LANNA ARCHITECTURAL CONSERVATION:

GUIDELINES FOR HISTORIC BUILDINGS IN NORTHERN THAILAND

By

Vitul Lieorungruang

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

Program of Architectural Heritage Management and Tourism

(International Program)

Graduate School

SILPAKORN UNIVERSITY

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The Graduate School, Silpakorn University has approved and accredited the Thesis title of “Lanna Architectural Conservation: Guidelines for Historic Buildings in Northern Thailand” submitted by Mr.Vitul Lieorungruang as a partial fulfillment of the requirements for the degree of Doctor of Philosophy in Architectural Heritage Management and Tourism

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VITUL LIEORUNGRUANG: LANNA ARCHITECTURAL CONSERVATION: GUIDELINES FOR HISTORIC BUILDINGS IN NORTHERN THAILAND. THESIS ADVISOR: PROF. WILLIAM R. CHAPMAN, Ph.D. 156 pp.

Architectural heritage conservation is universally accepted as an essential issue for people of every nation, culture and sub area. The diversity in architectural conservation, context and identity has resulted in philosophy and practice whose conservation techniques are employed to repair, preserve, but sometimes continue destruction of valuable works. Like in Northern Thailand, destruction occurs to architectural heritage as inappropriate methods and materials have been used because conservation focuses on the psychological and merits to protect their heritage rather than the disciplines of the physical fabric. Hence, this study is to focus on architectural conservation guidelines for historic buildings in the issues of investigation, materials, structural systems, and treatment, that are essential steps for conservation practice appropriateness for conservators, architects, building managers and owners as follows: a.) original and substitute techniques and materials; b.) pathologies and corrective interventions; c.) conventional threats to historic buildings; d.) adaptation of historic buildings to contemporary uses; e.) building maintenance plan; f.) preparing for a budget; g.) documentation for conservation projects; and h.) conservation policy. To revitalize deteriorated structures and the living heritage, whereby local people can make use of it and appreciate their identity, the suggested conservation practice can be adopted as one crucial way to prevent both the heritage value and the local wisdom from vanishing from the Lanna landscape.

Program of Architectural Heritage Management and Tourism   Graduate School, Silpakorn University   Academic Year 2008

Student's signature ....

Thesis Advisor's signature ....

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There were many questions about architectural conservation have considered since I started my career as a lecturer at Chiang Mai University in 1997. I became involved in conservation projects by my assigned duty, profession, own interest and curiosity. But many opportunities were offered to me from Professor Dr. Chulatat Kitibutr, Professor Vithi Panichpatra, and my colleagues from the Faculty of Architecture and Faculty of Fine Arts. There were and there are many cases of heritage buildings in Lanna appear to my profession with the involvement of many people; I would like to thank them all as they prioritized my full attention to the area of conservation.

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Chapter 1

Introduction

1. Background

Architectural heritage conservation is universally accepted as an essential issue for people of every nation, culture and sub area. The diversity in architectural conservation, including the context and identity, has resulted in diversity in both philosophy and practice. The western conservation process tend to focus on the physical aspects, and generally overlooks the cultural aspects, while some local Thai communities look carefully at the psychological needs as well as merit making, to protect their heritage rather than the disciplines of the physical fabric. Cultural background and practices in architecture provide direction for suitable conservation methods. In a knowledge-based society, conservators can discover and acquire a noteworthy array of information about conservation works for historic buildings.

In general, conservation techniques are employed to repair and preserve, but sometimes they may also contribute to the destruction of valuable works. Destruction occurs when inappropriate methods and materials are used. There are many reasons why an extensive review of the architectural conservation issues should be undertaken. This study focuses on the traditional wooden and masonry structures which dominate the south-east Asian cultural landscape and, in particular, the Lanna landscape. They are the bearers of immense values such as local innovation, creativity and inventiveness. They embrace the aesthetic and technological specialties, as well. Furthermore, an enormous number of historic buildings still perform very well and a vast number still require urgent and appropriate conservation.

While the principles that guide repairs vary among different cultures, the practices of repairs, replacement, restoration or substitution are common, especially in the areas where wood and brick, along with their craftsmanship are still readily available. But which process is suitable for each culture and reason is the key question—the conservation methods should be carefully adapted to suit the culture, identity and temperament of the target place.

