ridge and intermediate purlin. They do not strengthen the transverse frame anymore. The roof construction does not depend on the formation of closed configuration, thus allowing a wider variety of possibilities.

Fig. 4.46 combination of *tang yo* and rafter in the roof structure of the monk residence at Baan Luk monastery

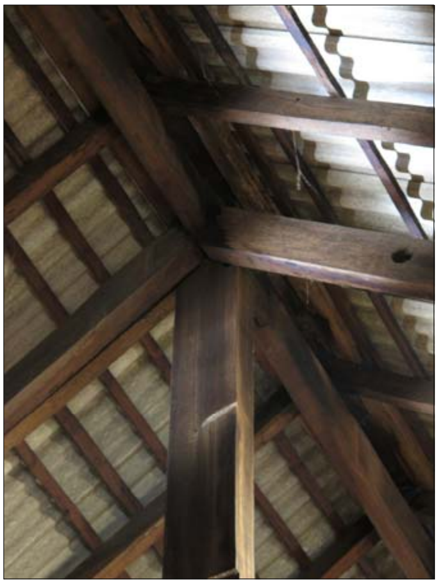


Fig. 4.47 Ridge purlin notched above *tang yo* and kingpost

Fig. 4.48 Carpenter deatched *tang yo* from the tie beam and placed it on lengthwise beam

4.6 Historical Aspects and Developments of *Tang Yo* and Early Rafter

Historians believe that the basic carpentry tools were available in old Lan Na, for instance axe, knife, hammer, pincers, etc. (Penth 2007, p. 110). A mural painting inside the viharn of Bua Krok Luang monastery in Chiang Mai dating from around 1850 or in the first half of 25th Buddhist century (Laohasom 1999, p. 81) illustrates an erection of viharn, assumingly by a group of Chinese carpenter. In this painting, we can see a chisel used for cutting a mortise hole, a plane used for furnishing the surface of building components, a two-man saw used for cutting a log. In addition, we can observe a person that looking like the head of the carpenters inspecting an erection process from a distance. The *Chronicle of Chiang Mai* mentions a usage of axe since the beginning of Lan Na by depicting an episode of a carpenter Kan Thom. He used his axe to shave the hair of a person "as bare as if were done with a razor, because he had precise hand and obtained an ax a with sharp blade (Wichienkeeo and Wyatt 1998, p.67-68).

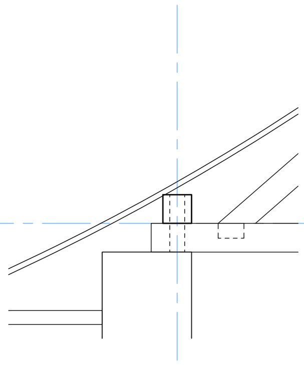
The oldest roof structure based on *tang yo* system known so far belongs to the viharn of Duang Dee monastery in Chiang Mai and the viharn of Ton Leang monastery in Nan province. For the latter case, my investigation observed the usage of axe for furnishing the surface of building components and the trace of chisel used for creating mortise holes of the *tang yo*'s footing. Among the group of Tai Lue viharns in Nan province: Nong Daeng, and Don Mun monasteries erected before 1800 (2350), my investigation observed less sophisticated joinery. E.g. the main aisle purlin was assembled to the crosswise beam without any recess. Both components were simply strung to the double-height tenon cut on top of outer pillar. We have seen precise double notched joint between purlin and beam that allowed a flush surface on top of the purlin in Lampang and Chiang Mai provinces. Carpenters had difficulties to produce comparable joints due to the lacking of accurate carpentry tools: hand saws and elaborated chisels. I state following assumption: The development of *tang yo* system until transitioning to modern rafter pertain to availability of imposed tools and its working experience. If so, I suggest to divide the development of *tang yo* system broadly into two phases: 1) before the arrival of modern tool and modern material and 2) adapted to modern tools and material.

4.6.1 Development before the Arrival of Modern Tools and Modern Materials

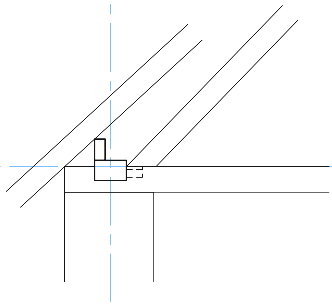
<u>Improvement of joinery and development of tool</u>

Early samples from the viharn of Nong Daeng and Ton Leang monastery exhibit the geometry of tenon footing of *tang yo* perpendicular to the crosswise beam. The surfaces of building components from these two viharns were executed with an axe. In investigation I could further observe a change in the tenon's geometry. The tenon was cut according to the wood fiber, that means following the direction of *tang yo*. The mortise hole is drilled accordingly (see Fig. 4.49). The tenon's head become adjusted to resistance diagonal force optimally.

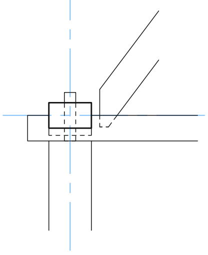
The sample from Phaya Wong house presents the tenon footing of *tang yo* resting on both crosswise beam and main purlin. The carpenter notched the main purlin above crosswise beam and



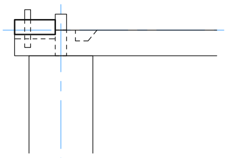
Viharn of Nong Daeng monastery
1787 (2330)



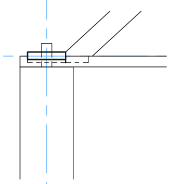
Viharn of Ton Leang monastery
1578 (2121)



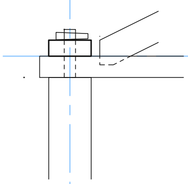
Rice granary of Phaya Ping
1807 (2350)



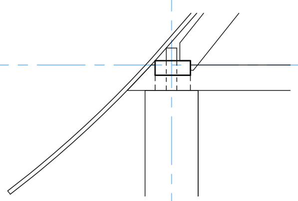
Pavilion of Baan Luang monastery
1850 (2330)



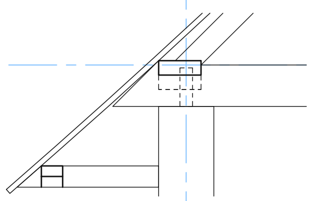
Tai Lue house
1940 (2490)



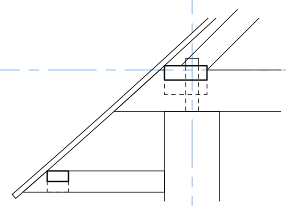
Rice granary in Chiang Kham
approx. 1930 (2480)



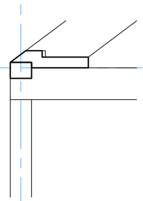
Phaya Wong house
1897 (2440)



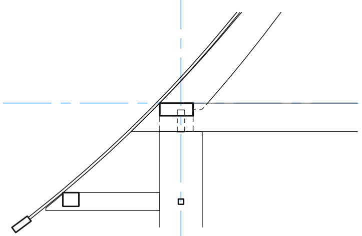
Ubosot of Sri Auan Monastery
1907 (2450)



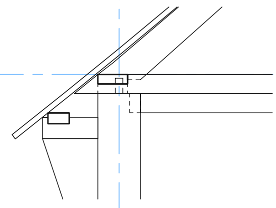
Ubosot of Phra Bath Mae Thai
1938 (2488)



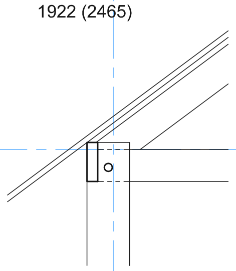
Viharn of Baan Mieng
1922 (2465)



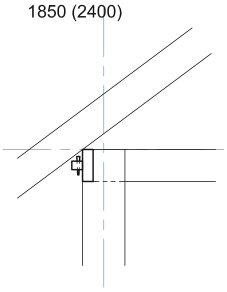
Mandapa of Ton Kwean Monastery
1850 (2400)



Viharn of Klong Kak Monastery
1880 (2430)

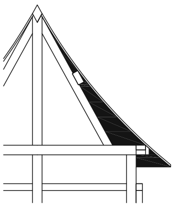


Colonnade at Mae Tha Luang
1943 (2486)

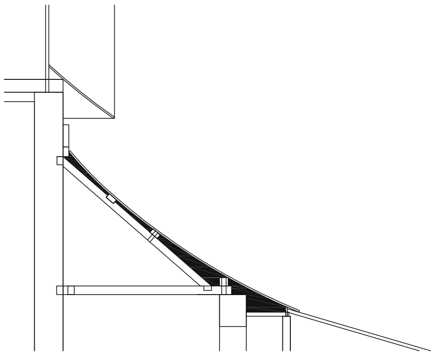


A house in Pong district, Phayao
province 1950 (2493)

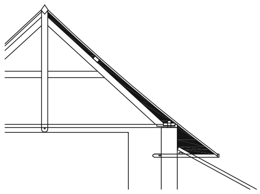
Fig. 4.49 Connection of *tang yo* - rafter to crosswise element



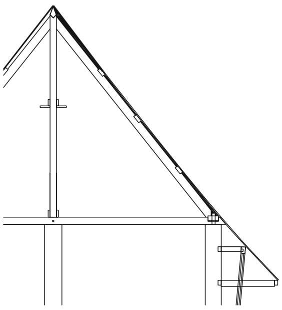
Viharn of Ton Leang monastery
1578 (2121)



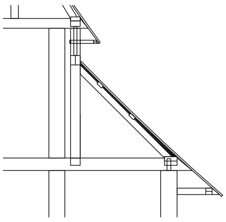
Viharn of Nong Daeng monastery
1787 (2330)



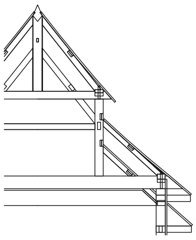
Tai Lue house
1940 (2490)



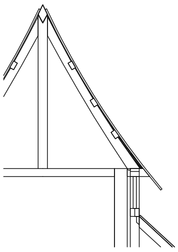
Phaya Wong house
1897 (2440)



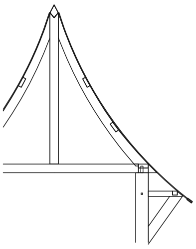
Ubosot of Sri Auan Monastery
1907 (2450)



Ubosot of Phra Bath Mae Thai
1938 (2488)



Viharn of Klong Kak Monastery
1880 (2430)



Open Pavilion of Ton Kwean
Monastery 1850 (2400)

Fig. 4.50 Curved roof formation based on *tang yo* system let the *tang yo*'s tenon of rest there. The longer surface resulting from the combination of crosswise beam and main purlin can resist the diagonal force in much better way. The mentioned joinery technique would not be possible without refined carpentry tools allowing a carpenter to cut precisely the recesses for notched joints and furnished their attached surface. Another two ubosots from Lampang province: Sri Auan and Phra Bath Mah Thai monastery demonstrate the *tang yo* that rest solely on main purlin (beam). The main purlins are notched in certain consistent height. The carpenter cut the footing of *tang yo* into bird's mouth shape in order to adjust it to the purlin.

It might be possible to see the improvement of joinery as summarized here in one light with the evolution of artistic style in old Lan Na since these two tendencies occurred simultaneously in the same period. Woralun Boonyasurat, carried out a study on the development of decorative pediments of Lan Na viharn from the beginning of 25th Buddhist century (approximately from 1850). She described a style based on the wooden carved work so called "ลายพันธุ์พฤกษา" (Flora decorative ornament). The work according to this style is an elaborated work requiring a refined tools e.g. sharp chisels. The carpenter had to carve the pediment presenting planting and flowering (Boonyasurat 1992, p. 262). So far we have no clear evidence where carpenters in old Lan Na obtained their tools. Refined tools might have been transported from China or Burma via British colonials.

Aesthetic improvement

We have analyzed grounded in two samples of the viharn of Klong Kak and the mandapa of Ton Kwen monastery that a curved *tang yo* presents the unity of form between the shape of the curved roof and the curved *tang yo* (see Fig 4. 50). Even though the curved *tang yo* requires no further adjustment of purlins set for constituting the curved roof plane in contrary to a straight tang yo, however this curved *tang yo* was anything but a simplified version of the system. The production of curved *tang yo* demanded more manpower and working hours. A group of carpenters had to carve the curved members into consistent configuration. The method of curved *tang yo* could only be possible in a society that provided organized man-power.

4.6.2 Development since the arrival of modern materials and tools

Modern materials, Application and Optimization

Vivat Temiyabandha provided an observation on the works of Lan Na carpenters. According to their encounter with modern materials and tools the carpenters had to adjust their knowledge on building technique and had to learn how to gain highest benefit from newly arrived technologies. Temiyabandha called a house erection at this time an "evolved typology after *ka lae*." He described the characteristic of house in this period as "the form of house is transformed according to the requirements and tastes [...] the planning of roof presented complex surfaces and fascination. The works reflect intelligence of local carpenters who were capable to adjust their prior knowledge and optimize it following the utilization of technology." (Temiyabandha 1993, p. 75).

Nevertheless, Temiyabandha did not provide a concrete explanation in terms of building technique e.g. how a carpenter created such a complex work; also not towards which means. According to the analysis in this chapter my study suggests a hypothesis that the local carpenter probably started from redefining his knowledge of *tang yo* system in order to respond to the technical requirements of concrete tiles. The carpenter's consideration likely resulted in the introduction of rafter. The early concrete tile was made locally. The owner of the house had to prepare a mold for producing tiles and the concrete admixture (Suebpong 2014, p. 88.) or sometimes people had to hire a craftsman from another village (SAC, MM-12-252). Early rafters looked like a roof shaping member in *tang yo* system that was flipped upwards. Afterwards crosswise beam and main purlin were assembled adjusted from former face upside to edge upside according to the change of load transfer.

My study suspects that this mentioned transformation process would not have been possible if new tools and machines had not been introduced. At an early stage, the carpenter used an axe to notch crosswise beam and longitudinal beam assembling edge upside to the top end of a pillar. He recessed the edge of the crosswise beam to a tenon and mortised it to the longitudinal beam. The connection is secured again by a wedge (see Fig. 4.49 - a house from Phayao). Consecutively, the building components were produced in saw-mills, the use of handsaws became widespread, and the arrival of bolt and nut facilitated the work of carpenters still more.

The development of rafter opened new horizons for the carpenter. The roof construction does not need to rely on the closed triangle configuration of *tang yo* anymore thus the planning of houses became more flexible corresponding to the needs and complex requirements.

Transformation of mentality

The decision of transforming old *tang yo* system to new rafter system was probably one of the most important historical moments presenting a shift of mentality in Lan Na society. The neglecting of *tang yo* meant the termination of hundreds of years of the curved roofs' development. The abolishment of curved roof had paid off for the sake of new system that allowed flexibilities in planning, roof form, and most important facilitated the constitution of personal identity (see Rapoport 1969, p. 7). A field note from the anthropologist Michael Moerman recording the erection of a house in the year 1960 can portray the atmosphere of this historical moment very well: "New large wooden house of cEn [cEn is used by Moerman to signify the phonetic pronunciation.] being built by CB [Chiang Ban] carpenter & his younger brother […] homeowner works some [homeowner works a little bit], oversees, distributes material like nails & bolts […] Roof will be of tile made on site by Lampang artisans […] who get 150 [bah]t per 1000 tiles. [A] House will take 3000 [tiles]. The carpenters [from Chiang Ban] are paid, the other workers are lianged [invited for meals]. The wood is pre-cut and very accurate so. The pEng [floor beam] are affixed with bolts through pre-drilled holes which fit truly with one another and with saw" (SAC, MM-1-12-252). "cEn's house will be expensive. All wood will be planed, the carpenter fee […] is ฿ 2,500 [baht] […] cEn seems quite proud of this house. […]

it is mostly of maj takean [woodspecies: Hopea odorata] & [erected] in a style [bungalow’s style] new to Phead [village]” (SAC, MM-1- 12-253).

Chapter 5

Neighbor regions of Old Lan Na

5.1 Relations of Lan Na to Neighbor Regions

It would be improper to carry out the analysis on Lan Na building techniques without considering the building culture of its neighbor regions. Lan Na was not an isolated cultural sphere at all. I believe it is necessary to overcome the institutionalized "Lan Na centric" perception when analyzing architecture built in the regions discussed in my thesis. The term Lan Na or the land of "million rice fields," appeared first on a stone inscription dated 1555 (2098) together with its old allies, Luang Phrabang of the "Lan Chang" kingdom. The word "Lan" in Lan Chang shares the same meaning of "Lan" in Lan Na which means "million," the land of "million elephants" (Penth 2007, p. 29). First and foremost, my study shall begin with the brief presentation of researches on the relations of old Tai polities. There are three issues that my study finds the most relevant for grounding the basis for building culture in general and building technique in particular: 1) Legendary myth and formation of Tai mueang, 2) Relations with autochthonous people, and 3) Expansion of Buddhism.

<u>Legendary myth and formation of Tai mueang</u>

There exist several stories and variants of a legendary king, "Khun Borom" sharing among different groups of Tai and autochthonous Mon-Khmer speaking people. Khun Borom fought war against Kaeo (assumingly old Vietnamese ruler) and won. He assigned his seven sons to rule the mueangs that later became Tai polities. The historians attempted to interpret the actual positions of these seven mueangs suggesting different possibilities: mueang Swa (currently Luang Phrabang), mueang Hua Tae (Sipsong Panna), mueang Keao (assumed to be mueang Hua Phan or somewhere in current territory of Vietnam), mueang Ngeon Yang Yonok (the predecessor mueang of Lan Na), mueang Ayothaya (some assumed Ayutthaya), mueang Hamsavati (mueang Pegu in Burma), and mueang Phuen (currently mueang Ponsawan in Laos), (see also Wyatt 2003, p. 9; Chonticha Sadyawadhna 1987, p. 170; Martin Stuart-Fox 2008, p. 165; Leeming 2001, p. 128). A historian estimated, if the legend of Khun Borm had really taken place, it would date around AD 8-9 (Schliesinger 2001, p. 32).

In spite of the ambiguity and myths narrated in Khun Borom legend, David Wyatt sees legend's storyline functioning to set up a spatial relationship among widely scattered Tai groups (Wyatt 2003, p. 9). Georges Condominas, a French anthropologist interpreted the purpose of above blood-tie narratives of the Tai rulers intended for avoiding any possible belligerence (Condominas 1990, pp. 40-43). The historian Grant Evans called such narration "a developed notion of aristocrat lineages" among the Tai mueangs (Evans 2002, p. 4). According to the historical sources, the kingdom of Lan Chang has been established in 1353 by King Fa Ngum at the current location of Luang Phrabang (Stuart-Fox 2008, p. vi). Fa Ngum had seized Xieng Dong Xieng Thong (Chiang Dong-Chiang Thong), and established the kingdom of Lan Chang Hom Khao, "Kingdom of Million Elephants and White Parasol" (Stuart-Fox 2008, p. 101). The Chronicle of Laos (Laos's version) depicts the event of Lan Chang's expansion towards the south. Fa Ngum seized several mueangs and took them under control until he reached the territory of Ayutthaya. The founding ruler of Ayutthaya, King U thong had invoked Fa Ngum that they both were in fact descended from Khun Borom, thus they shall not fight against each other. The kingdom of Lan Chang and Ayutthaya therefore made an agreement regarding their territory along the mountain chains of Phaya Fai and Phaya Po (Grabowsky 1995, p. 112). In addition, King U thong offered his daughter to be a wife of Fa Ngum.

The cross marriage between ruling classes can be seen throughout the history of Tai polities. The marriage is treated as a strategy for consolidating the power. The King Xetthathirat ruled both Lan Na and Lan Chang during the years 1548-1571. He was a son of Lan Chang king, Phothisarat, who married the Lan Na Queen. Xetthathirat grew up in Chiang Mai and then succeeded to the throne of Lan Na in the year 1546. Upon the death of his father Phothisarat in 1548, he went to Lan Chang and claimed his right to rule the kingdom. According to the historian John Clifford Holt, Xetthathirat's period led to an intensification of cultural influence of Lan Na on Lan Chang (Holt 2009, p. 66). One of his building projects was the Chiang Thong monastery, erected in 1559 (Boonyasurat 2004, p. 106). Recent scholars took the monastery's grand viharn as a key for exploring the artistic relationship between these two regions.

Relations with Autochthonous People

The autochthonous people in the region of old Lan Na before the arrivals of Tai, were Mon-Khmer speaking groups, e.g. Lua (Lawa). Condominas believed that they were the "key" to understand Chiang Mai's culture because of their early and significant roles in Mainland Southeast Asia (Renard 2015, p. 17). The interpretation of historical sources in Penth's studies suggests that the Lawa and Tai Yuan of Lan Na probably lived side by side and exchanged cultural elements (Penth 2004, p. 23). The expansion of Tai and the formation of lowland mueang had driven them into the mountains. The recollections of this episode are well preserved in form of oral history. Although the hypothesis of Condominas and Penth might seem rather speculative, hitherto several scholars present findings to show plausibility of the idea, e.g. how the cultural elements of autochthonous people co-existed with those of Lan Na. Shigeharu Tanabe's article on the cult of city pillar (Inthakin) in Chiang Mai traced back the integration of Lua's symbol into Lan Na cityscape. The adoption of predecessor's city pillar represents a strategy to incorporate Lua into Tai's polity (Tanabe 2000, p. 304).

Autochthonous people also played important roles in the coronation custom of the Tai kings. During the revival period of Lan Na 1158, King Kawila began his ritual for accession to the throne with the homage to Buddha Images outside the city moat of Chiang Mai. The king continued to lead his retainers to the northern gate (white elephant gate) and had Lua "leading dog" as an initial group entering Chiang Mai inner city, followed then by his own group (Wichienkeeo 2002, p. 2). While the relationship of Lua and Tai Yuan of Lan Na seems to be symbiotic, the relation of Lua and Tai Khoen of Chiang Tung appears contrary. Their rite seems to reflect the positions of victor and loser (Wichienkeeo 2002, p. 7). Wichienkeeo refers to an observation from Hugo Adolf Bernatzik during his visit to Chiang Tung in 1927. Bernatzik mentioned “the Shan [Tai Khoen] in Chiang Tung have an annual ceremony in memory of their taking control of this land. One Wa [Lua], dressed as an all-powerful person, is seated on the throne. Then a group of Shan [Tai Khoen] come and forcefully remove him. This commemorative act finishes with a victory feast,” (Bernatzik 1958 in Wichienkeeo 2002, p.4). Anthropologist Hjorleifur Jonsson assumed an incentive of uplander (Lua) in taking part in such rituals as it allowed them to establish or maintain beneficial relations with lowland courts and at the same time to separate themselves from a social order that they found unacceptable (Jonsson 1996, p.173).

Economic relation between Tai Yuan and Lua signifies the indispensable mode of exchange between lowland and highland. The mountain and forest were formidable territory for Tai, therefore lowland Tai had to depend on the Lua’s forest products, for instance: honey, bee-wax, animal horns, fragrant woods, etc. (see also Kunstadter 1967, p. 641). The most important Lua’s products were iron tools. They had access iron mines and expertise in mining and smelting iron (Grabowsky and Turton, 2003, p. 232). Srilao Ketphrom a philologist, read the Royal Order putting demands on Lua in the year 1409 (1952). In the Order, the Lan Na king listed the products that Lua should offer to the monastery under his patronage, in this specific case, the Pa Sak monastery, Chiang Rai. The list of iron products consisted of “[…] seven [units of] hoes, seven [units of] spades, seven [units of] axes, seven [units of] knives, seven [units of] chisels” (Ketphrom 1999, p. 5).

Expansion of Buddhism

Several scholars on Mainland Southeast Asia have explored how Buddhism played an instrumental role in unifying old Tai kingdom (see Evans 2002, Stuart-Fox 1996, Holt 2009). Each of them expressed different hypotheses on details of locals’ receptions and relations towards an introduction of religion. Nevertheless, most scholars tended to agree the significance of Buddhism. As Evans has put it, Buddhism provided “universal ideology able to draw disparate people into cultural framework” (Evans 2002, p. 10). Although Evans’s statement derived particularly from his previous studies on Lao history, his statement is also valid and bares some truth for explaining other old Tai polities in Mainland Southeast Asia: Lan Na, Sukhotai, Ayutthaya, etc.

According to studies on historical sources conducted by Prasert Na Nagara, the Philologist, the installation of Buddhism into the region of Lan Na derived from three major events. The first installation occurred in Hariphunchai era, during the reign of Camadevi 661 (1204). The second event took place in the year 1369 (1912) during the reign of Lan Na king Kue Na (rule: 1355-1385). A Buddhist mission had travelled and brought Tripitaka scripts from Sukhotai to Lamphun and Chiang Mai. The king founded Suan Dok monastery for them. The third event stemmed from the politics of religious institution inside Lan Na itself. A group of monks began to be skeptic toward the didactic of their superior. They arranged a journey to Sri Lanka in order to re-ordain and obtained more “pure” Tripitaka scripts. They came back to Lan Na in 1430 (1973), and established a new Buddhist sect, “New” Sinhalese sect” at Pa Daeng monastery. Suan Dok and Pa Daeng were the opponents constituting two different Buddhist sects. Both of them cannot carry out ritual ceremonies together. In

Na Nagara's article the study also presents the tension, conflict, and quarrels between these two (Na Nagara 1997, p. 35). The Buddhism in Lan Na transferred to Lan Chang during the reign of King Xetthathirat , who ruled both kingdoms. He took the important Tripitaka scripts, religious chronicles, and several Buddha Images along with him to Luang Phrabang (Payomyong 1997, p. 47).

The Buddhist institutions in Lan Na and in Chiang Tung were closely related. The first installation of Buddhism in Chiang Tung took place in 1339 (1882), when King Pha Yu of Lan Na assigned his son to rule Chiang Tung. The king arranged a group of monks to accompany him and founded a monastery there. The second installation derived from a group of Tai monks who received an education in Burma, travelled to Chiang Tung in the year 1374 (1917) for spreading their practices. In the year 1446 (1989) or 16 years after the founding of Pa Daeng monastery in Lan Na, the monks from Pa Daeng had gone on a pilgrimage to Chiang Tung. The ruler of Chiang Tung passed on the Royal Order to establish a monastery for them (Wichienkeeo 1994, pp.11-13).

In Chiang Tung Buddhism was employed to provide a hierarchical status for the autochthonous Mon-Khmer people inhabited the surrounding mountainous regions. The people prefer to be recognized from the outsider (e.g. from the lowlander) as "Tai Loi," literally translated as mountain Tai. But for communicating among Mon-Khmer speaking people, they refer to each other using specific ethnic names: Paluang, Blang, etc. in combination with their villages' name. For instance, the "Blang of Baan Ngek" means Blang people of Ngek village. They were the people that Lan Na historic sources connote as Lua. Scholar believes the background of these complicated ethnic labels (e.g. adopting the word "Tai"), derived from their intention to distinguish themselves from their "less civilized" relative (Renard 2015, p.500). A cultural practice and its element that represented their "civilized" was the conversion to Buddhism and erecting monasteries. A British colonial officer labeled Tai Loi as "Tamed Wa," in contrast to the "Wild Wa" who was not Buddhist and still practiced head hunting (Scott 1906, reprinted 1999; p. 136-137; and Guo; Miller & Xu 1994, p. 288). My study shall note that the early Buddhist chronicles in Lan Na frequently refer to Lua as "Milakkha" or barbarian.

5.2 Relation of Building Cultures from Lan Na to Neighbor Regions as Seen from previous Research

Woralun Boonyasurat carried out a comparative study between religious edifices in Chiang Mai and in Luang Phrabang under the larger research scheme *The Relations between Lan Na and Lan Chang: Cases of Religious Art in Chiang Mai and in Luang Phrabang* (2001). In her article, she employed the configurations of ground floor plan and the roof form as comparative materials. She stated that "the ground floor plan and roof form of the sim (viharn) belonging to Luang Phrabang type are similar to the viharn in Chiang Mai. But in some sim, for instance: the sim of Chiang Thong monastery, the curved roof appears more delicate [the roof profile appears more bended]. Whereas if the curved roof appears relatively straight and the ground floor plan looks smaller, then it is a sim belonging to Chiang Khoung type" (Boonyasurat 2001a, p. 58). She used the term *tang mai* for indicating the standing pillar in the roof structure of the sims in Luang Phrabang.

In 2004, she published a book *An Appreciation of Architecture: Buddhist Temples in Luang Phrabang*. Beside the similar aspect of the roof form that she has observed and maintained in her description since previous publication in 2001, she added another observation that the wooden joinery and proportion of the roof structures of Lan Na's viharn are different to Luang Phrabang's sim (Boonyasurat 2004, p. 84). But she did not provide any technical detail illustrating such differences. She only explained briefly that the delicate curved roof plane of Luang Phrabang sim derived from the arrangement of standing pillar above crosswise beam.

Taipat Puchitchawakorn carried out research on Lan Chang styled ubosot and viharn in Thailand. He described the appearance of these historic buildings similarly to Boonyasurat's statement as well as made a reference on the same building. He wrote the following, "…the Viharn of of Xieng Thong [Chiang Thong] monastery was erected in the golden age of Lan Chang. The king of Lan Chang ruled both Lang Chang and Lan Na. The viharns of Lan Chang present some similarities to the one of Lan Na, as for example, the elevated roof form, the division of roof planes, and the decoration of golden stencil" (Puchitchawakorn 2011).

For a general description of roof structures in these regions, a French scholar belonging to the circle of EFEO, Jacques Dumarcay had just a glance to the roof structures of religious buildings in Northern Thailand (Lan Na), in Laos and in Cambodia, thus stating that the carpenters applied similar structural frameworks. He named them in a generic term "bending" framework (Dumarcay 2005, P. 28). However, my research has to disapprove his survey since all of his drawings referring to the buildings in Lan Na and Lan Chang contain crucial mistakes pertaining to the principle of structural assembling. It is impossible to draw conclusion on his wrong surveys (cf. Dumarcay 2005, Fig. 20, Fig. 21 and Fig. 26).

The visual attraction stemming from the roof appearances continues to dominate a comparative building research, as Thai scholars expanded their research area attempting to draw a relationship of building culture to other Tai regions. Kreangkrai Kirdsiri was a pioneer of scholarly research on the architecture of Chiang Tung and its surrounding. He had encountered several monasteries of Tai Loi people in the mountainous areas of Northeastern Shan during his PhD research. An example should be sufficiently demonstrating how he began to perceive this area's building culture. He described an ubosot of a monastery in the following sentence: "The character of this building shares some similarity with the viharn of Lan Na, [as we have seen at the composition of roof]. From the frontal façade, the level of roof ridge elevated two times and lowered once toward the rear side." Kirdsiri interpreted his own observation of the visual similarity and proposed two reasons for such occurrence. Firstly he considered that the practice of Buddhism might be transferred from Lan Na and Chiang Tung resulting in the transmission of architectural forms. Secondly he considered the idea that similar utilization of space within the buildings might shape and result into similar visual appearance (Kirdsiri 2010, p.78). In his study, he has introduced an important term "shared Lan Na typology," ("*วิหารร่วมแบบล้านนา*") to outline such similarity of buildings in Chiang Tung with the type of Lan Na viharn (Kirdsiri 2010, p. 78).

Two publications of Kirdsiri "*The Monastery and Community of Baan Saen, Keng Tung*" (first publication 2007 and reprinted 2010) and "*Tai Doi (Lawa) Monastery in Shan State: Civilization Reflected by Sacred Architecture*" (2009) provokes some degree of enthusiasm to the larger group of Thai researchers. A research center in Chiang Mai University, Northern Archeology Center (NAC) carried out the investigation in Northeastern Shan state in the year 2009 under the research scheme *A Comparative Study on Buddhist Artwork of Tai Community in Keng Tung, Shan State Union of Myanmar and Mae Tha Community in Lampang Province*. In the description pertaining to historic building, the research report considers that the historic religious building in Chiang Tung first received influence from the outside (of Chiang Tung sphere) and then developed its own artistic style. The Lan Na's influence and "Lan Na type" seems to be a predecessor before receiving Burmese and Western influences. The report describes "the Buddhist edifices in remote areas: monastery of Baan Ngak, Baan Saen, Baan Kyen, Nong Long in Muang La still maintained the type of Lan Na viharn," as they are not affected by external factor (Aksrondit 2009, pp. 91-92). Undoubtedly, the roof's appearance played major role in the descriptions again: "The viharn of Nong Long monastery present the type of Lan Na viharn due to elevated and reduced levels of roof ridges" (Roopin 2009, p. 352). When report states that "viharn of Baan Saen monastery received a stylistic influence from the viharn of Lan Na," we must assume that the seemingly similar roof form and ornaments have caused and led to an interpretation as well as conclusion of Lan Na's influence (Ibid., p.356).

The recent publication of the Thai scholar Surapon Damrikun "*History and Art of Lan Na*" (2018) categorizes the type of viharn in old Lan Na into two groups according to their geographic setting: 1) viharn in the valley of Ping and Wang river and, 2) viharn in the valley of Kok and Ing river. The latter group is subdivided into three types again. Damrikun took two samples of viharn situated in Northeastern Chiang Tung: Baan Saen and Baan Ngek to support his categorization. The author believes that they have received stylistic influence from the Chiang Saen of Lan Na (Damrikun 2018, p. 200).

Pollavat Prapattong, an anthropologist, considered an aspect of similarity in different way. He carried out research on ritual practices in Lan Na and among Mon-Khmer people in Chiang Tung as well as its surrounding. He questioned a research approach that attempts to seek only supportive evidence for proofing: a stylistic expression found in remote area must have been influenced from a greater civilization in the centre. In his view, such approach leads to discriminate creative abilities of man and rejects local's ownership on objects [buildings] right away. For instance, an elegant monastery situated next to or in the village amid a peripheral region was frequently judged to owe its existence of a patronage from outsiders. Such a perspective has dismissed an internal origin or drive that formed an own expression; an identity conceived from particular local circumstances (Prapattong 2015, pp. 7-8).

Previous researches have presented (and we cannot deny) the existence of similarity in an appearance of roof form among historic building in Lan Na, Lan Chang, and Chiang Tung. For my research, such similarity can be implied to a fundamental aspect shared among them. But it should not overrule and lead to a conclusion that ultimately the principles of these buildings are the same and the carpenter erected such roofs employing similar technique. My study shall start the investigation with smaller elements that constituted the structural system and wooden joinery in order to read them through the knowledge of Lan Na building technique obtained in chapter 3 and 4.

5.3 Luang Phrabang

Sim at Chiang Thong (Xieng Thong) monastery, Luang Phrabang

The monastery of Chiang Thong was founded in 1558 (2101) during the reign of King Xetthathirat who ruled both Lan Chang and Lan Na (Boonyasurat 2004, p.106). The monastery went through the main restoration in the year 1928 during French colonial period, all timber structures were replaced. Afterwards another restoration took place in the year 1975 (Rampon 2004, p.108). We do not know to which degree the restoration works respected the original building techniques.

The roof form of Chiang Thong monastery's sim (viharn) features multi-tire roof, its profile appears more bended in comparison to the viharns of Lan Na. The structure of this sim is comprised of eight transverse frames presenting three different levels of ridge purlin (see Fig. 5.1). The first three transverse frames from the frontal entrance and the one of the rear side consist of a central nave structure and an aisle on each side. The four transverse frames of the principal hall have two rows of aisles, the inner aisle and the outer aisle that resulted from an extra row of outer aisle pillars. The measurements between the span of nave pillar and aisle structure are consistent to all transverse frames.

The arrangement of structural components in each transverse frame is significantly different from what we have analyzed so far in Lan Na cases (see Fig. 5.5). The nave pillar's cross sections are round and of aisle pillars's are square. All of them are made of brick as a load bearing structure. The nave roof structure comprises three levels of crosswise beams. Each level is reduced in length. A pair of *tang mai* carries the crosswise beam forming the seats for purlins. The main crosswise beam is placed on top of nave pillars and fixed there together with the main purlin by halved joint. There are no protruding edges of the crosswise beam beyond the head of nave pillars. We can immediately observe that the principle of roof structure of this sim has no application of flanking pillars. Thus there occur two consequences. Firstly, the carpenter had to mortise all aisle beams directly into respective pillars. The structural principle of this sim relies on the length of the main crosswise beam spanning the distance between a pair of nave pillar in stark contrast to Lan Na viharn, where distance of nave pillar and the length of main crosswise beam is not necessity coincided.

Secondly, the carpenter had to form the neck part ("*korgeeb*") exactly in the axis of pillar while in Lan Na the neck part situates along the axis of flanking pillar. The main purlin which was halved to crosswise beam functions as an upper frame of neck part. The carpenter fixed the uppermost aisle purlin by a through tenon functioning as the lower frame of neck part. But for the division and formation of necked parts between the inner and outer aisle structure, the carpenter defined the position in between inner and outer aisle pillar row. Such division of roof planes does not correspond

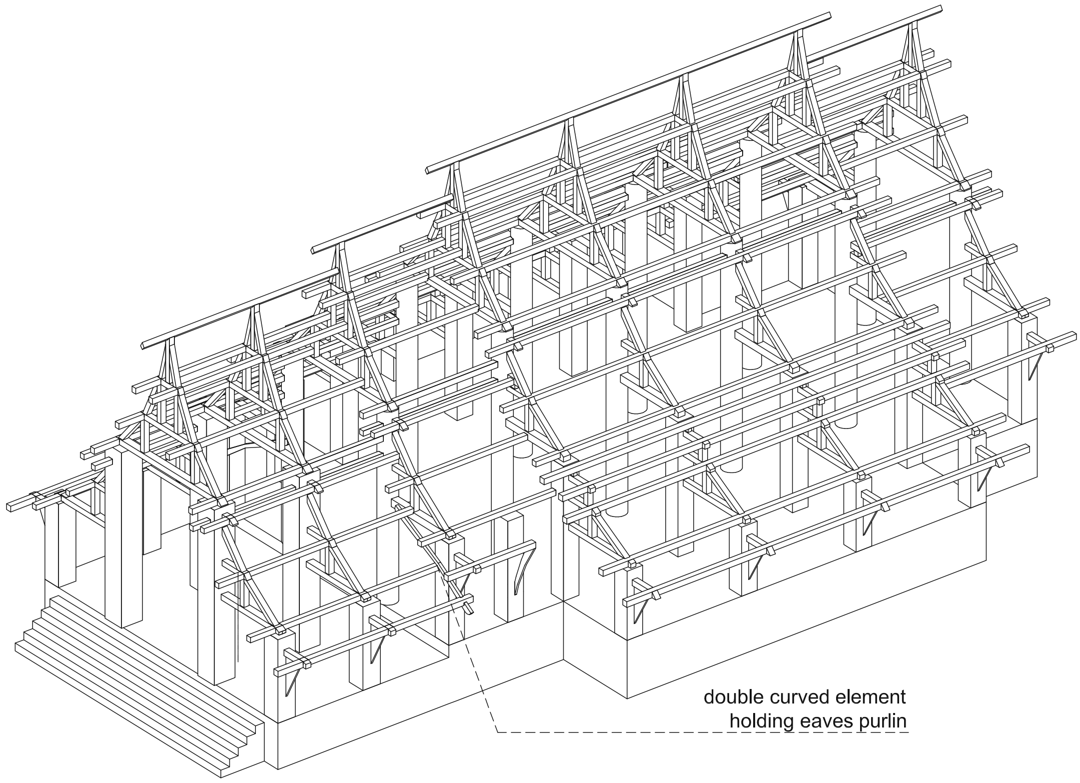


Fig. 5.1 Axonometric view of the sim of Chiang Thong monastery

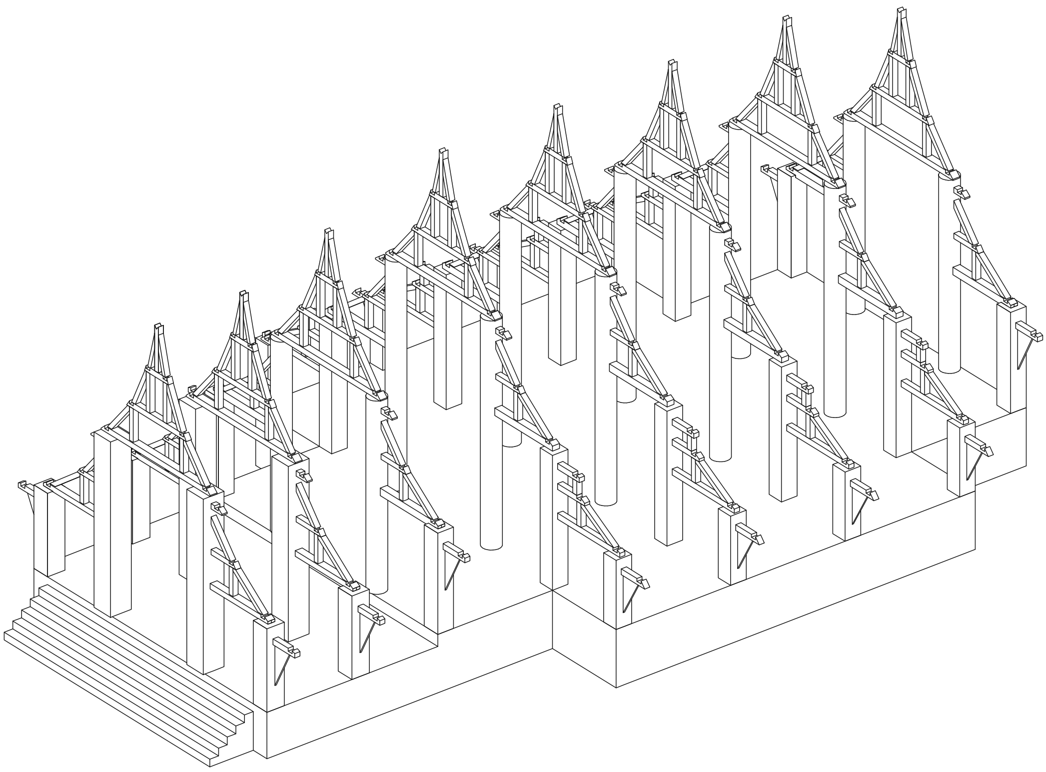


Fig. 5.2 Axonometric view of the sim of Chiang Thong monastery
without purlin

to the spans of aisles. My study supposes that the intention of this division was to reduce the distance of the curves planes between inner and outer aisles as much as possible.

Another distinct feature is the usage of inclined components, so called *si yua* (Singkamton 2001, p.32) together with *tang mai* frame. These inclined members were assembled to form a small closed triangular configuration. The upper edge of *si yua* is mortised at the junction of *tang mai* to crosswise beam. The lower edge is fixed inside the halved joint connecting crosswise beam and purlin. My study interprets the structural role of this *si yua* conceived of the roof shape that is strongly bended. The geometric ratios between the beams and *tang mai* change dramatically in each level from bottom to top, thus the system needs to be stiffened by a strengthening element.

With careful observation on the joinery, one would realize that the carpenter cut a small tenon at the lower edge of *si yua* along the wood grain for fixing it to the crosswise beam and left the rest flat for placing it above the purlin. An interpretation of this joinery suggests to an assumption how the assembling process of this building was carried out (see Fig.5.10). The position of *si yua* situated above lower purlin but underneath the upper level of crosswise beam implies that this *si yua* shall be fixed after the assembling of the lower purlin but before the higher crosswise beam, assumingly together with *tang mai*. If my proposed assumption holds some truth, the carpenter in Luang Phrabang had to work from bottom upwards, in contrary to Lan Na as the carpenter there had to erect all preassembled transverse frames and fastened them together with purlins.