This study investigates the architectural conservation environments of historic buildings in Northern Thailand, which are mostly wooden and masonry buildings. The study includes an approach for psychological and practical guidelines, which include principles and theories of conservation, organizations, management and controls for both sub-area and international inquiry. The study provides an inspection on ways to carry out conservation projects, how to complete the works on heritage places, the classification and degree of intervention, and the historic building type and number in each province. The study poses questions for investigation on common building problems prior to pointing in any direction and before the conservation project starts. The study includes an assessment of the building materials, specimen documentation, their limitations and weaknesses, and original bases. The study also provides an examination of the structure of certain systems, including their characteristics and typical forms of degradation. In addition, an examination for building treatment, restoration, security evaluation, propping or supporting, repairing techniques, dimensioning of consolidation devices and other relevant aspects are provided.

The proper architectural conservation of historic buildings in Northern Thailand will provide many benefits, including saving important heritage properties from demolition, assuring compatible new repairs, and making the correct selections of new materials and procedures for maintenance. This study provides concentrated guidelines for architectural heritage management in the Northern area. Moreover, as historic buildings provide the most important visual identity of the region, special consideration should be given to the conservation of these important markers of Lanna culture in the rich and diverse Thai cultural landscapes.

2. Goals and objectives

This study aims to:

a. Demonstrate substantial architectural heritage conservation philosophy and architectural conservation guidelines for historic buildings in Northern Thailand;

b. Examine the building materials, building systems and treatment, practice appropriateness, and maintenance of historic buildings; and

c. Provide a model document of a historic conservation manual for owners and managers.

3. Hypothesis

Architectural conservation of Lanna historic buildings in Northern Thailand provides evidences of the continuum of change with forward movement on knowledge and identity. The conservation methods can be temporarily stopped in preservation; moved forward to rehabilitation; moved backward to restoration; or reconstruction can be restarted. It is all about time that constitutes the philosophical framework and the guidelines for appropriate conservation treatments.

4. Scope of the study

This study investigates the background of conservation practices and applications specifically of the Lanna buildings in the upper northern region of Thailand, covering eight provinces: Chiang Mai, Chiang Rai, Lumphun, Lumpang, Payao, Prae, Nan, and Mae Hong Son. The study is related specifically to:

d. Historic buildings as nonresidential and residential including local government-owned and privately-owned historic buildings, religious buildings or temples, houses, and shophouses;

e. Buildings of at least 50 years old which qualify as historic places.

5. Research methodology

a. Documentary research
b. Physical investigation of selected places
c. Data gathering from oral sources and by questionnaire
d. Analysis and review of data

Chapter 2

Literature review

Since the second half of the twentieth century, conservation has grown to become generally accepted worldwide. The many facets of the world's heritage, together with the diversity of cultural conventions, have resulted in conservation philosophy and practice becoming a discipline of complexity. Beginning primarily as a Western phenomenon, architects have focused on the physical aspects of conservation, but have generally overlooked the discipline's *vital raison d'etre*, the cultural aspects. Often taken for granted, cultural traditions and practices that influence the form of the architecture provide clues not only to the understanding of the culture itself, but more importantly, to the direction for appropriate conservation practice. Not negating the many varied and compelling reasons for conservation, this study approaches the philosophy, both Western (European) in contrast to the oriental or Eastern counterpart, and the relationship to conservation within a cultural context. One compelling argument for this approach is that of the significance of cultural identity.

1. The architectural heritage conservation philosophy

The concept of "a universal heritage" which was gradually developed during the eighteenth and nineteenth centuries was eventually to reach a formal expression in international agreements and conventions. In the eighteenth century, Emmerich de Vattel (1714-67), a Swiss jurist, in *Le Droit Des Gens* ("The Law of Nations or the Principles of Natural Law", 1758 http://www.lonang.com/exlibris/vattel/) stated on Book I: Of Nations Considered in Themselves, Book II: Of a Nation Considered in Her Relation to Other States, Book III: Of War, touched on the question of works of art, i.e. public, common, and private property being the common heritage of mankind, and the consequences of this concept in conservation.

a. The western (European) architectural heritage conservation philosophy

The study's approach to the Western European philosophy in conservation, Jukka Jokilehto's "History of Architectural Conservation," has been known to several generations of ICCROM's Architectural Conservation Course participants. They are familiar with it as the author's D.Phil. thesis, "A History of Architectural Conservation: the Contribution of English, French, German and Italian Thought towards an International Approach to the Conservation of Cultural Property," since its presentation to the Institute of Advanced Architectural Studies at the University of York, UK in 1986.