On the matter of longitudinal integration, the alignments of *tang mai* in each frame are uniform, thus the purlins from lower positions of smaller transverse frame can be connected on the *tang mai* of the larger one. The carpenter used tenons with key nails to fix them against pulling strength. The main purlins are set on the nave pillar like the uppermost aisle purlin is mortised into. There is a special situation with the inclined element defining the lowest eaves in the third frame. The carpenter shaped it as a doubled curved element held under second purlin and laid above main aisle purlin in order to hold the eave purlin (see Fig. 5.1). The structure is stabilized due to the moment force of the 2nd aisle purlin and the eave purlin. I am going to provide further discussion for this exception execution at the end of this chapter.

The assembling technique of combining the horizontal beam, standing pillar, purlin is common to the one of old Lan Na. The carpenter fixed horizontal crosswise beam to the tenon on top of standing pillar. He created a seat for the purlin along the vertical axis of the connection point. Purlin and crosswise beam are connected by a halved joint.

Fig. 5.3 "Delicated" curved roof plane of the sim of Chiang Thong monastery

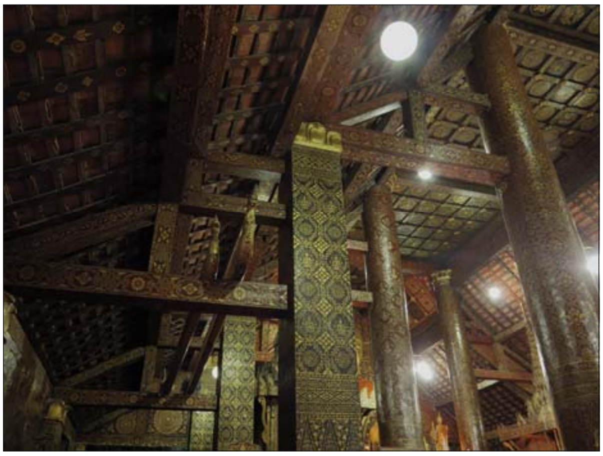


Fig. 5.4 Carpenter defined the neck part in the middle of outer aisle's roof

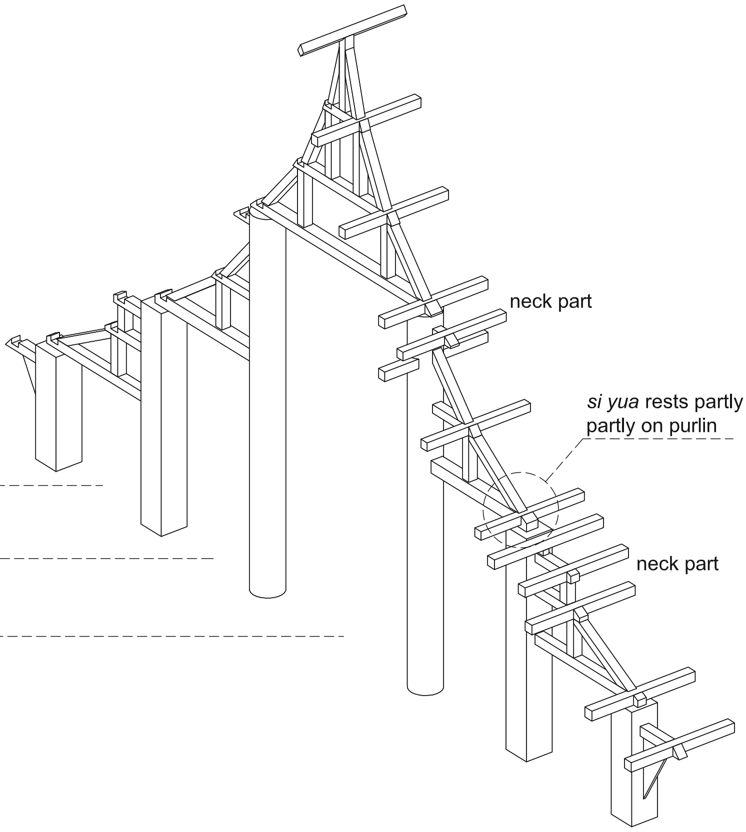


Fig. 5.5 Typical transverse frame of the sim of Chiang Thong monastery

Sim at Pa Fang monastery, Luang Phrabang

Pa Fang monastery was founded in 1700 (2243). According to the historical sources, the current sim of this monastery was erected in 1799 (2342) during the reign of king Anurut (Boonyasurat 2004, p. 136; Rampon 2003, p. 67). The building is relatively small in comparison to the sim of Chiang Thong monastery. The structure of Pa Fang's sim consists of seven transverse frames presenting three levels of ridge purlins (see Fig. 5.8). The first transverse frame defines frontal façade of porch area. From this position, we can perceive a strong impression of an interrupted continuation of curved roof plane, running down from the ridge until the eaves end, regardless to the division of nave and aisle by pillars. From the second transverse frame onward, the carpenter enclosed the building by brick wall. The heights of transverse frames are elevated by 65 cm. In order to create the hierarchical space of the principle hall, the carpenter elevated the nave roof structure of the third to sixth transverse frame by 60 cm detaching it from surrounding aisle roof which remains in the same level as the one above the second frame. Together they produce a homogenous planed of curved roof.

My study shall analyze how carpenter managed to create a roof surface appearing as a single continual curved plane. The structure of nave roof consists of three levels of crosswise beams. The main beam is placed above the pair of nave pillars and fixed there together with the main purlin by use of a halved joint. We assume that the carpenter embedded a wooden piece on top of the brick bearing pillar functioning as a tenon. The aisle roof structure also consists of three levels of beams; all of them mortised directly into the brick pillar without interruption of a flanking pillar and without the shaping of a neck part. The carpenter fixed a relatively long slanting roof shaping member ("*gon*") approximately 7m, down from the ridge purlin. It rests on different purlins that are seated on crosswise beams: two intermediate purlins above the nave structure, main nave purlin, two intermediate aisle purlins, main aisle purlin, and eave purlin. A critical position of arranging the purlins occurred between the nave and aisle structure where the roof shaping member must pass smoothly (see Fig. 5.9). My study supposes that these positions must have been predefined whether relying on texts (treatises) or by preassembling experiments. In general practice, one possibility for dealing difficulty is to introduce a separation between nave roof and aisle roof as we can observe in principal hall. The curved roof plane was divided into two parts resulting in two different sets of roof shaping members. Neck part is formed at the space in between main nave purlin and uppermost aisle purlin.

The carpenter employed *si yua* to strengthen the roof structure similar to the sim of Chiang Thong monastery. But by closer inspection of joinery the analysis reveals a deviated notion and possible different assembling process (see Fig. 5.11). At the sim of Pa Fang monastery, *si yua* is fixed, at the upper end to *tang mai* and at the lower end to the crosswise beam only next to the seat for purlin. There is no overlapping to the top of purlin itself. The position of joinery could suggest a development of assembling process. Since *si yua* does not rest on purlin, the carpenter can erect each complete transverse frame before assembling sets of purlins to fasten the whole structure in longitudinal direction.

Fig. 5.6 The continual curved roof of the sim of Pa Fang monastery

Fig. 5.7 Carpenter elevated to roof defining the principal hall

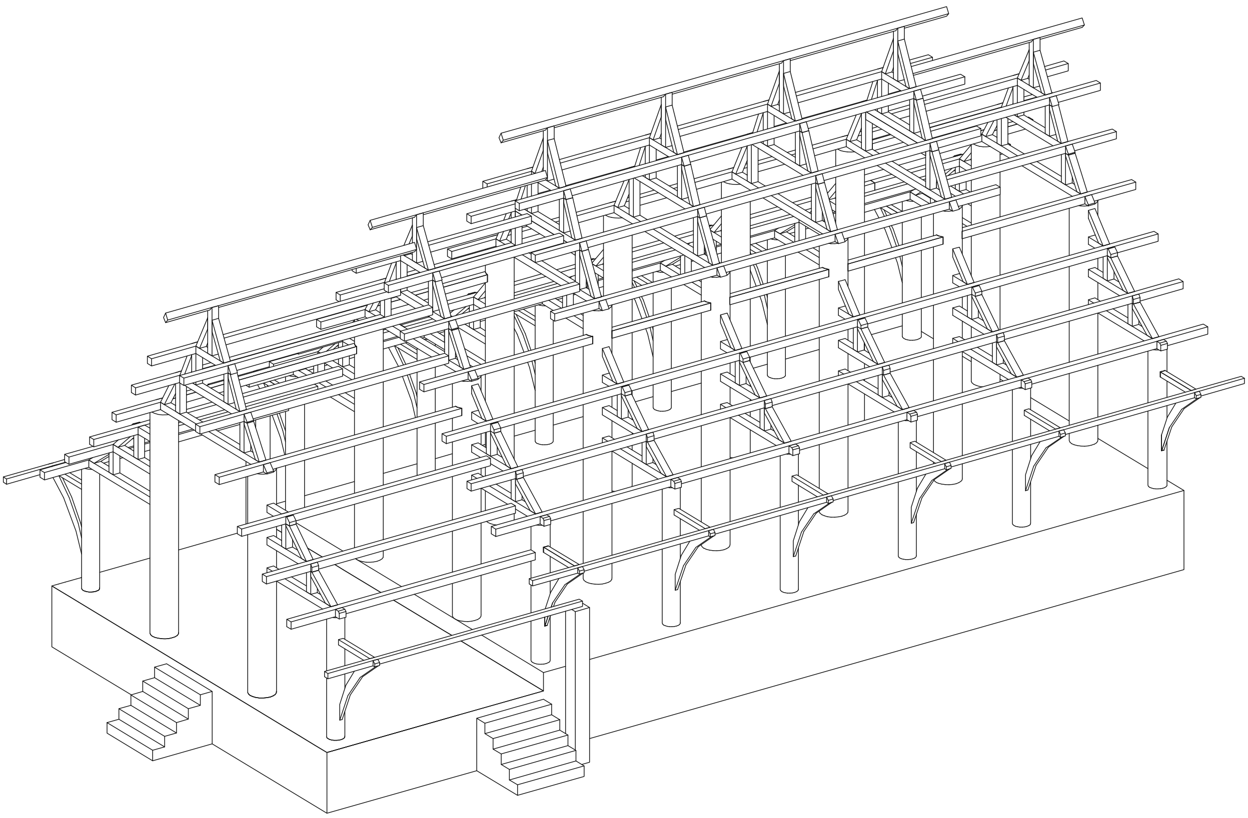


Fig. 5.8 Axonometric view of the sime of Pa Fang monastery

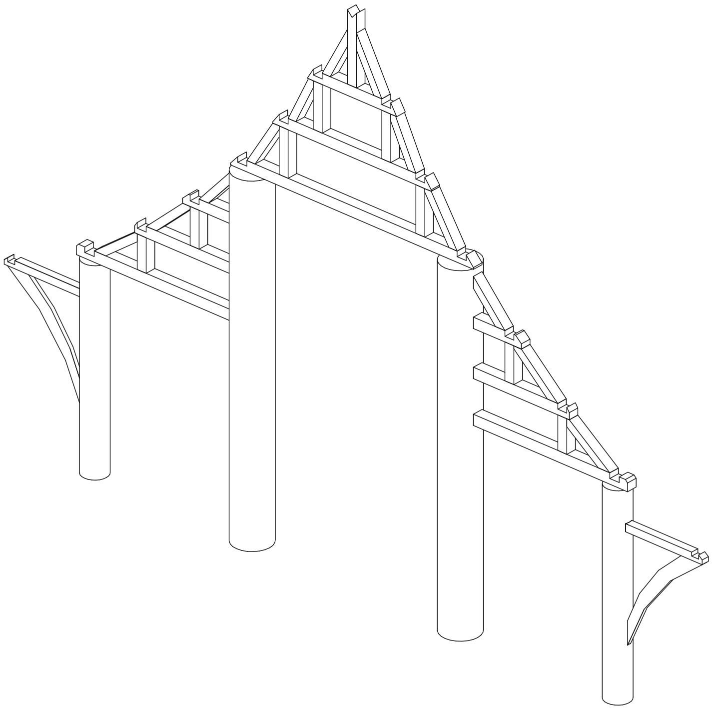


Fig. 5.9 Second transverse frame of the sim of Pa Fang monastery; presents the structural arrangement that formed single continual roof plane

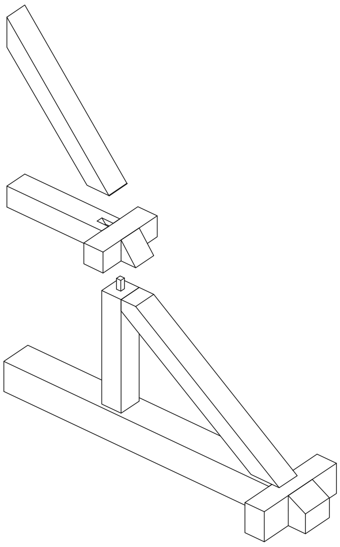


Fig. 5.10 Junction of crosswise element, *tang mai*, and *si yua*; sample from the sim of Chiang Thong monastery

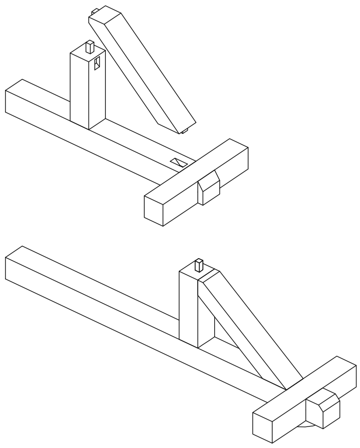


Fig. 5.11 Junction of crosswise element, *tang mai*, and *si yua*; sample from the sim of Pa Fang monastery

Regarding the longitudinal connection, the *tang mai* in each transverse frame is situated in the same alignment since there is no change in spans of nave and aisle structure. The purlin from shorter transverse frame adjoined *tang mai* at its appropriate height of the taller frame. The carpenter secured the connection using tenon with key nail.

5.4 Chiang Tung

Grand Viharn of Baan Saen monastery

Baan Saen monastery is located in the Northeastern region of Chiang Tung (Shan state). The route to this monastery is branched off from the main road to Mueang La, 10 km uphill. The monastery of Baan Saen is situated next to a village of Blang people, a Mon-Khmer speaking group. They inhabit in long-house, providing living space to more than 40 people in a unit.

Hitherto architectural and art historians cannot date the exact age of Baan Saen monastery. By referring to the expansion of Buddhism from Lan Na to Chiang Tung, Kirdsiri estimated that the monastery should be erected not earlier than the reign of King Kue Na (rule: 1355-1385) of Lan Na (Kirdsiri 2010, p. 94). Also, we cannot find a description of the monastery and village of Baan Saen in the *Gazetteer of Upper Burma and the Shan States* (1901) surveyed during the late nineteenth century by James George Scott. Perhaps the settlement was known under a different name. The compound of Baan Saen monastery comprises several building types: grand viharn, viharn of Phra Jao Ton Luang (viharn of Buddha Image), ubosot, kuti (monk residence), etc. My study takes the grand viharn for the analysis since this building plays the central role in the monastic compound.

The structure of grand viharn of Baan Saen monastery is comprised of ten transverse frames presenting three different levels of ridge purlins. The principal hall occupies three bays in the middle, from fourth to seventh transverse frame. The carpenter reduced the height of ridge purlin twice symmetrically to the frontal and to the rear side. The structural articulation in each frame consists of central nave and aisles on each side. The carpenter placed the main crosswise beam on the nave pillars fixed by tenons at their top. The lengths of beams are consistent in all transverse frame. The roof structure is characterized by stacking different levels of crosswise beam and carried by short pillars. The structural principle is similar to *tang mai* of Lan Na. My study cannot carry out further investigation at the nave roof structure due to a subsequently installed ceiling at the level of main crosswise beams.

The carpenter employed flanking pillars to separate aisle roof structure from nave pillars, thus allowing the nave pillars to be independence of roof structure. At the transverse frame in front of the Buddha Image, we can immediately realize an explicit reduction of nave span similar to a strategy that is also commonly used in old Lan Na (see Fig. 5.16 and Fig. 5.17). Nevertheless among the buildings in Lan Na, despite careful measurement, this kind of reduced span is hard to detect. At Baan Saen monastery, the carpenter moved both pillars of nave structure approximately 40 cm inwards on each side, while flanking pillars remain in the same positions for maintaining the roof span. The arrangement constituted the clear distinction of ritual space in the principal hall. The large gap between nave pillar and flanking pillar is in filled with decoratively carved wood elements.

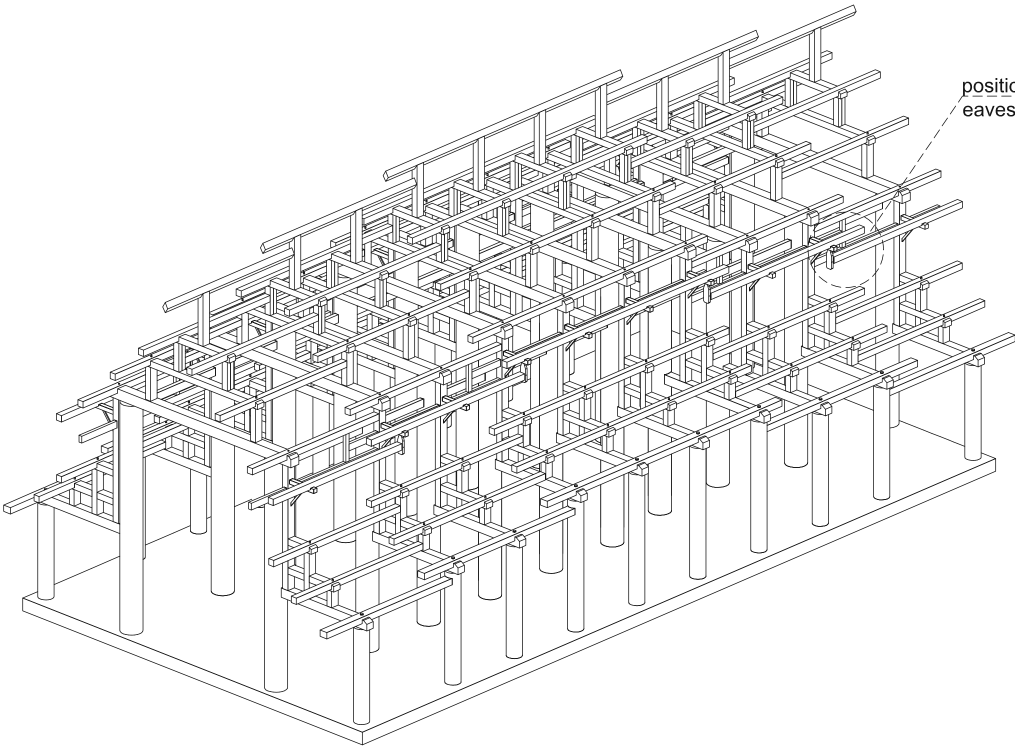


Fig. 5.12 Axonometric view of the grand viharn of Baan Saen monastery

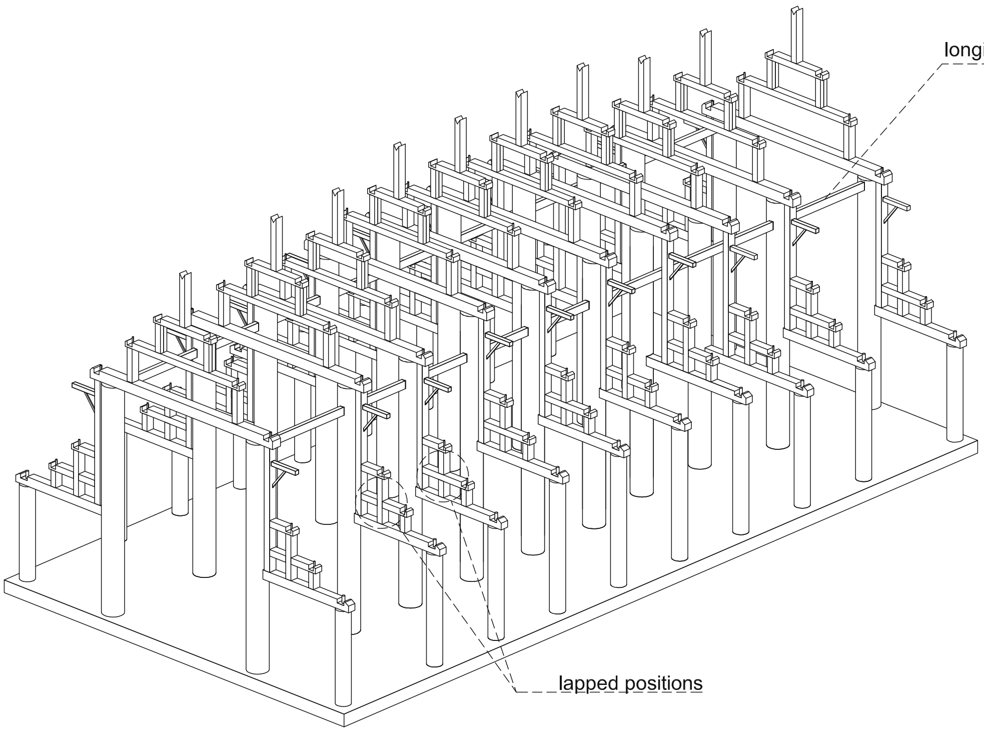


Fig. 5.13 Axonometric view of the grand viharn of Baan Saen monastery; the carpenter halved standing pillars supporting third aisles beam to the second aisle beams, some of them face frontal facade, some face rear side

Fig. 5.14 Frontal facade of the grand viharn of Baan Saen monastery

Fig. 5.15 Interior of the grand viharn; at the transverse frame in front of principal Buddha image, the carpenter infilled the gap between nave pilalrs and flanking pillar with decorative elements as these nave pillars moved innerward

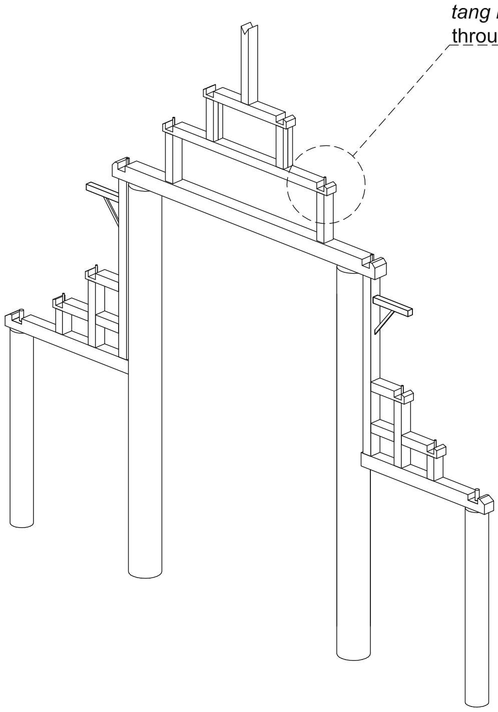


Fig. 5.16 Fourth transverse frame

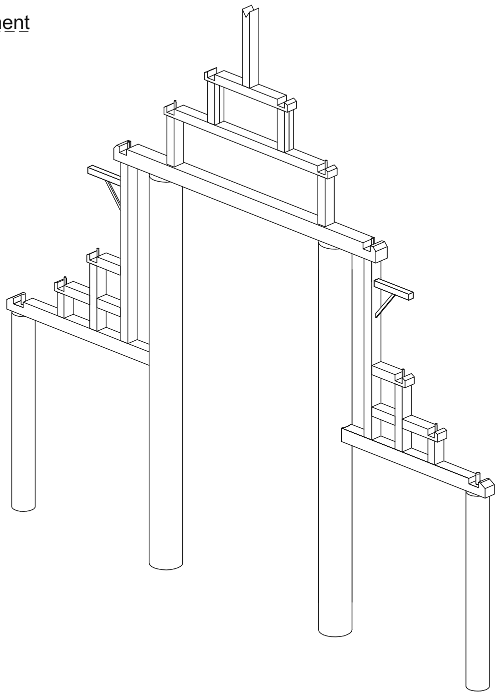


Fig. 5.17 Seventh transverse frame; the carpenter moved nave pillars innerward emphasizing the frame of principal Buddha image

We can observe a difference in structural arrangement deviating from Lan Na methods. In Lan Na, the *tang mai* carrying the third aisle beam and third purlin normally stand on second aisle beam, but here the *tang mai* is placed directly on the main aisle beam. The member stands upright, laps to the second aisle beam, and rises up carrying the third aisle beam. Throughout the building the orientation of recession for halved joints is inconsistent (see Fig. 5.13). On some beam, the carpenter cut a recession on the surface of a beam facing the frontal side and sometime he chose the rear side.