Elena Charola and Fernando M. A. Henriques summarized in the Journal of the American Institute for Conservation, vol. 40, n. 2, 2001, on Jukka Jokilehto, “A History of Architectural Conservation”, 1999, that even though the material was rearranged to present it in a slightly different manner with some newly added information, the main features and the large majority of examples included in the thesis were kept in the original order. This indicates that they were written for an academic purpose, a clearly noticeable fact that becomes evident in the singular way some chapters of the book are presented. This purpose indelibly marks the style adopted throughout the text (http://www.dec.fct.unl.pt/seccoes/smtc/pub14.pdf).

Jokilehto's book is definitely not to be taken lightly as it provides a solid foundation to the discipline. The breadth of this enterprise is given in the foreword by P. Philippot, "*The modern concept of restoration . . . was shaped in the eighteenth century with the development of Western historical thought*" but emphasizing that "*the first decisive step towards a specifically European form or relation to the past occurred in Italy, when Renaissance humanism recognized in antiquity ... a historic epoch of the past*." The chapters in the book are organized in chronological order, though a chronological approach is difficult when trying to address the history of architectural conservation in various parts and countries of Europe, where different though similar processes took place in what can be called a staggered manner. The difficulty is even greater when trying to assign a specific date to thoughts and concepts that evolved over time. Although, in many cases, the original concept can be traced to its author, in other cases when thoughts become common knowledge, the best speaker or writer will be recognized as the author, even though his or her function was merely that of promulgating these ideas (Jokilehto 1986, p.217).

The amount of information provided by the author in Jokilehto’s book - as in his dissertation - is remarkable, constituting a fundamental tool to all those willing to achieve a better understanding of both past conservation tendencies and present-day movements. The analysis of past interventions - and particularly the reasons that led to the specific solutions adopted - cannot be accomplished without the help of a sound, historical and theoretical background. The same applies to understanding current theoretical approaches that are obviously based on historical background. The book is outstanding and constitutes a fundamental landmark for an in-depth view of conservation concepts.

The collection of information is also remarkable, however some of the comments included are sometimes peculiar (Jokilehto, p.217), such as when Jokilehto, referring to the work of Alois Riegl (*Der Modern Denkrualkultus: Sin Wesen und Seirte Entstehung*, 1903), states, “*Riegl had conceived his theory in a very abstract and condensed form and it is not necessarily easy to translate*.” This statement is certainly at odds with the statement by Françoise Choay in the preface to the French translation (*Le culte moderne des monuments: son essence et sa genese*) of Riegl's book: *“unique in its kind since its appearance, the text is unmatched until today,”* and *“his position as an observer is neither that of an architect ... integrating the historic monument concept in the theory of their discipline, nor that of an homme de lettres who made of architectural heritage the subject of a* *passionate crusade. In favor of this distance he could, for the first time, perform the inventory of the non-referred values and the non-explicit meanings subjacent to the concept of historic monument."* And, concluding, "Riegl's book should be an obligatory reading for all those involved in architectural conservation". It should be remembered that one of Riegl's main achievements was to be able to express his ideas in such a concise and clear form that even 100 years later they keep all their strength and brightness. A similar statement was made by Ernst Bacher in the introduction to the book of Riegl's writings he edited (*Kunstwerk oder Denkmal? Alois Riegls Schrfiten zur Denkmalpflege*, 1995).

Jokilehto's book, awaited for more than a decade by all those involved in the theory of conservation, is finally available to reach a wide audience and to provide a considerable amount of essential information that would otherwise be hard to obtain. "*One cannot understand modern humankind without the background knowledge of history"* (Charola and Henriques, 2001). The same applies to conservation: history of conservation is fundamental to the correct interpretation of present-day international conservation approaches. Within this context, the book is unique. No work is ever perfect and, certainly, this one by Jokilehto is no exception to this rule. Yet, if taken in the above context, it is worth its (high) price because it is a landmark in modern conservation efforts (Charola and Henriques, http://www.dec.fct.unl.pt/seccoes/smtc/ pub14.pdf).

b. Charters on architectural heritage conservation

Both the Venice Charter, (1964) and Burra Charter, (1999) being the most recognized conservation instruments, are pitched at monuments. They critique the widely held assumption that these charters apply to a certain area and are limited to individual buildings. Raymond Lemaire, founder and former president of ICOMOS, *rapporteur* for the committee that prepared the Venice Charter stated that *"the Charter was never intended as a dogma; the intention was rather to provide some basic principles which could be interpreted and even changed if time and circumstances showed the necessity for this", an important and "politically incorrect" statement in these days when the charter has assumed a taboo position, in spite of being "used to justify all applications,"* (Jokilehto1986, p.289).