Unlink to Lan Na, the purlins rest in the seats of crosswise beams by notched joints. The carpenter cut a recess only on the upper side of beam. As a result the top of purlin exceeds from the upper face of beam. This connection is secured once again by the doubled height tenon from *tang mai*. The upper most purlin of aisle roof is fixed to flanking pillar by through tenon not by halved joint. The positions of main nave purlin and uppermost aisle purlin are not in perfecy alignment. The carpenter filled this gap with wooden balustrades.

The method of adjusting the purlins from smaller transverse frame to the larger has been done in straight forward way. All *tang mais* in each frame are positioned in alignment, thus the purlins from the shorter frame can be mortised directly to the *tang mai* of the taller frame. The carpenter secured the connection using wooden nails. Additional observation shall be mentioned. At the eaves part of a transverse frame where different heights of roof frame meet, two purlins lying exactly above each other have to be integrated into construction. Lan Na carpenters solved this issue by creating a compound of eaves elements holding these purlins. The carpenter of Baan Saen had employed another method (see Fig. 5.41). He provided only a single eaves element for seating the higher purlin and then suspended another element downward for holding the lower purlin. It is not only the purlin that connect different transverse frames. The carpenter put longitudinal beam through nave pillars from the first to the last transverse frame for bracing them (see Fig. 5.13).

Viharn of Baan Ngek monastery

The community of Baan Ngek is situated five kilometer away from Baan Saen in Southeastern direction. Baan Ngek has been recorded in the survey report of Scott describing that the village belonged to the “circle” of “Hsipha Wan” or the group of fifteen villages (Scott 1901, p. 173). The term “circle” as used in Scott’s report does not imply the cluster of villages in physical sense, but rather the connection between different villages regardless to the distance. We cannot date the age of Baan Ngek community but the oral history of inhabitants narrates that their ancestor had to flee the expansion of Tai Yuan during the reign of Lan Na’s first king, Mang Rai. The villagers of Baan Ngek migrated and settled at the current place together with the villages Baan Dong and Baan Aw (Pomkao 2009, p. 14). These two villages as mentioned in oral history are currently located in Western direction of Baan Ngek and have been listed in the same “circle” of village according to Scott’s report. The monastery of Baan Ngek is situated in higher terrain above the village. The compound of buildings consists of viharn, monk residence, ceremony pavilion, stupa etc.

The structure of viharn comprises of seven transverse frames presenting two different levels of ridge purlins with an interval between them of approximate by 80 cm. The principal hall occupies three transverse frames defining two central bays. The levels of roof ridges are lowered symmetrically toward the front and the rear side. The height of main crosswise beam is consistent in each frame. The structural composition in a transverse frame consists of central nave and aisles on both sides. The carpenter employed flanking pillar to separate nave structure and aisle structure.

The roof structure is based on inclined members constituting the formation of a stable triangle. The system is comparable to the *tang yo* of Lan Na. The upper end of inclined member is fixed to the kingpost of nave structure and to the flanking pillar of aisle structure. The carpenter had sharpened this upper end and pierced into their counterparts. At the lower connection the inclined member rests partly on the crosswise beam and extends partly to form the eaves ending. It is the joinery that allows the carpenter to act in twofold way: resting the inclined member and simultaneously cantilevering the eaves (see Fig.5.20 and Fig. 5.24). This joinery is subject of my analysis. The width of inclined member is approximately 10 cm. The carpenter assembled it into the forked beam, measuring 15.5 cm in width. There left 2.75 cm on a side of beam’s two shoulders holding the inclined member. According to the gathered information from an external inspection, my study suggests that the carpenter cut a notch on this beam presenting an inverted L-shape forming a seat in correspondence to the recessing of inclined members. The carpenter strengthened this inclined member again using a knee brace.

The connections between inclined members and beams are more complicated at the third and fifth transverse frame where the transitional dimension of transverse frame takes place. At these two frames, the carpenter of Baan Ngek assembled two inclined members in a beam in order to hold two different sets of purlin: one of the larger and one of the smaller frames (see Fig. 5.21). My analysis supposes that the carpenter began preparing and assembling the components from the measurement deriving from the smaller frame. He then elongated the main crosswise beam for nave

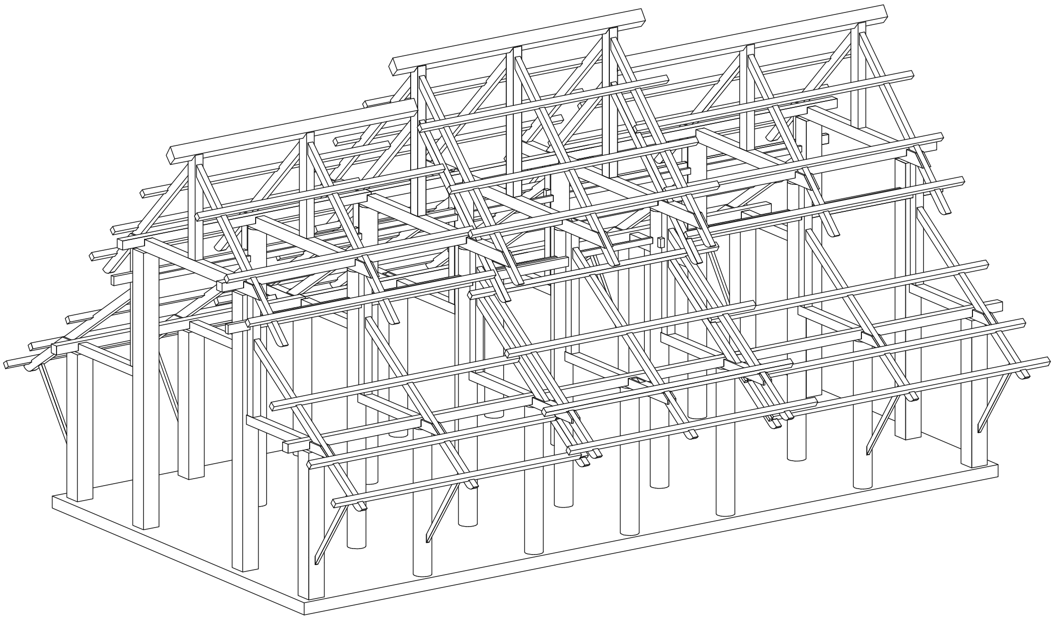


Fig. 5.18 Axonometric view of the viharn of Baan Ngek monastery

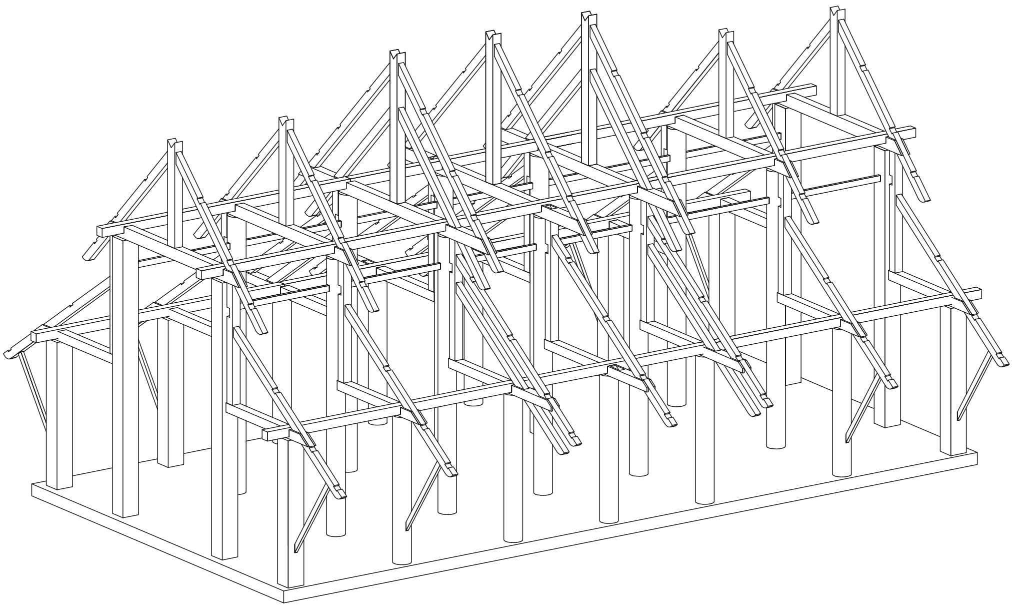


Fig. 5.19 Axonometric view of the viharn of Baan Ngek monastery without purlin

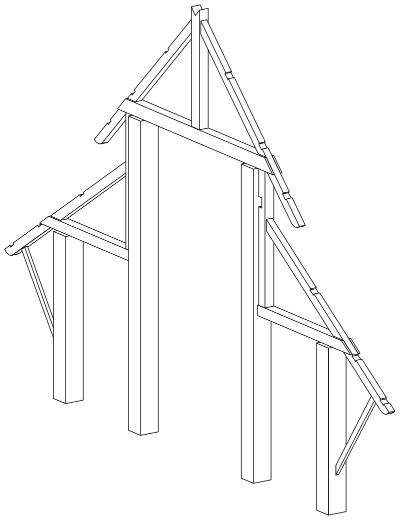


Fig. 5.20 First transverse frame; the inclined member partly rests on crosswise element, partly cantilevers forming the eaves part

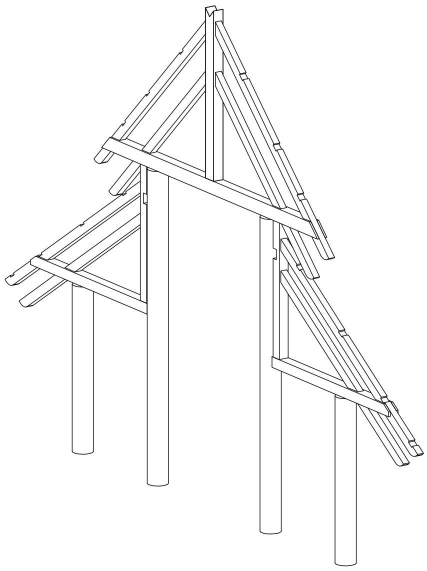


Fig. 5.21 Third transverse frame; the carpenter elongated the edges of crosswise elements in order to provide a place for upper inclined members

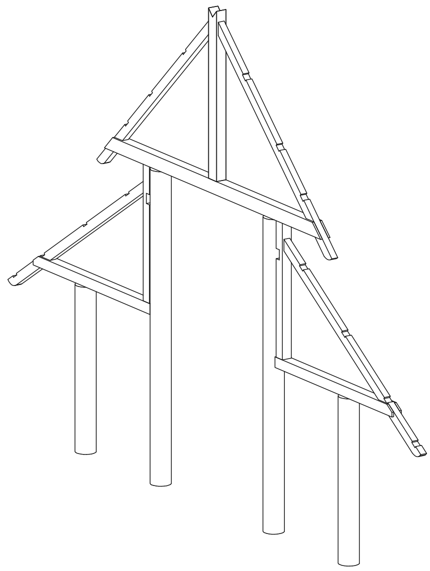


Fig. 5.22 Sixth transverse frame

Fig. 5.23 The frontal view of the viharn of Baan Ngek

Fig. 5.24 The carpenter recessed the ending of purlins into tenon and mortised them into inclined members securing by keyed wedge

structure and the aisle beam for aisle structure about 1 m beyond the seat of previously assembled members. At the edge of this protruded beam, he placed another inclined member parallel to the previous one. He fixed at a higher position, thus creating a higher transverse frame. We shall observe a consequence caused by the assembling method. The heights of all crosswise beams as well as the aisle beams are equal in all transverse frames despite different levels of roof ridges. This is unlike to the system of *tang yo* in Lan Na where the carpenter lifted the whole roof structure including the beams (see Fig. 4.28 for a comparison to Lan Na).

The building treatises of Lan Na suggest the carpenter to begin his erection process from the principal hall and then deduce the sizing of roof down at the adjoining hall. The arrangement of structural components at Baan Ngek presents a contrary possibility of assembling. The larger transverse frame is extended from the smaller frame giving a clue that the erection process might start from the smaller to the larger frame.

The roof's curved plane appears less pronounced. The roof shaping member only bends from uppermost intermediate purlin to the ridge purlin. My investigation observed four purlins for a side of nave and five purlins for a side of aisle roof structure. The carpenter notched purlins on inclined members by cutting the recess around one-fifths of their thickness. The eaves purlin of the lower frame was fixed differently to the higher frame. Reduced to a tenon, the purlin's end was mortised to inclined member keyed by wedge against pulling strength (Fig. 5.24). We observed the usage of longitudinal bracing connecting all traverse frames together.

Long house at Baan Ngek community

The survey report of Scott describes the long house as a “well” erected living unit offering “several families [to] live in each" (Scott 1901, p. 173). The report presents data of Baan Ngek mentioning that it consisted of five long houses in the late nineteenth century. In 2014, my investigation found only four units. The orientations of houses in this village follow the geographic terrain of the site. The long houses as seen are the pile dwellings. The floor level is elevated 1.7 meters from the ground. The roof form is characterized by a hipped gable. The configuration of floor plan presents a rectangular shape enclosing the living area combined with a under covered terrace on pediment sides. The stair cases are attached to the two terraces oriented to the main gate.

Along the transverse axis of the long house, the building’s structure comprises a main hall at the centre and private living compartments on both flanks. Two rows of hearths are placed within this hall along the longitudinal axis of the house. The structural arrangement in a transverse frame corresponds to the described spatial planning. There are five pillars in a frame, the central one only reaches down to the main floor beam. The inner pair of pillars defines the main hall and another two pillars on both edges outline private living compartments. All pillars in a transverse axis are tied together by a transverse beam carrying the floor board.

For the structure of main hall, the carpenter erected a pair of pillars along the central hall sides in order to support a main crosswise beam. He fixed the main beam via tenon on the pillar’s top ends and cut recesses for seating purlins directly above the pillars rows. A doubled height tenon penetrates the beam and the purlins securing them in place. The carpenter employed a combination of standing pillars and inclined members building up the roof of long house. He erected a pair of standing pillars on top of the main crosswise beam for supporting a higher beam, again fixed by tenon. The seats for purlin are prepared likewise as beneath allowing the tenon of standing pillar to secure the intermediate purlins in place. The carpenter placed the ridge supporting pillar in the middle of main crosswise beam. The pillar stands upright halved against the upper level of crosswise beam. The carpenter secured this connection using wooden nail. A pair of inclined members is fixed on the lower end to the crosswise beam and on the upper end to the ridge supporting pillar. The carpenter tapered the inclined members’ ends to tenon like shape for piercing them into respective recesses. The inclined member passes upper crosswise beam and ridge supporting pillar without any connection. Only first and the last frame were executed slightly difference. There the carpenter used the full height of pillar standing on the ground to support ridge purlin. The corresponding inclined members at these two transverse frames did not pierce the ridge supporting pillar. They were halved to each other forming scissor crossing.

The roof structure above private compartment was created by connecting the pillar of the main hall to the pillars defining the edges. The carpenter pierced a component into the top end of the main pillar directly beneath the crosswise beam and to the head of outer pillar creating an inclination. The head of outer pillar is notched in order to hold longitudinal purlin. The roof shaping members are made of bamboo. The carpenter arranged them into a pair and hanged them on different levels of

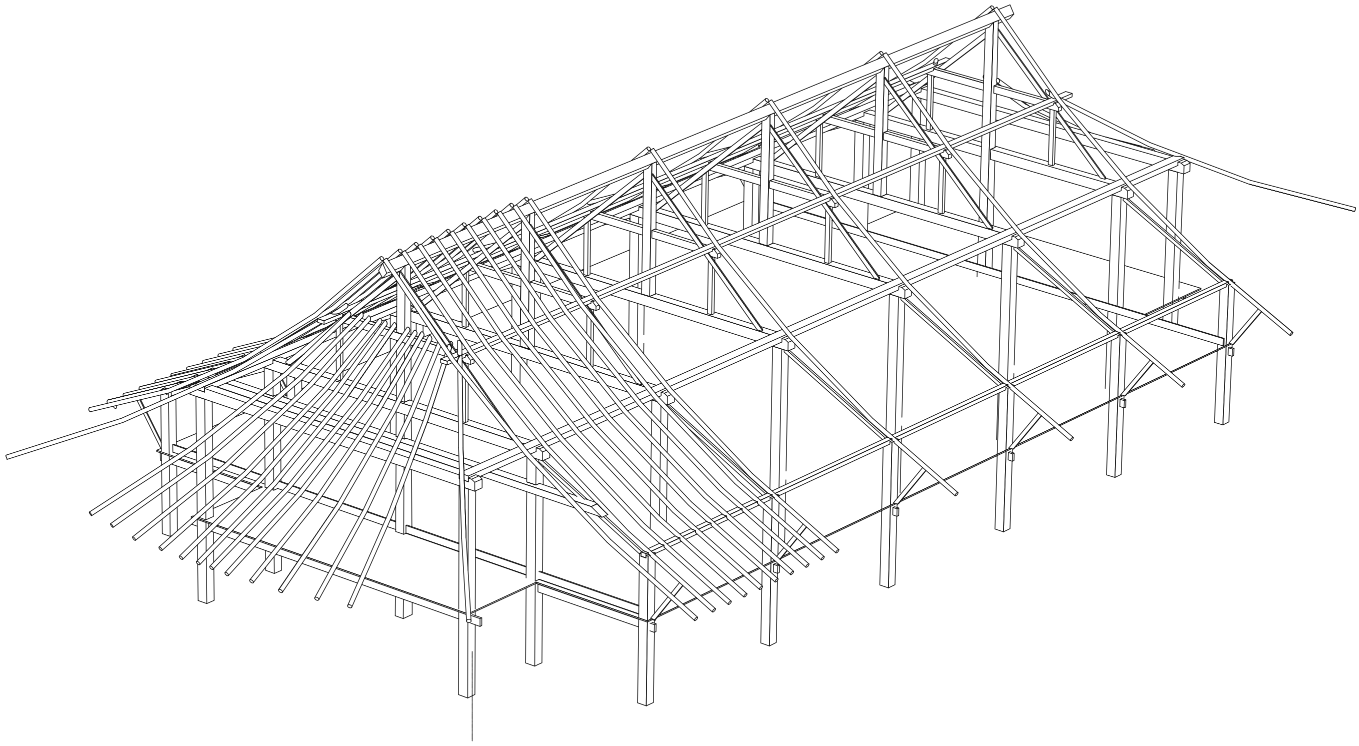


Fig. 5.25 Axonometric view of a long house at the village of Baan Ngek
showing roof shaping element made of bamboo