The international charter for the conservation and restoration of monuments and sites, the Venice Charter, 2nd International congress of Architects and Technicians of Historic Monument, Venice, 1964 stated that, imbued with a message from the past, the historic monuments of generations of people remain to the present day as living witnesses of their age-old traditions. People are becoming more and more conscious of the unity of human values and regard ancient monuments as a common heritage. The common responsibility to safeguard them for future generations is recognized. It is our duty to hand them on the full richness of their authenticity. It is essential that the principles guiding the preservation and restoration of ancient buildings should be agreed upon and laid down on an international basis, with each country being responsible for applying the plan within the framework of its own culture and traditions.

The International Council on Monuments and Sites (ICOMOS) has its jargon or shorthand language for describing what it does. Most of the terms are listed and defined in the Burra Charter as prepared by Australia ICOMOS, the Australian membership organization for heritage professionals. A few definitions from the Charter include:

Conservation means all the processes of looking after a place so as to retain its cultural significance. It includes maintenance and may according to circumstances include preservation, restoration, reconstruction and adaptation and will commonly be a combination of more than one of these.

Place means a site, area, building or other work, group of buildings or other works, together with associated contents and surroundings.

Cultural significance means aesthetic, historic, scientific or social value for past, present or future generations.

Maintenance means the continuous protective care of the fabric, contents and setting of the place, and is to be distinguished from repair. Repair involves restoration or reconstruction and it should be treated accordingly.

Preservation means maintaining the fabric of a place in its existing state and retarding deterioration.

Restoration means returning the existing fabric of a place to a known earlier state by removing accretions or reassembling an existing component without the introduction of new material.

Reconstruction means returning a place as nearly as possible to a known earlier state and is distinguished by the introduction of materials (new or old) into the fabric. This is not to be confused with either recreation or conjectural reconstruction, which are outside the scope of the Charter.

Adaptation means modifying a place to suit proposed compatible uses.

Conservation can also be defined as preservation from loss, depletion, waste, or harm. From its early beginnings, which included the controversial “restorations” of great historic buildings which so outraged John Ruskin in the nineteenth century, the field expanded to encompass the more scientific preservation of a heritage of great and small older buildings for the use and enjoyment of our own and future generations (Weaver 1993, p.1).

The period since the Second World War has seen not only a rapid development of the technology of conservation but also a matching development of the philosophy and ethics of conservation. In the same period, the term “conservation” has been adopted to refer specifically to the professional use of a combination of science, art, craft, and technology as a preservation tool. The conservation of historic buildings or buildings of heritage value has thus developed into an extremely complex process involving a team of many professionals, specialists, trades, and crafts-workers (Weaver, p.1).

Conservation processes are continuously threatened by the infatuation of our society with the latest products and mysteries of science and technology. All too often it is discovered that physical and chemical changes in the latest "wonder" products have seriously and adversely affected historic building materials to which they have been applied in the name of preservation! Once the original materials have been thus treated and damaged the processes are found to be irreversible and the products can not be removed without destroying the very resource which was to be preserved. To guard against the harmful consequences of insufficient knowledge leading to misuse of technology and ill-considered actions, professional conservators have adopted codes of ethics and guidelines which are in themselves a mark of the growing maturity of their profession. The following guidelines are significant in this context:

… The conservator shall endeavour to use only technique and materials which, to the best of current knowledge, will not endanger the cultural and physical integrity of the cultural property. Ideally, these techniques and materials should not impede future treatment or examination. Whenever possible, the conservator shall select the techniques which have the least adverse effect on the cultural property. Similarly, the conservator shall use materials which can be removed most easily and completely (International Institute for Conservation-Canadian Group1989, p.7).

The conservation process is divided into many distinct phases beginning with a phase in which the initial decision is made to conserve the building or resource and "a conservation dossier" is created. The continuously documented process then moves through phases of research, analysis and design to physical conservation measures and ultimately to continuing conservation or maintenance. It can readily be appreciated that such a process is cyclical in nature. It does not really matter whether we use precisely this process or some variation. It is imperative, however, that the process is organized and carefully managed so that all relevant disciplines, skills, and individuals are involved at every appropriate stage (Weaver, p.1).