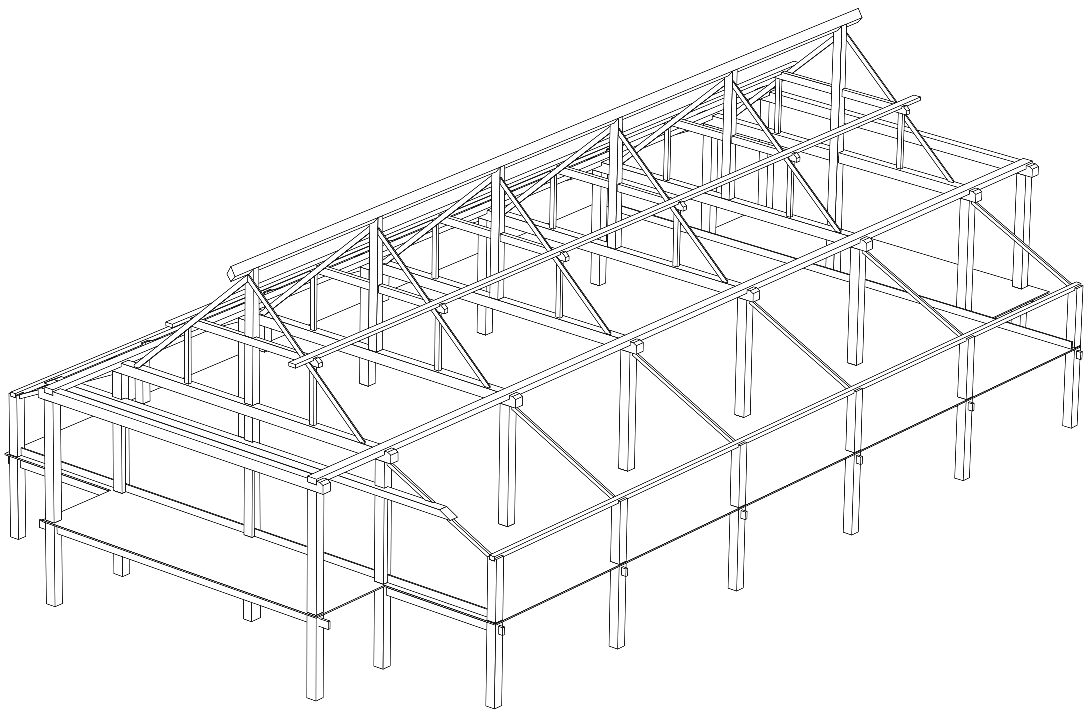


Fig. 5.26 Axonometric view of a long house at the village of
Baan Ngek showing main structural frames

Fig. 5.27 A long house in Baan Ngek; we can observe an undercover terrace

Fig. 5.28 Interior of a long house seeing through the second transverse frame

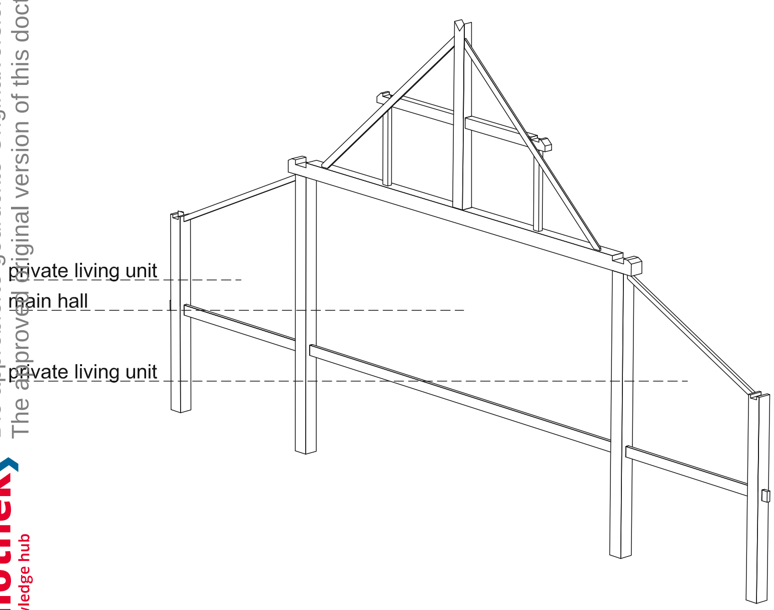


Fig. 5.29 Typical transverse frame of a long house in Baan Ngek village

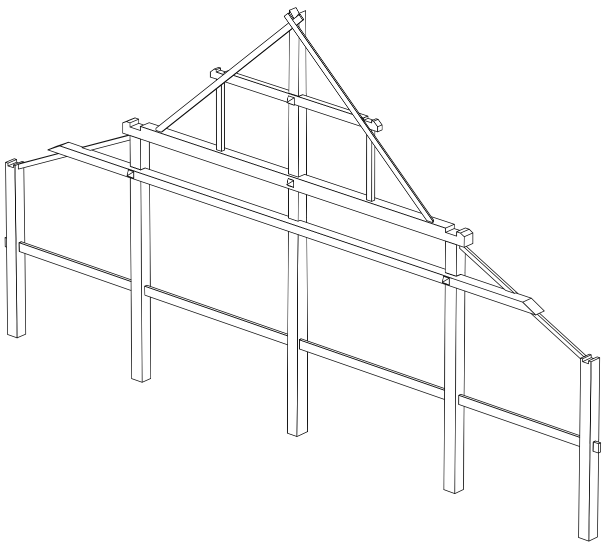


Fig. 5.30 Trasnverse frame at the frontal and rear side of a long house in Baan Ngek village

support from roof ridge to the purlin above outer pillar. Knee braces allowed to install protruding eaves.

Viharn of Baan Kyen monastery

Baan Kyen village is located in the Mueang La Township, a sub division of Chiang Tung. In Scott's report, the village of Baan Kyen is included into the group of fifteen villages or "Hsipha Wan" similarly to the village of Baan Ngek. The report indicates that in the late nineteenth century the village consisted of ten houses, the monastery and two brick buildings (Scott 1901, p. 173). During my survey in 2014, the inhabitants had already moved their houses away, settled down at a new place closer to the road, thus left only the monastery in old Baan Kyen settlement. The compound of monastery as seen consists of grand viharn, the pavilion and monk residence. Previous studies believe that the grand viharn of Baan Kyen shared aesthetic expression common to Lan Na (see Suksamret and Saksit 2009; and Rupin 2009). No scientific research on this viharn has been carried out up to now. However, my study finds enough potential to read the carpentry technique in this building and to oppose it to the introduced knowledge of Lan Na. My resume presents both convergence and divergence in building principles.

Grand viharn of Baan Kyen is one of the largest religious edifices. The viharn's structure comprises of seven bays. The first bay is the porch area. From the second bay onward the building is enclosed by a brick wall. The structure in between third and sixth transverse frame constitutes to the principal hall. The carpenter raised a part of nave roof structure in fourth bay in order to create a hierarchical area (see Fig.5.31 and Fig. 5.32). The carpenter installed a ceiling at this elevated roof, so it was not possible to carry out further inspection. Starting with the structure of principal hall, the level of ridge purlin is lowered symmetrically twice towards the front and rear side. In total, the building presents four different levels of roof ridge with approximately 40 cm intervals. It is necessary to mention that the crosswise beam is not presented in all transverse frames, so we cannot refer to it as we have done previously, but it is safe to mention that all spans of nave roof are consistent in each frame.

The first transverse frame appears as a frontal façade displaying an exceptional structural arrangement. Thus the analysis of the first frame shall be treated separately. Along the transverse axis facing the principal Buddha Image, the structural composition of the building can be seen as a central nave, a single row of aisle on right side and double rows of aisle on left side (see Fig. 5.35). The carpenter created the outer aisle on far left by built up a separation wall in between rows of aisle. The roof shaping members were extended from the inner aisle to cover the outer aisle. These roof members are rested on the outermost aisle brick bearing wall. The space of outer aisle is long and narrow, utilized for walking meditation (see Fig. 3.34).

It would be misleading to conceptualize the nave roof structure of the viharn of Baan Kyen as a stacking system. The structural principle is different to *tang mai* used in Lan Na. In each transverse frame the main crosswise beam supports five standing pillars that create the topmost roof inclination.

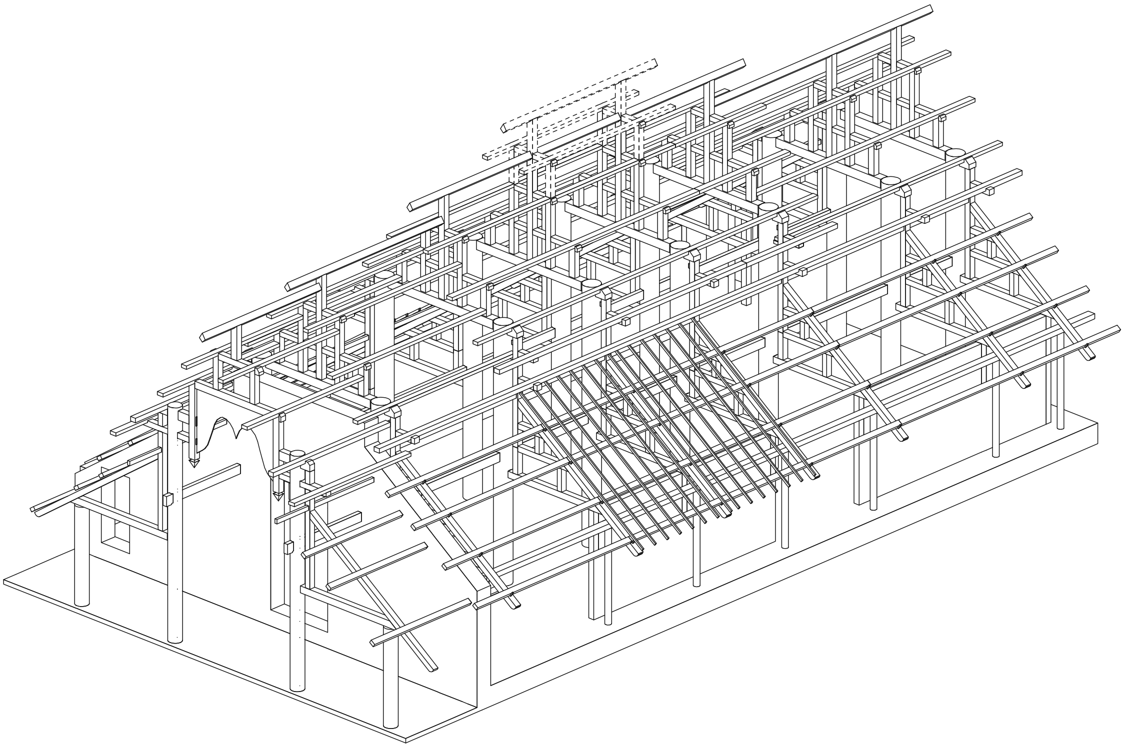


Fig. 5.31 Axonometric view of the viharn of Baan Kyen monastery
showing purlin and roof shaping member

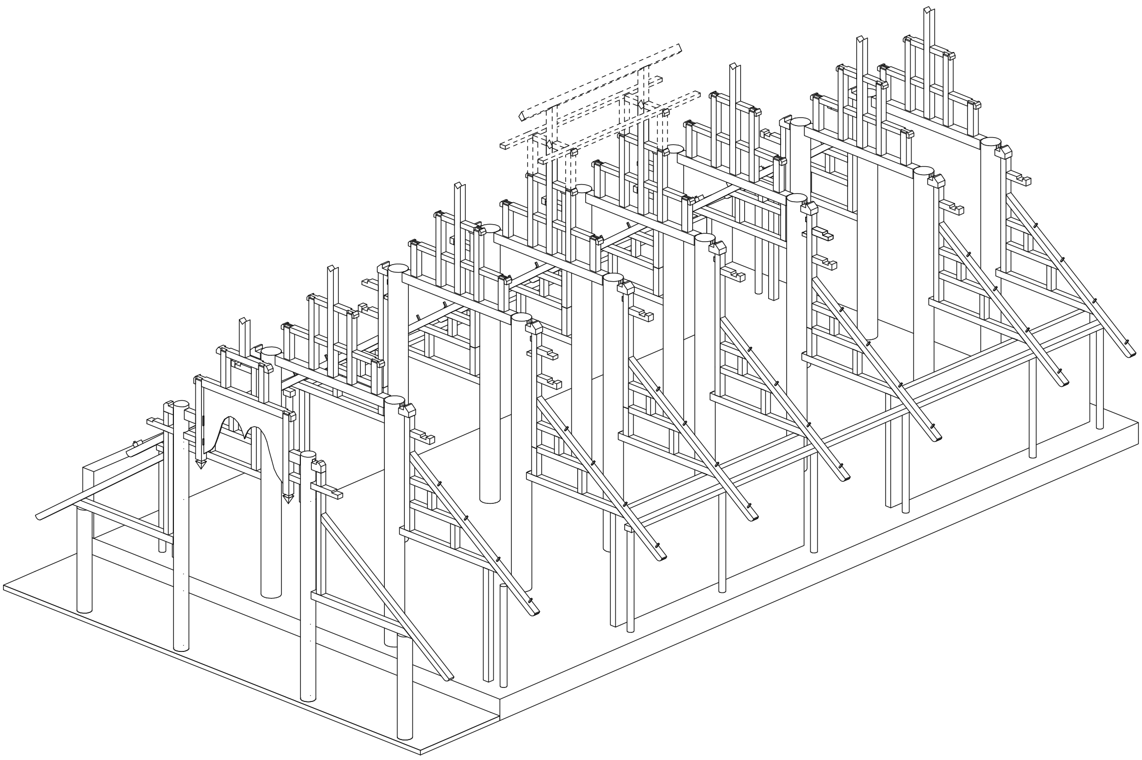


Fig. 5.32 Axonometric view of the viharn of Baan Kyen monastery
showing all transverse frames

The pair of outermost pillars carries the next higher setting of crosswise beam. The joinery is remarkable. The carpenter cut the standing pillars' head into fork shaped, but very shallow. The accordingly recessed crosswise beam's ends were fixed in the forks only half height of the beam's height. The carpenter's idea was to leave a seating for the notched purlin (see Fig. 3.41-8). Inside the outermost pillar stands a pair of higher pillars. They carry a third crosswise beam. Pillar, beam, and purlin are assembled likewise. The ridge supporting pillar stands in the middle of the main crosswise beam. The two upper crosswise beams and the three inner pillars overlap. The carpenter halved all elements. The structural arrangement must be described as bracing rather than supporting.

The carpenter employed different structural systems in the nave and the aisle roof. Basically the structure of aisle roof relies on the formation of close triangle strengthen by beams and small standing pillars. Main cross aisle beam, flanking pillar, and inclined member are the three components that outline the configuration of a triangle. The carpenter fixed the inner edge of main aisle beam to nave pillar, and put the outer end on a bearing wall made of brick. The outer aisle beam's end was executed as tenon in order to be mortised into an inclined member. The flanking pillar is placed on the main aisle beam and fixed at its upper end to the cantilever edge of the main crosswise beam of nave roof structure. The carpenter left a gap in between flanking pillar and nave pillar similar to Lan Na. Two levels of intermediate aisle beams and supporting pillars are assembled to strengthen the aisle roof structure. The inner edges of intermediate beams are fixed to the flanking pillar, while the outer ends are cut obliquely and equipped with a tenon for securing the inclined member. In order to complete the construction of aisle roof structure, the carpenter assembled the inclined member by mortising its upper end to flanking pillar, secured by a wooden nail. The underside of inclined member is mortised at three heights corresponding to the three levels of aisle beams. The lower edge of inclined member cantilevers beyond the lowest connection point at main aisle beam forming the eaves part. The carpenter stiffened the structure by assembling knee braces. The purlins are placed perpendicularly to the inclined member. The carpenter nailed wedges to the inclined member directly beneath each purlin for preventing their slipping down. These purlins support the set of roof shaping members. They were held in place via a recessed hook on their upper end.

Without a proper understanding of the principle of structural arrangement, one would not realize the demonstration of skill in the frontal façade of the viharn of Baan Kyen. If the definition of main crosswise beam refers to an element that ties a pair of nave pillars together, such an element does not exist here. The beams that sit on top from both sides of nave pillars end in a pair of pillars that are forked to the second crosswise beam (see Fig. 5.36). These hanging pillars are held in place by torn-main crosswise beams. Housed in the forked main pillar, their inner end is mortised into the hanging pillars. Yet the main supporting elements that carry the hanging pillar is a lower horizontal beam protruding through main pillar, flanking pillar and therefore be strong enough to act as a cantilever arm. In the frame beneath the second crosswise beam, the carpenter assembled a decorative curved panel, grooved into the hanging pillars. Above the second crosswise beam, the

Fig. 5.33 Frontal facade of the viharn of Baan Kyen

Fig. 5.34 Double aisle space at the viharn of Baan Kyen; the outermost was extended utilizing for walking meditation,
(image is courtesy of Klaus Zwerger)

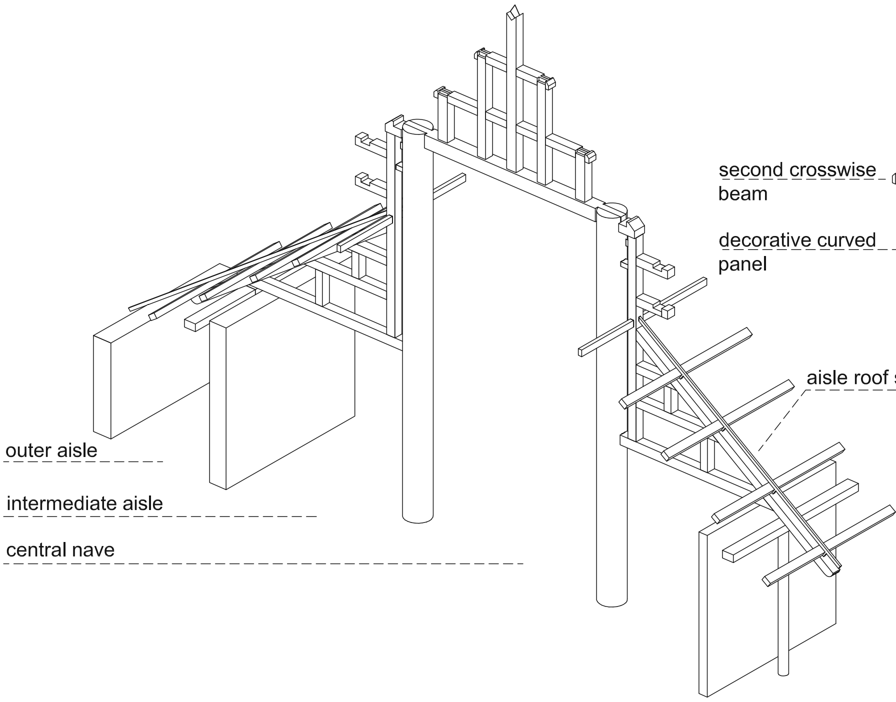


Fig. 5.35 Transverse frame at the principal hall; carpenter halved three standing pillars of the nave roof structure to two levels of crosswise beams

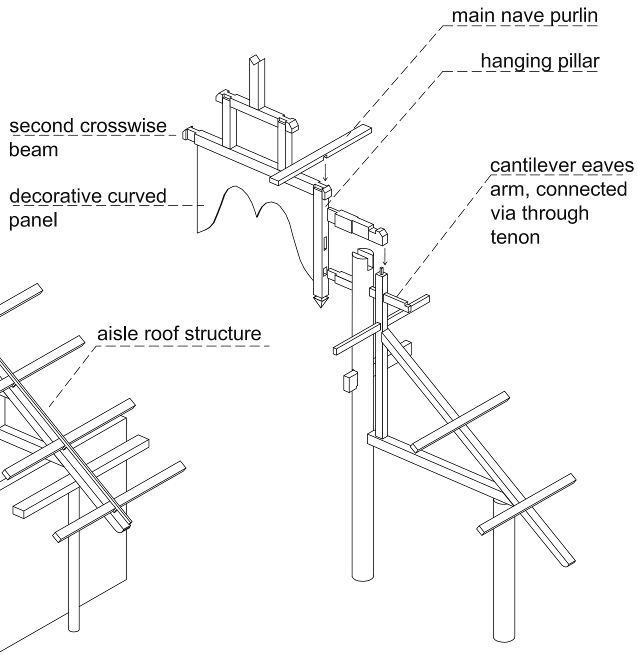


Fig. 5.36 Assemble drawing of the first transverse frame

assembling details standing pillar, crosswise beam, and purlin follow the method described earlier at nave roof structure.

A question remains unanswered when analyzing the structural arrangement in this frontal façade: How this transverse frame is reinforced if there is no crosswise beam? We cannot answer this question without taking the decorative panel into account. The panel was made of two thick wooden boards that were grooved into the hanging pillars. Thus it has served for stiffening the components simply put together at right angles. The combination of second crosswise beam, pair of hanging pillars, beams on top of nave pillar, eaves elements, and decorative panel have constituted a structural frame that enable the whole nave structure to be stiffened. Nevertheless, we can assume that the moment force at the joinery between hanging pillar and beams are tremendous since the loads from nave structure are transferred to this point. The carpenter applied a principle of counter balance, employed the load of cantilevered eaves to stabilize the structure. It is of important that he fixed the eave element using through tenon joint.

Although much of the analyses on components in transverse frame present the divergence from Lan Na's building technique, there are some aspects in longitudinal connection that still share a common basis to Lan Na. The set of purlins originating from smaller transverse frame are fastened to the larger frame at a standing pillar. The carpenter used tenon joints, secured by key nails. Quite interesting is an application of dovetail in a hidden position. The main nave purlin from smaller transverse frame notched on the support point in larger frame. The carpenter cut the notch in dovetail shape against the pulling strength. This connection somehow reminds us to the carpentry in Lampang analyzed in chapter 3 (see Fig.5.3 and Fig. 5.38).