Each action involving a physical intervention on the resource or a commitment to such an intervention must first be carefully considered and tested against the highest professional and technical standards before the actual intervention takes place. Permanent records must remain of the states of the resource before and after conservation; and of the reasons for the decisions (Weaver, p.1).

c. The Thai architectural heritage conservation philosophy

The philosophy of Thai thinkers is like most of that in the oriental arts, it differs greatly from Western philosophy. The processes of thinking in an oriental and occidental manner are different, but can lead to the same result or answer. The philosopher or thinker of the Eastern influence does not follow steps when thinking, but instead uses the intuition a great deal, and this can be unacceptable for the Western philosophers as it seems too abstract. This can be compared to the creation of piece of art. For example, the Chinese artist does not copy what he is seeing, but creates the work from what he feels is impressive, without any model to follow.

Table 1: Comparison of Western and Eastern conservation concepts

Western	**Eastern**
Analytic	Intuition
Portrait	Symbol, abstract
Mimesis	Beliefs and religion
Rules	Skills
Permanence	Aesthetic
Based on the previous model	Inheritance of beliefs
Palaces and monasteries	Palaces and monasteries
Funds and associations focus on participation	Governmental organizations, not much participation

The Thai view emphasizes *"boon,"* that both the conservation and creation of artworks are for the next life and are considered to be a donation. This reflects the conservation that things do not last permanently; they can be changed and ceased, like what is taught in the Buddhism precepts. However, a more westernized philosophy has come and been accepted since the reign of King Rama IV, along with new examples from the Westerners who come to Thailand (Suksawas 1996, p.10-11).

2. The architectural heritage conservation organization

Internationally, conservation organizations started at palaces and monasteries along with the support of donor funds, private organizations, local organizations, and associations together with public participation. In Thailand, governmental member organizations play important roles, along with non-governmental organizations, civic and amenity societies. However, people cannot participate very much. In Thailand, like many other countries, international organizations take part in the conservation of architectural heritage, for example.

a. International Council on Monuments and Sites (ICOMOS)

ICOMOS is an international non-governmental organization of professionals, dedicated to the conservation of the world's historic monuments and sites. *L'ICOMOS est une organisation non-gouvernementale internationale de professionnels, qui oeuvre à la conservation des monuments et des sites historiques dans le monde.* ICOMOS works for the conservation and protection of cultural heritage places. It is the only global non-government organization of its kind, which is dedicated to promoting the application of theory, methodology, and scientific techniques to the conservation of the architectural and archaeological heritage. Its work is based on the principles enshrined in the 1964 International Charter for the Conservation and Restoration of Monuments and Sites (the Venice Charter). ICOMOS is a network of experts that benefits from the interdisciplinary exchange of its members, among which are architects, historians, archaeologists, art historians, geographers, anthropologists, engineers and town planners. The members of ICOMOS contribute to improving the preservation of heritage, and the standards and the techniques for each type of cultural heritage property: buildings, historic cities, cultural landscapes and archaeological sites.

ICOMOS National Committees are organizations that are created at the national level in countries which are members of UNESCO. They bring together individual and institutional members and offer them a framework for discussion and an exchange of information. ICOMOS currently has over 110 National Committees. Each National Committee adopts its own rules of procedure and elaborates its own program according to the goals and aims of ICOMOS. Each Committee implements the programs proposed by the Advisory and Executive Committees of ICOMOS. ICOMOS roles are as follows:

- to bring together conservation specialists from all over the world and serve as a forum for professional dialogue and exchange;
- to collect, evaluate and disseminate information on conservation principles, techniques and policies;
- to co-operate with national and international authorities on the establishment of documentation centers specializing in conservation;
- to work for the adoption and implementation of international conventions on the conservation and enhancement of architectural heritage;
- to participate in the organization of training programmes for conservation specialists on a world-wide scale;
- to put the expertise of highly qualified professionals and specialists at the service of the international community.