Fig. 5.37 The carpenter cut notch in recessed dovetailed bottom, sample from the viharn of Baan Kyen

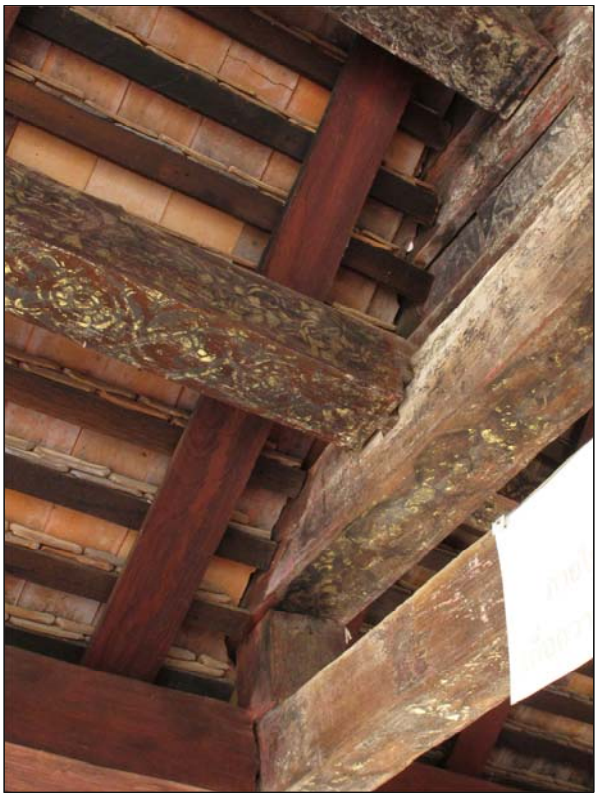


Fig. 5.38 The fastening of purlin using recessed dovetailed shape also found in Lan Na region, a sample from the viharn of Lai Hin Luang, Lampang province

5.5 Convergence and Divergence of Building Techniques

Brick bearing pillar versus wooden pillar and flanking pillar

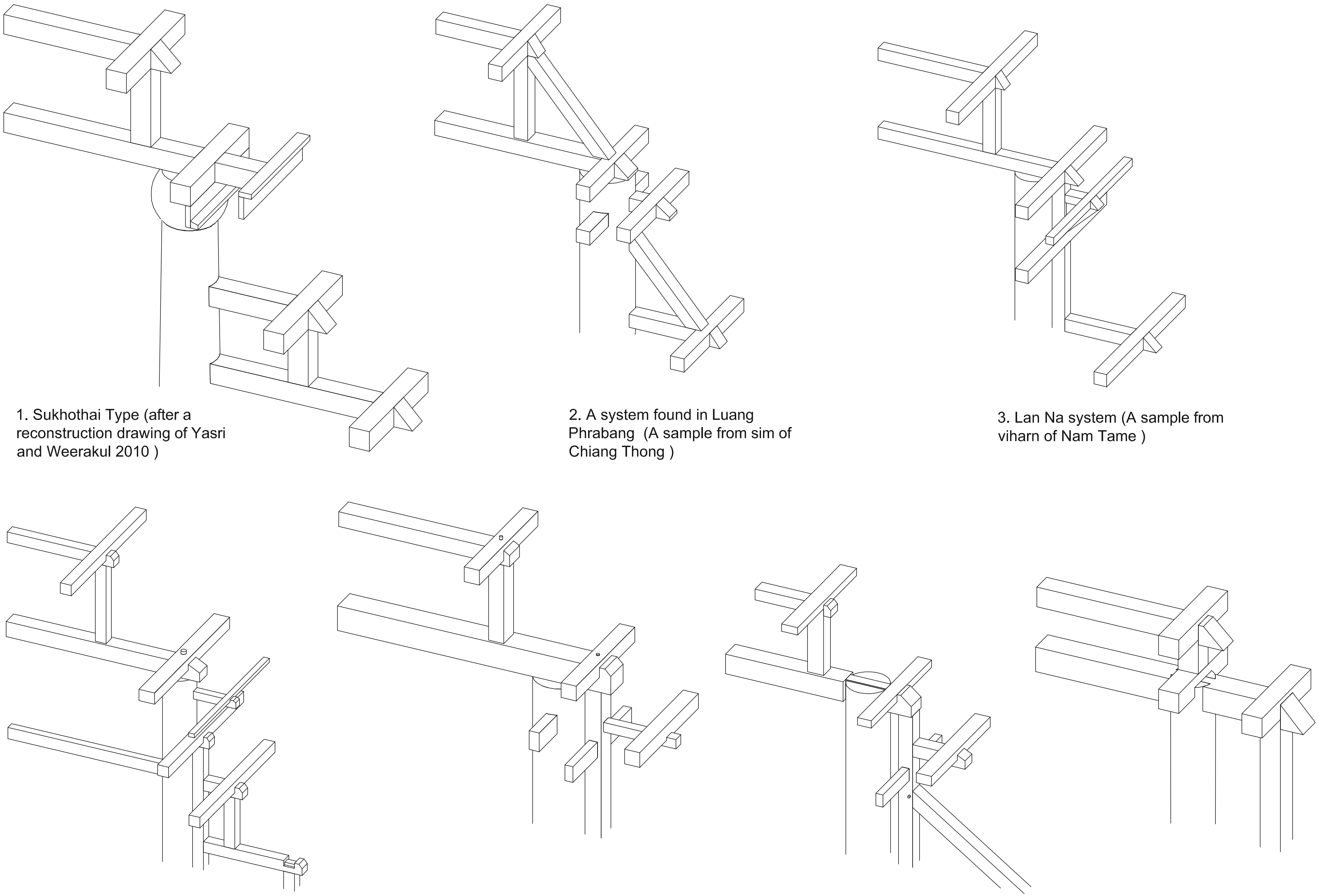
The carpenter built up nave pillars made from brick in the sim of Chiang Thong and of Pa Fang monastery, this was not unique. We also observe such practice in other religious edifices in Luang Phrabang (See sim of Pak Khan, sim of Wichun monastery, etc.). Carpenters' products in Lan Na and in Chiang Tung were very different. They mostly erected wooden nave pillars. My study reveals an interesting distinction between the usage of brick and timber. Wooden nave pillars strictly correlate with the addition of flanking pillars. The application of this building component only exists in Lan Na and Chiang Tung (see Fig. 5.39).

Without flanking pillar, Lao carpenters in old Luang Phrabang had to fix the main nave purlin on a dowel on top of the pillar. They had to drill through mortise holes for fixing uppermost aisle purlin and they had to prepare holes to plug in second and third aisle beams. We find an exceptional case in Lan Na. There the carpenter erected a pair of nave pillars without flanking pillars at the first transverse frame of the viharn of Pong Yang Kok. Thus he had to apply a similar method as described for Luang Phrabang carpentry (see my analysis on chapter 3). The same assembling method might have been applied at the historic buildings of Sukhothai. The ruins of buildings evidence brick-stone nave pillars showing traces of mortise holes at different heights. We can suppose that these were the holes housing previously the installed supports of second and third aisle beams. As they were made of timber they are already deteriorated (See Gosling 1996). Several mortise holes are a very strong indication that Sukhotai carpenter did not use flanking pillar next to their brick-stone nave pillar either.

The usage of flanking pillars in combination with timber nave pillars appear to be a distinctive character of building technique found in between the regions Sipsong Panna and South of Lan Na (see Fig. 5.40). At this stage my study provides just a comparison of facts and refrains from offering any hypothesis or interpretation pertaining to the flanking pillar. This topic shall be treated separately in chapter 6.

Standing Pillar and Inclined Member System

In Lan Na, the carpenter employed the principle of *tang mai* and *tang yo* in separated structural frames. Nonetheless, in Luang Phrabang, we have seen the utilization of inclined member strengthening the frame of standing pillar. The combination of the two structural principles allows Lan Chang carpenters to develop a curved roof with distinct characteristics. The viharn of Baan Kyen in the surrounding of Chiang Tung shows an entirely different approach to deal with this task. The carpenter employed the principle of standing pillar to support the inclined member stabilizing the cantilevered eaves. At the first and the last transverse frame of a long house in the village of Baan Ngek, the structure displays two continuous standing pillars and inclined member frames that are merely bound together.



1. Sukhothai Type (after a reconstruction drawing of Yasri and Weerakul 2010)

2. A system found in Luang Phrabang (A sample from sim of Chiang Thong)

3. Lan Na system (A sample from viharn of Nam Tame)

4. A system found in Chiang Khong (Currently located in Open-Air Museum near Bangkok)

6. A system found in Chiang Tung region (A sample from viharn of Baan Saen)

7. A system found in Chiang Tung region (A sample from viharn of Baan Kyen)

8. A system found in Sipsong Panna (A sample from Suan Mon monastery in Sipsong Panna)

Fig. 5.39 Brick bearing pillar versus wooden pillar and flanking pillar

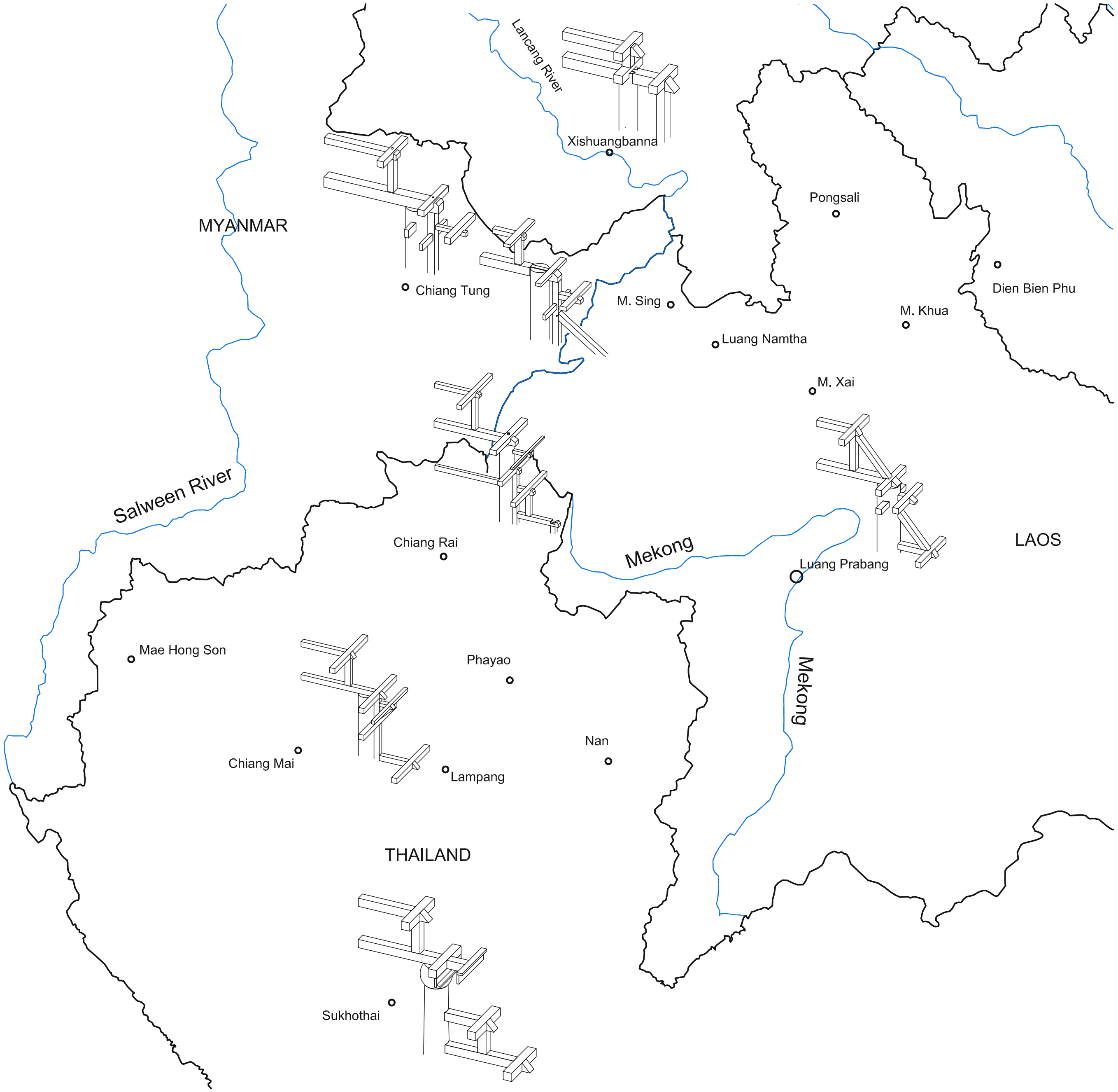


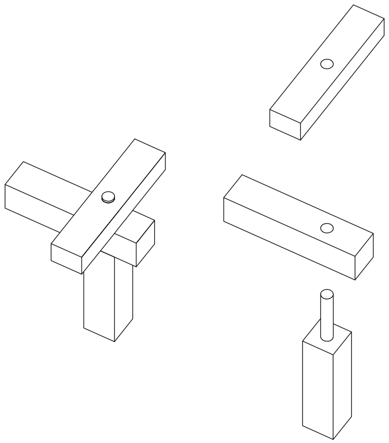
Fig 5.40 Map: brick bearing pillar versus wooden pillar and flanking pillar

Although the purposes for employing the principle of standing pillar in Buddhist edifices in Lan Na, Luang Phrabang, and Chiang Tung share the common intention to create a curved roof plane, still the carpenter had realized this idea by developing different technical solutions in each region. The carpenters in Lan Na and in Lan Chang fixed standing pillars separately on each level of a crosswise beam creating an image of carrying structure. In Baan Saen and Baan Kyen, the standing pillars are put directly on main crosswise and aisle beam, thus the carpenter had to halve them to the second and third crosswise beam. Such a kind of assembling reflects the idea of bracing much more than supporting. It was a fascination experience. The longer we searched the more possible technical outcomes we have encountered. The aim of forming a curved plane appears simple. Yet the found solutions are as diverse as the technical possibilities.

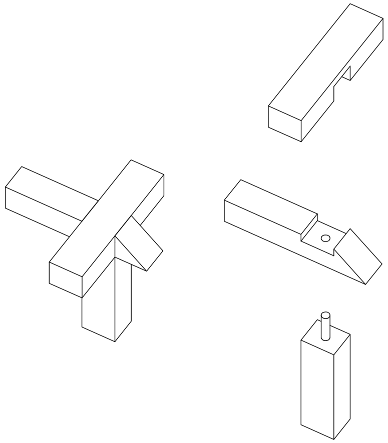
The lower edge of inclined member in Lan Na always ends at the crosswise or aisle beam. The Lan Na carpenter created the eaves by employing roof shaping members as presented in chapter 4. At the viharn of Baan Ngek and Baan Kyen, we found the inclined member fixed to the crosswise beam as well, but this does not restrict the inclined member cantilevering across the connection point in order to form the eaves. The concept was never implemented in Lan Na but known and practiced by a group of Lao carpenters. The field work of French scholars in the region of Vientiane presents a documentation of the mentioned detail. The Vientiane carpenters notched the crosswise beam to the top of pillars and cut an open mortise at the edge of crosswise beam. The mortise shows a slanting edge according to the angle on the inclined member. This inclined member is fixed in its position by a wooden nail drilled through pillar, crosswise beam and inclined member (Charpentier 1982, p. 59-60). Another variant of this fixation concept found in Hua Phan, however displaying a much simpler form. The carpenter fixed the crosswise beam several 10 cms below the pillar's top using a through tenon secured by wooden nail. The reason is to reserve the pillar's top for inserting the inclined member without having to consider the combination of structural elements. On the top of pillar, he cut open mortise showing a slanting edge and assembled the inclined member in this mortise.

<u>Assembling Techniques: purlin, crosswise beam, and pillar</u>

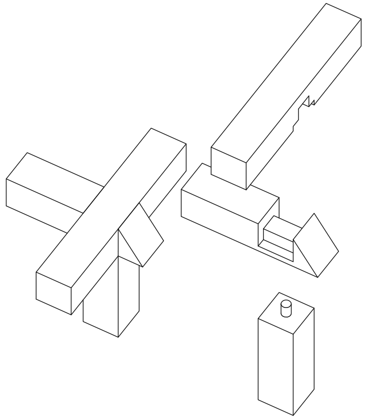
In the conclusion of chapter 3, my study presents four variations of connecting purlin, crosswise beam and pillar as following: (1) purlin joint on the beam and fixed by doubled height tenon, (2) purlin halved to the beam and fixed by the tenon, (3) purlin halved to the beam with doubled recesses, and (4) purlin halved to the beam and secured by crosswise forked pillar (see Fig. 3.41). We found the fourth type (forked pillar) only in Nan province of Lan Na region in the building related to Tai Lue culture. In the region of Chiang Tung, the principle of forming such forked pillars seems to be widespread. The executed variants range from (6) purlin halved to crosswise beam and secured with forked pillar, (7) purlin notched to the beam and secured with crosswise forked pillar, (8) purlin notched only to crosswise beam and secured with forked pillar. The practice is in fact the primary convention of the carpentry in Sipsong Panna, a region of Tai Lue people. An exception can be found in the grand viharn of Baan Saen (5). The carpenter noticed purlin and beam secured then by a double height the tenon on top of pillar. This method shares common conceptual idea with Lan Na rather than its surrounding.



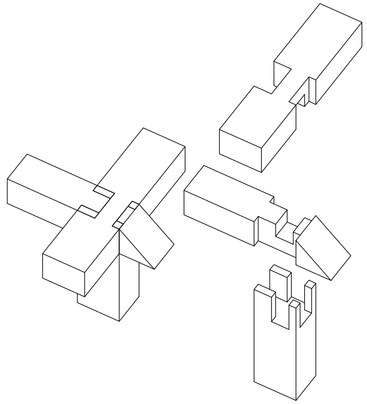
1. purlin placed on the beam fixed through the tenon



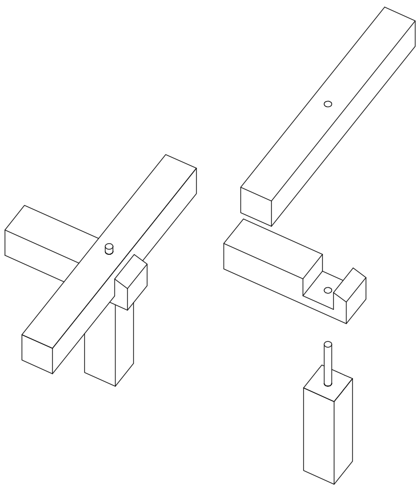
2. purlin halved to the beam



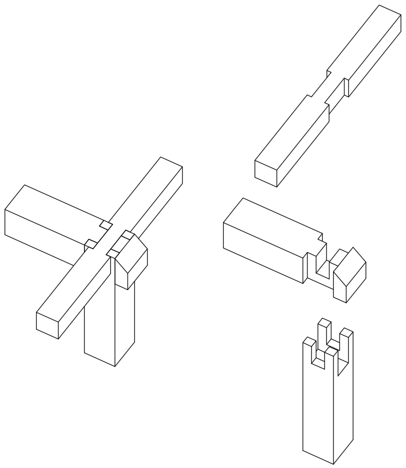
3. purlin halved to the beam with double recesses



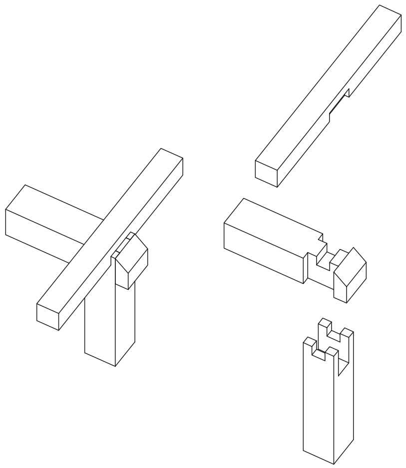
4. purlin halved to the beam and secured by crosswise forked pillar



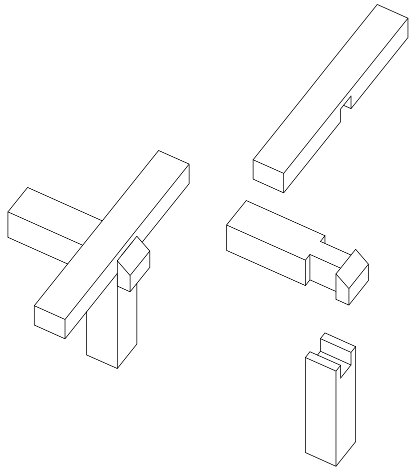
5. purlin notched to the beam fixed through the tenon



6. purlin clasped to the beam and secured by crosswise forked pillar



7. purlin notched to the beam and secured by crosswise forked pillar



8. purlin notched to the beam and secured by forked pillar

Fig. 5.41 Assembling techniques: purlin, crosswise beam, and pillar

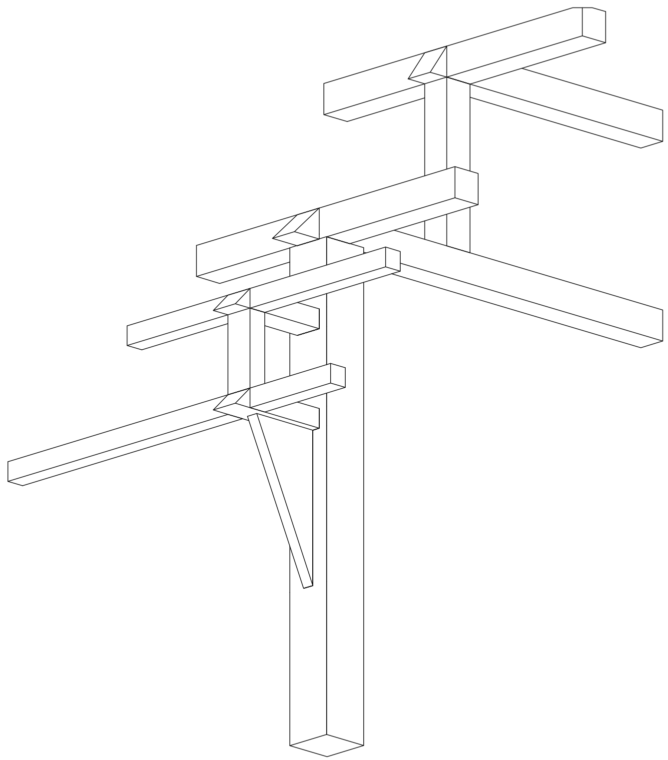
Fig. 5.42 Map: assembling techniques: purlin, crosswise beam, and pillar

The old Lan Na carpenters shared the continuation of flanking pillar and wooden pillar with Chiang Tung's and Sipsong Panna's carpentry. They totally disagreed concerning the assembling technique of purlin, beam and pillar. The Lan Na methods are much closer to old Sukhothai and Lan Chang considering the conceptual background (purlin and beam are put on top of pillar) regardless to an absence of flanking pillar in the latter two (see Fig. 3.42). Confronted with such an investigation we get an idea that the historic timber construction did not develop in straightforward way. We cannot simply say, for example, Sipsong Panna's carpentry influenced Lan Na's or the other way round. We recognize a mixture not even easily separable and thus must conclude that ideas were exchanged seen within a larger picture.