ICOMOS provides information for architectural heritage conservation, along with preparing International Charters for conservation and restoration, and other documents and guidelines such as:

- International Charter for the Conservation and Restoration of Monuments and Sites (Venice Charter 1964)
- Historic Gardens (Florence Charter 1981)
- Charter for the Conservation of Historic Towns and Urban Areas (Washington Charter 1987)
- Charter for the Protection and Management of the Archaeological Heritage (1990)
- Charter on the Protection and Management of Underwater Cultural Heritage (1996)

- International Cultural Tourism Charter (1999)
- Charter on the Built Vernacular Heritage (1999)
- Principles for the Preservation of Historic Timber Structures (1999)
- ICOMOS Charter – Principles for the analysis, conservation and structural restoration of architectural heritage (2003)
- ICOMOS Principles for the preservation and conservation/restoration of wall paintings (2003)

Other documents include:

- Guidelines on Education and Training in the Conservation of Monuments, Ensembles and Sites (1993)
- Nara Document on Authenticity (1994)
- Principles for the Recording of Monuments, Groups of Buildings and Sites (1996)
- Stockholm Declaration (1998)
- ICOMOS International Scientific Committee for Analysis and Restoration of Structures of Architectural Heritage (ISCARSAH)

And others in wooden architecture and vernacular architecture include:

- WOOD. International Scientific Committee on Wood. Colombo: ICOMOS, 1993
- Vernacular Architecture. International Scientific Committee on Vernacular Architecture. Colombo: ICOMOS, 1993

The 110 National Committees are from different countries which have adopted their own rules of procedure and established their own programs according to the goals and aims of ICOMOS. One such important committee is the Australia ICOMOS which has prepared and provided useful information for conservation (http://www.icomos.org/australia/) as follows:

- The Australia ICOMOS Charter for Places of Cultural Significance (Burra Charter) Australia ICOMOS, Canberra, 1999,
- Australia ICOMOS, Conservation Guidelines for Building Surveyors 2002
- Australia ICOMOS, Principles for the Preservation of Historic Timber Structures 1999
- UNESCO, Towards the Preparation of the Hoi An Protocols for Best Conservation Practice in Asia, Draft professional guidelines for assuring and preserving the authenticity of heritage sites in the context of the cultures of Asia. November 2003 Draft
- Principles for the Conservation of Heritage Sites in China, English-language translation, with Chinese text, of the document issued by China ICOMOS, edited by Neville Agnew and Martha Demas

b. The International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM)

ICCROM is an intergovernmental organization (IGO) dedicated to the conservation of cultural heritage. It exists to serve the international community as represented by its Member States, which currently number more than 110. It is the only institution of its kind with a worldwide mandate to promote the conservation of all types of cultural heritage, both movable and immovable. The decision to found the International Centre for the Study of the Preservation and Restoration of Cultural Property was made at the 9th UNESCO General Conference in New Delhi in 1956, at a time of mounting interest in the protection and preservation of cultural heritage. It was subsequently established in Rome in 1959 at the invitation of the Government of Italy. ICCROM aims at improving the quality of conservation practice as well as raising awareness about the importance of preserving cultural heritage. ICCROM contributes to preserving cultural heritage in the world today and for the future through five main areas of activity: Training, Information, Research, Cooperation and Advocacy (http://www.iccrom.org/eng/00about_en/00_00whats_en.shtml). ICCROM provides E-docs on http://www.iccrom.org/eng/02info_en/02_04pdf-pubs_en.shtml for architectural conservation including:

- A Laboratory Manual for Architectural Conservators, Jeanne Marie Teutonico, ICCROM, Italy, 1988
- Crafts and Conservation: Synthesis Report for ICCROM, Lucy Donkin, 2001
- Standards in Preventive Conservation: Meanings and Applications, Rebeca Alcántara, 2002. ICCROM. Report
- Teamwork for Preventive Conservation, Neal Putt and Sarah Slade, 2003. ICCROM. Manual

c. National Trust UK

The National Trust was first founded in 1895 in the UK to conserve its cultural heritage. The National Trust is a charity and is completely independent of the government. It relies for income on membership fees, donations and legacies, and revenue raised by commercial operations. It now has 3.4 million members and 43,000 volunteers. More than 12 million people visit its pay for entry properties, while an estimated 50 million visit its open air properties. It protects and opens to the public over 300 historic houses and gardens and 49 industrial monuments and mills (http://www.nationaltrust.org.uk/main/w-trust/w-thecharity.htm).

d. The Society for the Protection of Ancient Buildings (SPAB)