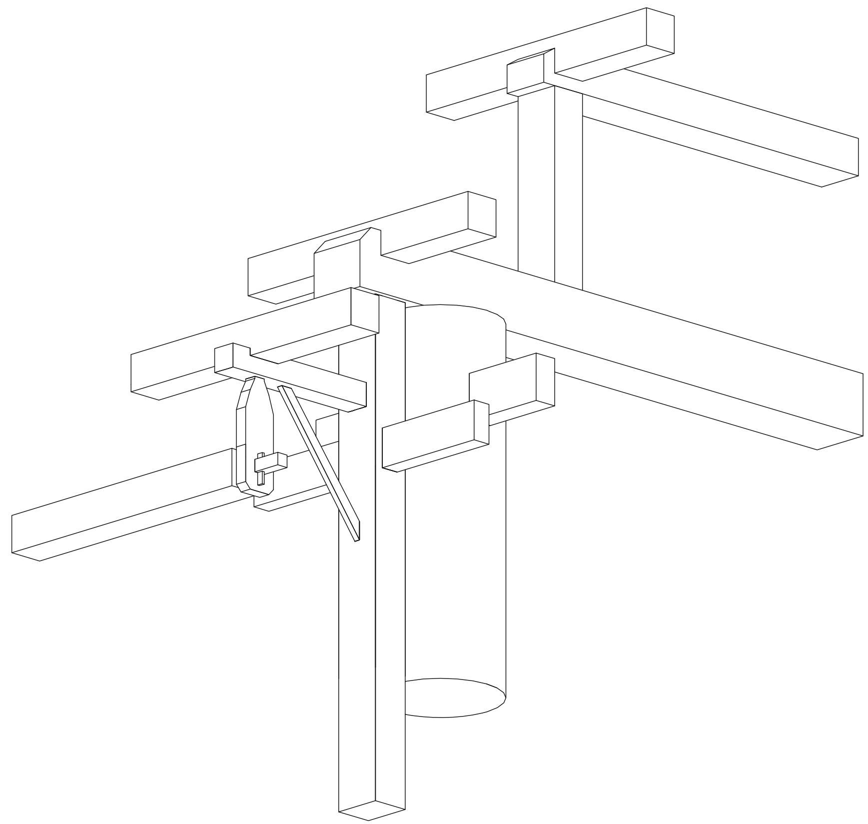
Longitudinal Connection

In Lan Na, Lan Chang, and Chiang Tung, a common practice for fastening purlins from smaller transverse frame to the larger one is the connection via tenon joint. The carpenter fixed a purlin to the standing pillar and secured the through tenon with key wedge or nail. The idea of using a keyed tenon joint demonstrates the carpenter understands that he had to react to pulling strength. Nonetheless, there is a crucial point that shows their different practices. This point is at the eaves structure where two different levels of eaves purlins meet. The purlin arriving from the lower frame must be secured in the higher frame in some way. Carpenters in old Lan Na were aware of this problem, thus described a working solution on treatise (see third paragraph of Treatise Nr.1). They introduced a method so called "*yang sone pae*" which is based on the formation of an eaves construction consisting of two levels of eaves elements held in distance by a short standing pillar. Two horizontal arms protrude out of the pillar equally. The lower arm is supported by the bracket. This bracket also supports the upper arm via short standing pillar (see Fig. 3.43).

In the region of Chiang Tung at the viharn of Baan Saen, the carpenter used to hang the rear end of the lower frame's lowest purlin. He pierced a board suspending from the braced purlin supporting arm of the higher transverse frame and fixed the lowest in it. Again the protruding tenon is secured with a key wedge. The Tai Loi practiced this method. We can observe the same assembling at the grand viharn of Nong Long monastery. It is rather surprising that such a practice did not exist in Lan Chang carpentry. At the sim of Pa Fang, the carpenter let the eaves purlin of smaller transverse frame end abruptly as a cantilever. Later on the structure seems to have failed and had to install an additional pillar to carry it. In more elegant buildings, the carpenters employed curved shaped components that were hooked to intermediate purlins of aisle structures and cantilevered beyond the main aisle purlin holding eaves purlin.



A method of forming eaves compound in Lan Na



A method of hanging purlin; a sample from Baan Saen

Fig. 5.43 Two different methods of fastening eaves purlin

Chapter 6

Hypotheses on the Development of Flanking Pillar

6.1 Theoretical Discussion

My study found the application of flanking pillar in the area between southern Lan Na region (to be precise from Thoen district, Lampang province) and Sipsong Panna, Yunnan, China. Thai scholars are well aware of the significance of flanking pillar and its important role played in Lan Na architecture (see Boonyasurat 2001b). Nevertheless, the origin of this component remains unknown.

Chaiyosh Isavorapant, a Thai scholar attempted to propose a hypothesis on the evolution of flanking pillar in his Ph.D. dissertation *A Study on Documents of Traditional Architecture in Thailand* (2004). But his hypothesis is firstly based on an incorrect chronological order of building erections, and secondly limited to the political regions of Northern Thailand. The cultural sphere of old Lan Na was significantly larger. He proposed that a flanking pillar or *sao sagoen* evolved from a standing pillar or *sao tang*, that had been assembled in order to support the of crosswise beam that defines the span of nave roof (see Fig. 6.1).

Isavorapant developed his idea from observing the structural arrangement of the viharn in Lai Hin Luang monastery. There the carpenter applied the method of flanking pillar at the frontal façade and the method of standing pillar at the principal hall. Isavorapant believed that the structural arrangement in this viharn is, in his words reflecting an “early or experimental stage” (Isavorapant 2004, p. 40). According to his conviction, the system was still in an evolving process. Afterwards the application of flanking pillar became “mature” presenting in the roof structure of viharns in Phra That Lampang Luang monastery: the grand viharn and the viharn of Nam Tame (Ibid.). I cannot follow Isavorapant’s arguments. The grand viharn and viharn of Nam Tame are much older than the viharn of Lai Hin. Historical sources elucidate the erection period of these two viharns at approximate by 1496-1501 (2039-2044), while the viharn of Lai Hin was erected in 1683 (2226). Throughout his dissertation, Isavorapant ignores to discuss chronological data of building erections apart from the viharn of Lai Hin monastery.

If we leave the inconsistent chronological order for a moment, the standing pillar and flanking pillar express an evolutionary process according Isavorapant’s hypothesis. He described that, the carpentry in Western Lan Na developed the flanking pillar method, while in Eastern Lan Na the application of standing pillar system is still maintained. Hence the evolution presented different regional characteristics between West and East. In regards to the transition from standing pillar to flanking pillar, Isavorapant considered that the carpenter became acquainted with the method of flanking pillar as shown in the roof structures of viharn of Nam Tame and viharn of Pong Yang Kok monastery. He tried to make sense to the existence of a pair of standing pillar at the frontal façade and at the rear side of the viharn of Nam Tame (see Fig. 3.12) and argued “the carpenters were unable to abandon their traditional idea” (Ibid., p.41). My study has discussed in detail the role of this

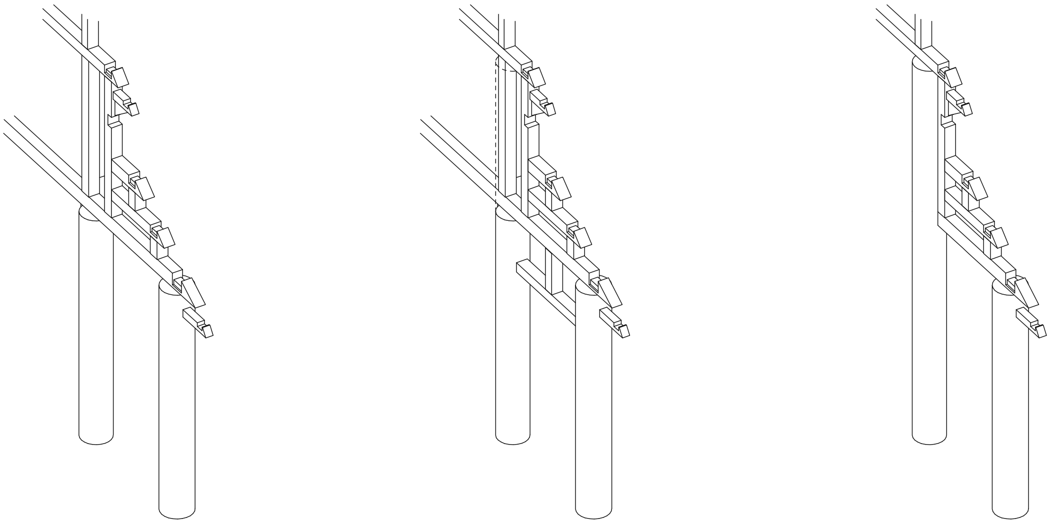


Fig. 6.1 Transformation from standing pillar to flanking pillar according to Isavorapant's hypothesis

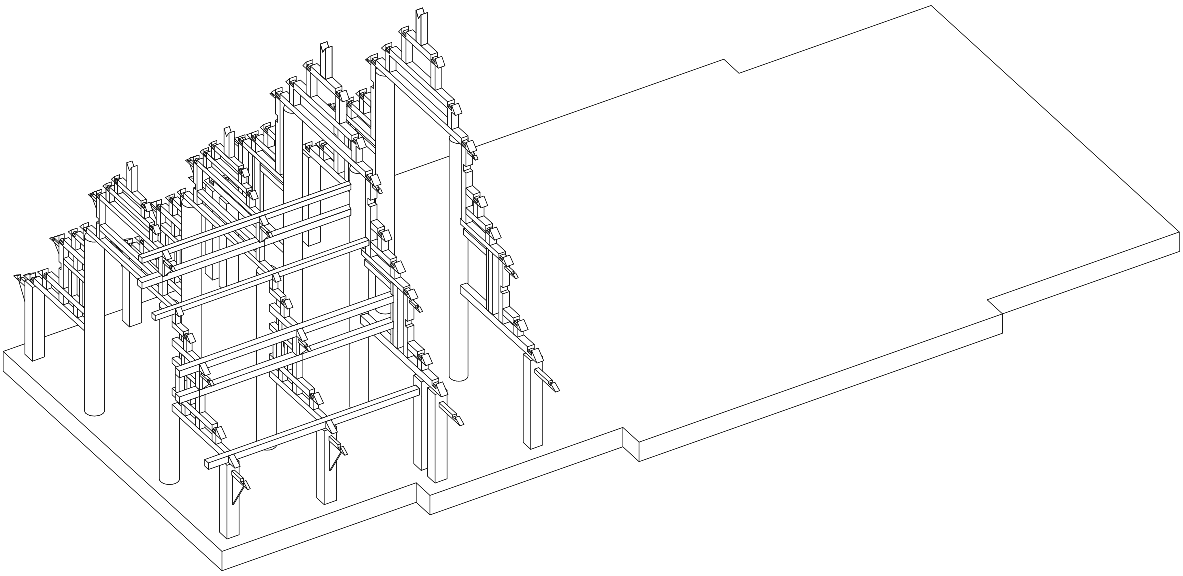


Fig. 6.2 Application of Standing Pillar in the first two transverse frames of the viharn Luang of Phra That Lampang Luang monastery

pair of standing pillars in the viharn Luang , viharn of Nam Tame, and viharn of Wieng Thoen. I have demonstrated that the carpenter employed the standing pillar to allow a certain degree of flexibility in reducing the roof size without disturbing the span of nave pillar (entrance). Especially at the viharn Luang of Lampang Luang monastery the carpenter assembled the standing pillars supporting main crosswise beams in the first two transverse frames and not only at the frontal façade. I am convinced that the structural arrangement represents an intention of carpenter for maintaining the whole nave space, while keeping the reduction of the roof continues (see Fig.6.2 and my analysis on chapter 3). My study does not support the idea that the existence of standing pillars in these viharns pertains to the traditional practice that could not yet be abandoned. I have analyzed that flanking pillar and standing pillar must be interpreted as different methods in defining the length of crosswise beam and nave span. The coexistence of these techniques offers carpenters choices to solve specific problems.

Another hypothesis on the development of flanking pillar is conceived as a retrospective reasoning. The scholars took the so called “class type” of viharns into consideration (the structural arrangement of viharn that presents the reduction of the length of crosswise beam and the level of ridge purlin twice toward the frontal and once toward the rear side) and then analyzed a utilitarian role of flanking pillar (see Baokerd 1998; Boonyasurat 2001b). By this logical framework, the intention of employing a flanking pillar is interpreted as related to the reduction of roof size. The length of the crosswise beam corresponds to the positions of flanking pillars placed adjacent to nave pillars. The main nave purlin of the smaller transverse frame is halved to the crosswise beam assembling directly above the pillar’s central axis. It runs along longitudinal direction and is fixed to the nave pillar of the larger frame (See Fig.6.14). Nonetheless, no further explanation and assumption on the development process have ever been provided. Therefore I feel obliged to examine this idea.

6.2 Hypotheses on Development of Flanking Pillar

My study on the flanking pillar began by following basis on premise given by Thai scholars. I had recognized their statement on the existence of a flanking pillar as a given fact. Nobody has ever tried to investigate its emergence. I produced series of drawings considering a speculated development process. I testified the offered assumption against counter arguments developing as a consequence of numerous on site measuring. The result was an alternative view on the flanking pillar. In order to avoid the mistake of choosing and developing one single idea that cannot be proved sufficiently, my study puts two hypotheses that appear plausible to me up for discussion. I state explicitly that the following explanation of the two hypotheses must be regarded as a tentative conclusion aiming at promoting the discussion on the flanking pillar.

6.2.1 Hypothesis: A

The assembling of flanking pillar is the result of a structural simplification process.

If the intention behind flanking pillar is really related to the reduction of roof size as believed generally by Thai scholars, its assembling might be interpreted as the result of improvement how to connect two different sizes of roof edges in a practical, comfortable, and pleasing way. There are two structural features that could support the above given hypothesis.

Firstly, throughout historic roof construction in Sukhothai, Ayutthaya, and Luang Phrabang, carpenter fixed the purlin of the nave pillar via a dowel. It appears comprehensible to me that those familiar to these regions eventually started to scrutinizes the main purlin's positioning in Lan Na's construction. It is difficult to explain a logical reason to have main load carrying horizontal element not directly supported by load bearing structure.

Secondly, we always found the outer aisle pillar duplicated when two differently sized roofs met. The duplicated pillar was needed to fix the main aisle's purlin at its inner end. Putting this image in mind and speculating on carpenter's ideas how they might have started with solving this same problem in the nave. I tentatively place two nave pillars side by side. In case this speculation holds some reasonable ground, the development process might look as following (see Fig. 6.3).

Diagram 1 shows the plan and the elevation of a principal hall in simplest structural setting. Diagram 2 shows an addition of a smaller roof structure lower than the principal hall. This could be a porch structure, for example. Diagram 3 shows the additional reduction of pillar's span supporting the smaller roof structure and how it is connected to the principal hall. Diagram 4 presents an attempt to form a smooth transition in opening the width of the pillar's span as well as to arrange the purlins linkage from smaller roof in alignment with *tang mai* in the principal hall. Diagram 5 shows plan and cross section of extended aisle structures. This extension was executed in principal hall as well as in lengthwise added lower and narrow structure.

Diagram 6 depicts the structural arrangement as executed in Lan Na construction. The crucial question is whether there has been a transition from diagram 5 to diagram 6. If so, the follow on question is how and when this transition took place? Regarding the outcome in diagram 6, the carpenter's challenge to improve the unsatisfying hypothetical structure in diagram 5 was a structural simplification and a reduction of the most expensive building elements. These were without question the nave pillar in the principal hall. Considering the viharns user's point of view the intention of eliminating one of two massive pillars standing next to each other is perceived as considerable improvement. The construction appears lighter and the views are less restricted.

Three major steps had been done. Firstly, the shorter nave pillar in the transitional frame had to be elongated up to the height of the main crosswise beam in order to undertake the task of supporting this beam. Secondly, the aisle beam had to be elongated and be fixed to the nave pillar elongated in step one. Thirdly the former nave pillars of the principal hall are replaced by a pair of shorter and smaller vertical components on the outer "flank" of the new nave pillars elongated in step one. These newly introduced vertical components support the main purlin and offer connection point for the inner end of the uppermost aisle purlin. In order to bear this weight they are supported by the aisle beam mentioned in step two. These steps are strictly connected to each other and cannot be thought independently.

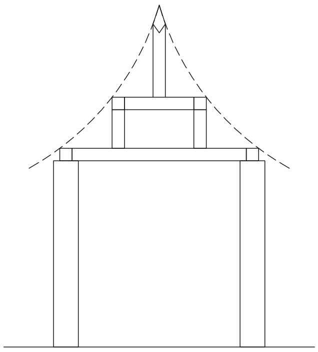


Diagram 1

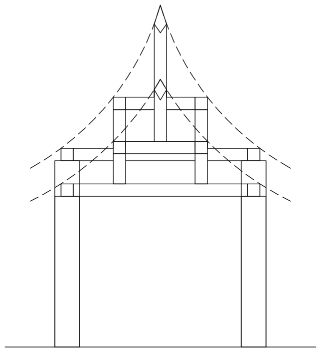


Diagram 2

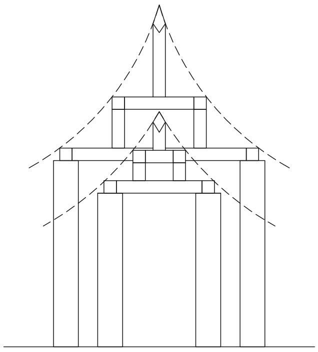


Diagram 3

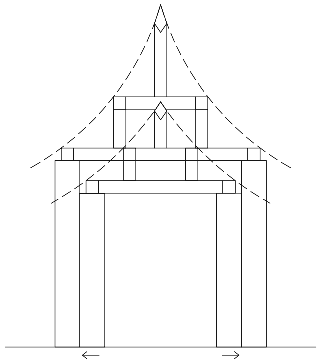


Diagram 4

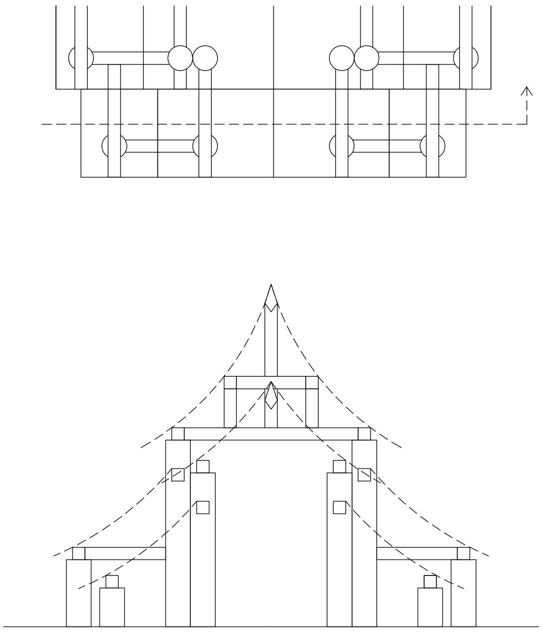


Diagram 5

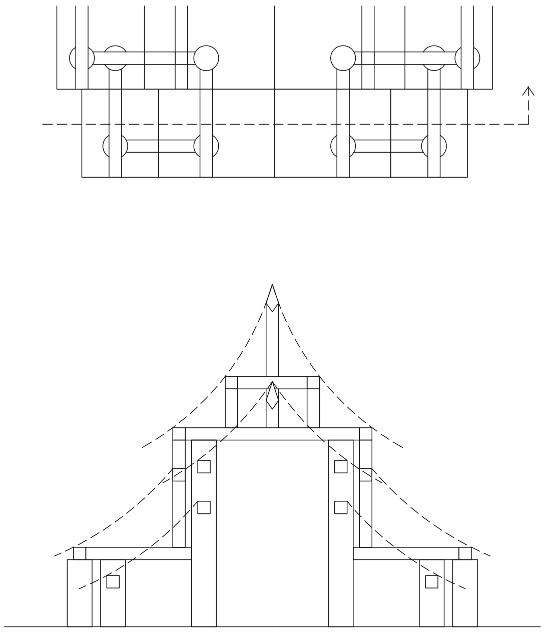


Diagram 6

Fig. 6.3 Hypothesis A

The proposed transition from the hypothetic diagram 5 to 6 leaves doubts. At least two aspects open up additional questions. Aspect one: We have observed that the carpenter assembled flanking pillars in historic roof constructions regardless the reduction of roof size. We found its application in buildings that present equally wide transverse frames, even in some Tai Lue buildings in Sipsong Panna that have hipped and gabled roof. It does not lead to a more useful result to continue arguing. The flanking pillar could have become part of a structural principle after its implementation. Its use could have spread for general application in building. Not least we found it in *tang yo* system as well.

Aspect two: Hitherto, we have not found an evidence of doubled pairs of nave pillars as shown in diagram 5. The reason might be seen or eventually found in historical events. Lan Na was approximate 200 years under Burmese rule. At that time many areas were abandoned. Buildings in these regions were destroyed and turned to ruin. However: Is not so strange that we not only have no evidence of a hypothetic stating construction as drawn in diagram 5 but also no evidence of any intermediate step? This lead immediately to the follow-up question: Could the introduction of the flanking pillar have been such a completed self-contained structural system that intermediate development step did not happen? Could it be that the flanking pillar system rests on the shoulder of one or a group of ingenious carpenter working together? I must leave all these questions unanswered. Notwithstanding the above, my investigation search in very different considerations. Again, I cannot prove them and present them as Hypothesis B.

6.3 Hypothesis B:

Carpenter invented the flanking pillar in order to facilitate the assembling of structural component.

Timber is a naturally grown material. We mentioned that especially the main pillar were very expensive building components. Due to their impressive presence in a viharn they were carefully selected and most probably reserved as an expression of distinction; distinction not only towards ordinary building but also towards other viharns. Yet, several occurrences could force carpenter to fall back on less representative material e.g. lack of available material, insufficient donation amount for re-erection, poverty of the community financing the erection, etc. Less selected material made construction more difficult and therefore more expensive. If aisle beams have to be mortised into a nave pillar at different heights and the nave pillar are not straight or does not have equal diameters, each component would have to be adapted singularly. Precutting and preassembling would become impossible. Finally the recourse to less perfect building material would be paid back by significantly longer working time. In order to avoid such an undeserved consequence, carpenters were asked to ponder a solution. The introduction of the flanking pillar could have been a way out of the dilemma. If all component that need structural contact to the nave pillar can be jointed to a much linear, lighter and, shorter element that can be shaped perfectly in an reasonable way; the whole erection process of the a viharn could be accelerated significantly. This intermediate element, the flanking pillar, stayed independent of the nave pillar of whatever quality it was.

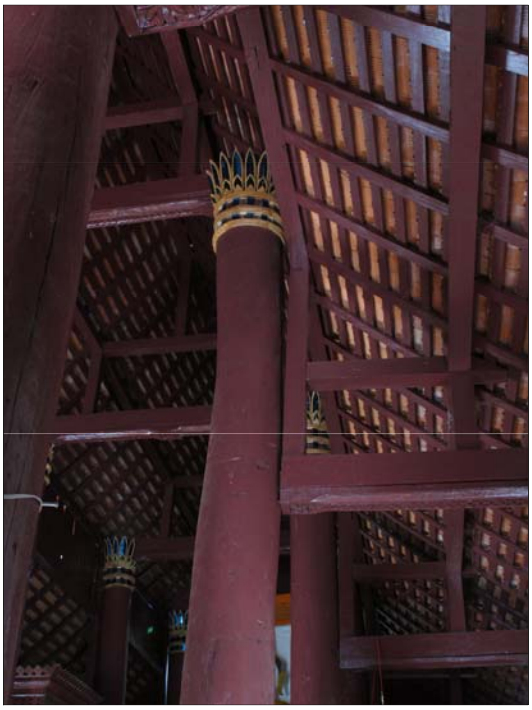


Fig. 6.4 and 6.5 Sample from the viharn of Tor Ruear monastery and viharn of Huay Rin monastery show a significant role of flanking pillar to adapt a measurment between flanking pillar and nave pilalr

As discussed in hypothesis A, we found the flanking pillar in most cases of historic structures from Lan Na to Sipsong Panna regardless to the combination of different sizes of transverse frames. Thus hypothesis B explained the origin of flanking pillar entirely different from hypothesis A. Hypothesis B suggests the concept of flanking pillar as solution for a technical consideration in a single transverse frame.

The meaning of flanking pillar or *sagoen* in Tai Yuan language of Lan Na can also be interpreted from etymological point of view. "*sa-goen*" is a combination of 2 words: "*sa*" is a verb meaning to intervene, to intercept, to obstruct (Royal Society of Thailand 2009, p. 1149); while "*goen*" is a noun. One of its meanings refers to the wooden hole (Royal Society of Thailand 2009, p. 155).Thus "*sa-goen*" can be understood as a structural component intercepting another component/ preventing an occurrence of mortise hole (on nave pillars).

Hypothesis B seems to provide us the technical concept on the origin of flanking pillar, but still leaves some open questions as well. Hypothesis B cannot explain why the main nave purlin was shifted away from nave pillar toward the alignment of flanking pillar. My study considers this aspect as consecutive developments. The Lan Na carpenter took benefit from the existence of flanking pillar and improved structural notions that differentiated their building culture from Chiang Tung and Sipsong Panna. We will assess the particulars of Lan Na in the following section.

6.3 Structural Notions as Consequence from Flanking Pillar

The existence of flanking pillar in a transverse frame according to the hypothesis B opened new horizon to the carpenter inviting him to implement new ideas. There are two structural inventions that can be seen as the consequences of introducing the flanking pillar: 1) the exemption from nave pillar and 2) the “reduction of roof size.”

Exemption from Nave Pillar

My study discusses an attempt of carpenters to release the nave pillar from its obligation of defining the roof span. The main nave purlin was shifted away from the alignment of nave pillars. It moved towards the edges of crosswise beam, and eventually rested on the alignment of the flanking pillar (see Fig. 6.6, 6.7, and Fig. 6.8). In the previous sample we analyzed the structural arrangement of the viharn of Chiang Khong monastery where the main nave purlin is fixed together with the crosswise beam via double height tenon on the pillar’s top end. The flanking pillar is disassociated from the connection of main crosswise beam and main purlin. The samples of viharns from the surrounding of Chiang Tung show that the flanking pillar is connected with the main crosswise beam but has no additional contact to the main purlin. Only when the main nave purlin is shifted from the nave pillar to the top of the flanking pillar and fixed there, the nave pillar become completely independence. As exempted from all jointing obligations, the nave pillar becomes free standing. At this stage of development, the Hypothesis A and B meet the same situation.

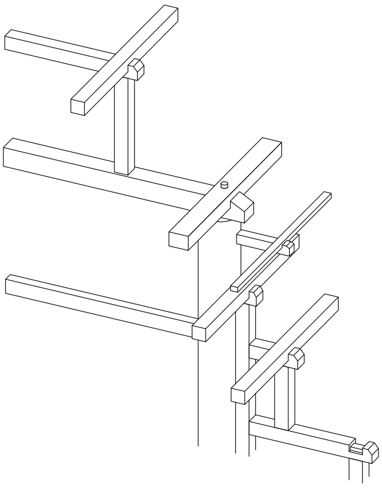


Fig. 6.6 Sample from the viharn of Chiang Khong monastery

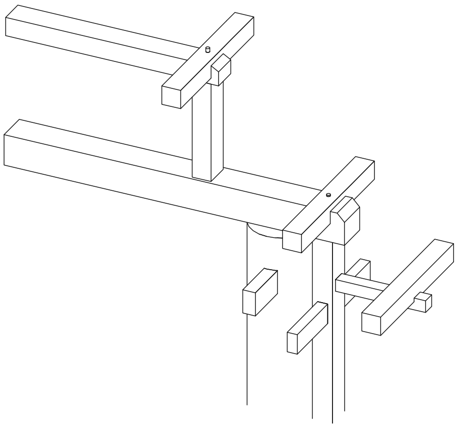


Fig. 6.7 Sample from the viharn of Baan Saen monastery

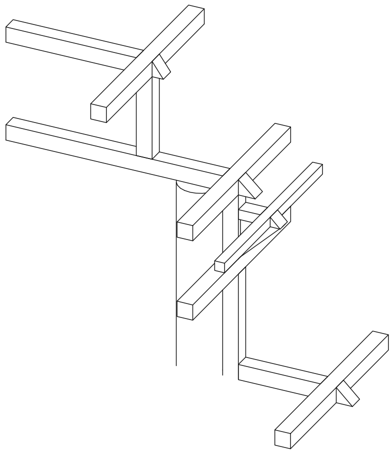


Fig. 6.8 Typical viharn in Lan Na

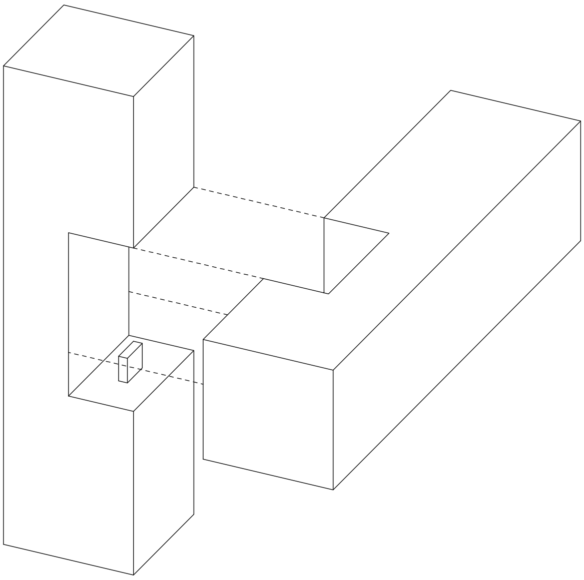


Fig. 6.9 Assembling drawing presents halved joint between flanking pillar and uppermost aisle purlin


Fig. 6.10 Dismentaled flanking pillar from the viharn of Prao Nhum, Mae Cham district, Chiang Mai province

As a side product to the assumed development process, my study observes two aesthetic ideas evolving in parallel to the emergence of flanking pillar and free standing nave pillar: a) formation of *korgeeb* and b) reduction of distance between a pair of pillars.

A) Formation of *Korgeeb* (Neck Part)

When the main nave purlin and the uppermost aisle purlin are perfectly placed in alignment with the flanking pillar, the neck part or *korgeeb* was formed. The Lan Na carpenter developed a special joinery technique unique to Lan Na and distinguishing itself from their neighbors. The carpenters in Chiang Tung and in Sipsong Panna connect the uppermost aisle purlin using through tenon, while Lan Na carpenters employed specific hlaved joints in combination with a small tenon (Fig. 6.9 and Fig. 6.10). The carpenter cut a recess along the outer side of flanking pillar (facing outside). In this recess, he prepared a small tenon at the bottom face showing shoulder to all four sides in order to secure the uppermost aisle purlin against pulling strength. Regarding the way of assemblage, the height of this recess at the flanking pillar is larger than the purlin. The height of the recess measure height of purlin plus height of tenon, thus allow the carpenter to insert the purlin from above. In building treatises, carpenters used the word "*lin*" (tongue) to signify this small tenon, and the uppermost aisle purlin is called "*pae lin harn*" meaning the "purlin that is recessed for tongue".

The combination of main nave purlin, flanking pillar and uppermost aisle purlin created a frame open to outside. Lan Na carpenters filled this opening with wooden boards and applied lacquer to protect and smooth the surface. The *korgeeb* is an area providing Lan Na artists to demonstrate their unique golden stencil work and mural painting (see Fig 6.11 and 6.12).

B) Reducing the Distance between Nave Pillars

The carpenter in old Lan Na as well as in Chiang Tung took advantage from the nave pillar's exemption from all former tasks. Previous scholars observed the fact that the distances between pair of nave pillar are increasing in each transverse frame from the first frame onward. The arrangement of the positions of nave pillars is interpreted as "anti-perspective" (Boonyasurat 2001B, p.356). Yet all previous research did not consider the overall arrangement in the buildings and did not mention that the distance between pillars was frequently reduced significantly in front of Buddha image or shrine. As discussed in chapter 5 my study found the unique arrangement at the viharn of Baan Saen. These carpenters had shifted the nave pillars 40 cm inwards from the flanking pillars on each side. This is apparent to everybody. This action did not counteract perspective illusion at all, but instead take benefit from it. Maybe we should call such action "playing with perspective" rather than "anti-perspective."

<u>Reduction of Roof Size</u>

The Lan Na carpenter realized the large potential when he shifted the main purlin away from nave pillar. He exploited the main purlin's structural trait as defining a longitudinal axis to full advantage by inventing an extraordinary pattern of combing different transverse frames (see Fig 6.13). Starting

Fig. 6.11 Golden Stencil work at the *korgeeb*; sample from the viharn of Suchada, Lampang province

Fig. 6.12 Mural painting at the *korgeeb*; sample from the viharn of Klong Kak, Chiang Mai province

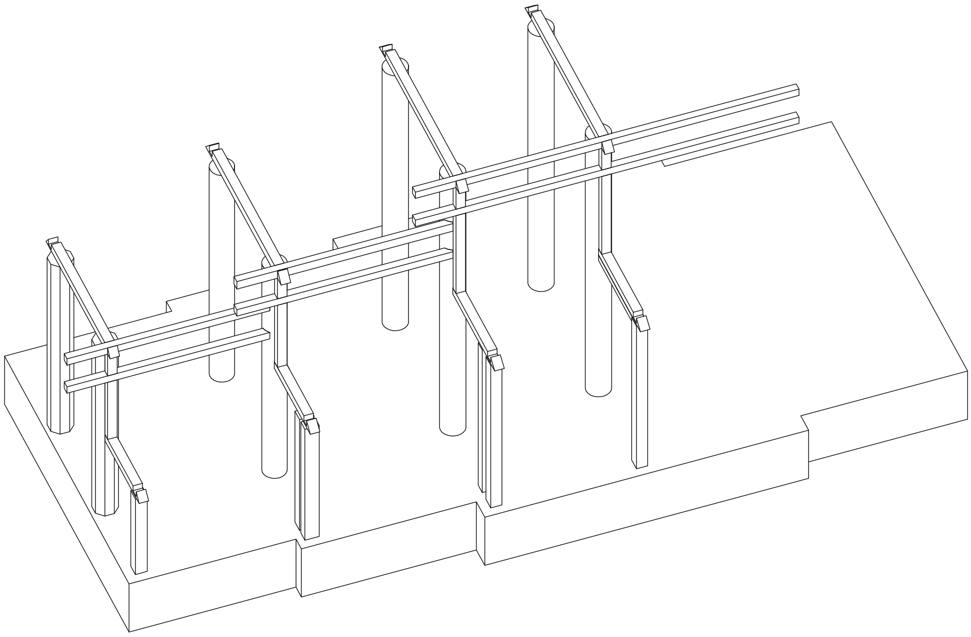


Fig. 6.13 Pattern of combining different transverse frames resulting to the reduction of crosswise beam and the roof

inside with the principal hall, the carpenter mortised the main purlin's inner end of the adjacent roof to the principal hall's nave pillar. The nave pillar stands insider the respective flanking pillar supporting the main purlin. The carpenter followed the structural consideration consequently from every larger frame to smaller frame. Looking at the main crosswise beam, we realize a continuous reduction in length. The result of this ingenious connecting pattern has characterized the scheme of viharns in Lampang and in Chiang Mai regions as previously analyzed in chapter 3.

Scholars classified the viharn following this pattern of connection as the "classic type." Their appearance is interpreted as a metaphor for an "enshrined ship" that transports humans to the nirvana (Puapansakul 1996; and Boonyasurat 2001B, p. 272). Apart from this symbolic meaning, my study finds a structural advantage of this arrangement. The transverse frame is held in upright position by the main purlin in direction to the larger frame and by the aisle purlin in direction to the smaller frame. The principle of stabilization shares similar idea with the longitudinal bracings as seen in viharn of Chiang Khong, viharn of Baan Ngek, viharn of Baan Saen, etc. Yet Lan Na classical style appears more considered.

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List of Figures

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Higher Education

2007 **Master of Architecture**, Major in Architecture, Chulalongkorn University, Bangkok , Thailand
Thesis title: A Study of Vieng Phra Dhatu Lumpang Luang Historic City for Establishing Tradition Based Conservation Concepts

2002 **Bachelor of Architecture**, King Mongkut Institute of Technology Lardkabang (KMITL), Bangkok, Thailand

Experience

Research Experiences

2009-11 **Old Town Revitalization,** authorized and funded by Housing Authority of Thailand. The objectives of project are to renovate the residences in historic district and to establish the Local Museum according to the policy of housing standardization and the reuse of housing stock 2008. The role: Conservation Architect.

2010 **The Study of Impacts of Sub-Way Development on China Town, Bangkok,** commissioned by Crown Property Bureau. The objectives are to assess the impact of transportation development and to initiate the local participation. Local Museum and Oral History are employed as the instruments to provoke the public dialogue. The role: Field Architect

2005-09 **Samchuk Community Revitalization Project,** commissioned by Thai Community Foundation, the objective of project is to rehabilitate the socio-economic and preserve the historic market toward the community participation process. The role: conservation planner and researcher
The project achieved the UNESCO "AWARD of Merit," Dec 2009

2008-09 **Myanmar Reconstruction Project,** authorized and funded by Associate of South East Asia Nations (ASEAN) and Architecture For Humanity (AFH): A post-disaster intervention project. The role: Project Chief. The procedures of project are listed as follow:
- To assess the building condition in devastated area.
- To plan and implement the reconstruction project on the approach of "Local Based Efforts."
- To reconcile the socio-economic of the village in disaster area.
- To reconstruct the public facilities: Monastery (Myanmar kyaung), school ,and health care etc.

Published on Al Jazeera
http://english.aljazeera.net/focus/2009/11/2009111913035210689.html

Published on Open Architecture Network
http://www.openarchitecturenetwork.org/node/2151/oanattachments

2008-10 **Conservation of Historic Village at Tak province,** funded by local community. The project goal is to conserve the historic timber village in North West of Thailand. The role: conservation consultant

2007 **Vernacular Field Trip,** organized by Faculty of Architecture, King Mongkut Institute of Technology Lardkabang (KMITL), Bangkok, Thailand (July-August 2007). The objective is to collect the empirical data of traditional architectures in northern part of Thailand.

2004 **Exchange Scholar/Researcher at at Angkor Wat**, the World Heritage site of Cambodia (1 month). Cultural exchange program organized and funded by Ministry of Culture, Thailand (May 2004); the procedure and objectives of this research can be concluded as follow:
- Observing the conservation management of Angkor Wat Historic Site
- Interviewing the various groups of conservationist
- Comparing their concept and its strategies
- Concluding and conducting a research; "*The conservation project management of Angkor Wat Historic Site"*

Pedagogy Experiences

2010-2012, Lecturer for 1st year design Studio.

2009, Aug Visiting Juror for design studio on the project "Art House" of 2rd year student, KMITL, Bangkok.

2009, Jan Project Coordinator for NTNU's student. Working as an organizer and lecturer for one-day site visiting at "Samchuk" conservation area. This trip was arranged to support NTNUs field trip programme in Thailand. The programme leader is Associate Prof. Hans Skotte.

2008, **Oct** Lecturer and project organizer for 3 days field trip on the subject of historic settlement and conservation project for the 5th year student, KMITL.
2008, Sep Visiting Juror for design studio on the project “Public Library” of 3rd year student, KMITL, Bangkok.
2008, July Assistant Lecturer for 9 days field trip of the 5th year student, KMITL**.**

Planning and Design Experience

2013- Present Architect at HOLODECK architects, Vienna, Austria

- Austrian Embassy in Bangkok

2006- Architect at Four Aces Consultant Co., Ltd. Bangkok, Thailand. The responsive tasks are;

- Design the resort in northern Thailand
- Design the Residential design in Bangkok, Thailand
- Design the Residential design in Khartoum, Sudan

2003 Junior Architect at Four Aces Consultant Co., Ltd. Bangkok, Thailand. The responsive tasks are;

- Design the resort and hotel in tourism area of southern Thailand
- Design the resort in Abu Dhabi

Titles and dates of publication

2016 "Tang Yo: Historic Roof Construction in Lan Na," in *NaJua*, pp. 35-61.
2015 "From Convention to Tradition: An Overview on Use and Abuse of Building Techniques in Historic Timber Structure Restoration Project in Northern Thailand," in *Proceeding: Timber Heritage and Cultural Tourism: Values, Innovation, and Visitor Management*. Bangkok: ICOMOS, pp. 154-168.
2012 “Wangkrot Historic District: Reinterpreting History toward Design Intervention,” in *NaJua*, pp. 186-214.
2008 The article “Parallel Nippon”
a book review: Art4d magazine (02: 2008)
2007 The master dissertation *“*A Study of Vieng Phra Dhatu Lumpang Luang Historic City for Establishing Tradition Based Conservation Concepts*”*
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Scholarships, prizes (Awards)

2009 **Award of Merit, UNESCO Asia Pacific, Samchuk Conservation Project.**
2003 **Honorable Mention in Architectural Design Competition**, Art & Living Heritage Company
Theme: Cultural Heritage and Revitalization
2003 **Selected work and published**, The architectural design competition for Nippon Paint head quarter; Bangkok, Thailand
Theme: Color Design Center
2003 **2nd prize in Architectural competition**, **Praya Tai Palace foundation**
Partial renovation of Praya Tai Palace (The historic palace of Bangkok)
2002 **Honorable Mention in Architectural competition**, The French Embassy of Thailand
Theme: Re’sidence Pour Artistes A’ Chiang Mai
2002 **Architectural Licensed, Council of Architects, Bangkok, Thailand**
2000 **3rd prize in ASA Design Competition**, ASA(The Association of Siamese Architects)
Theme: Bangkok as a City of Superstructuration
1999 **Selected participant of Student workshop**, ASA (The Association of Siamese Architects)
Theme: Revival and Living Thai style
1998 **Selected participant of Student workshop**, Chulalongkorn University Bangkok
Theme: Where shall we go