The Society for the Protection of Ancient Buildings was founded by William Morris in 1877 to counteract the highly destructive 'restoration' of medieval buildings being practised by many Victorian architects. Today it is the largest, oldest and most technically expert national pressure group fighting to save old buildings from decay, demolition and damage (http://www.spab.org.uk).

e. The Association for Preservation Technology International (APT)

The Association for Preservation Technology International is a cross-disciplinary, membership organization dedicated to promoting the best technology for conserving historic structures and their settings. Membership in APT provides exceptional opportunities for networking and the exchange of ideas (http://www.apti.org).

f. Civic or Amenities Societies

State, county, and city organizations in the US, European countries and Australian states develop their societies based on architectural heritage conservation, guidelines and principles. For example:

- Heritage Council of Victoria, Heritage Victoria, Australia Heritage Victoria is the Victorian State Government's principal cultural heritage agency and it is part of the Department of Sustainability and Environment (http://www.heritage.vic.gov.au).
- Heritage Office, NSW, the Heritage Office, Department of Planning, a State government agency based in Parramatta, New South Wales, Australia (http://www.heritage.nsw.gov.au).
- City of Madison, Historic Preservation Commission complied with Design Criteria, preservation standard & guidelines for changes to designated properties. Madison's local preservation program is administered by the Madison Historic Preservation Commission (HPC), established in 1987. This dedicated volunteer board protects the community's wealth of historic resources, first listed in the National Register of Historic Places in 1974. Because of the work of the HPC, Madison also qualifies as a Certified Local Government (CLG) community (http://madison.townware.com).
- Environmental Policy and Planning Unit, Christchurch City Council issued their Heritage Conservation Policy - City of Christchurch
- Heritage Policy – Safeguarding the Built Heritage is a conservation plan by Scotland, UK

g. Conservation organizations in Thailand

The Fine Arts Department of the Ministry of Education is the main organization which takes care of and conserves pieces of art work and cultural heritage in Thailand. There are nine divisions for the office of the Fine Arts Department to be responsible for different regions in Thailand. For the Northern region, the 7th division at Nan province and the 8th division are responsible for archeological sites and the national museums at Chiang Mai province (http://203.153.176.79/th/index.php).

3. The architectural heritage conservation management and control

a. Architectural heritage conservation management and control abroad

The National Trust in the UK is a non-government organization which is active in the conservation of architectural heritage. In 1882, *the Ancient Monuments Act* was created to prepare the list and register about 12,000 sites which were built before 1714. There were about 700 sites which were under the control of the Department of Environment along with some which were managed by local organizations. However, the Department of Environment and the municipalities also funded or bought some sites to manage by themselves. In 1895, the National Trust was established due to the growth of industry which could affect the cultural heritage. The government supported the National Trust in some cases, for instance the assets belonging to the National trust were free from tax.

The National Trust was managed by the board which was made up of different organizations and associations which helped conserve the buildings and assets. If the assets can not be sold, the National Trust has to be responsible for them, and this requires a large amount of money for their maintenance. At present the National Trust does not accept donated assets unless the budget for their maintenance is also given. The National Trust allows people to rent their buildings or rent the lands for agriculture. However, in 1947 *the Town and Country Planning Act* was prepared due to the urban development which affected the environment, including the archeological sites and cultural heritage. This Act is the model for the urban law of Thailand as well. This Act took action for both the new buildings and the old listed buildings which were historically and architecturally valuable. The buildings included the magnificent buildings of great architects which symbolize different periods, including those which were specially designed for industry, craftsmanship and handicrafts, or those related to important people or events, and also the trains. At present, there are 120,000 sites with four different levels of significance.

In 1967, *the Civil Amenities Act* was created as the law for conservation areas like groups of buildings, sub districts, or ancient towns in the UK. *The Civil Amenities Act* was then implemented in many areas and managed by the local people, which is a strong point because an organization managed by the municipality may be stopped at any time such as when the municipal working staff are changed or moved to other cities (Suksawas 1996, p.15).

b. Architectural heritage conservation management and control in Thailand

In Thailand, there is not only the Fine Arts Department who plays important roles in conserving the cultural heritage, but also other organizations who work for this. For example:

- Governmental organizations

- The Fine Arts Department under the Ministry of Education was established during the reign of King Rama VI. This organization was designated to be responsible for the artworks, cultures, archeological sites, artifacts, and national museums of Thailand. There are acts and controls for the operations as listed below:

1. *Ancient Site Artifact, Piece of Art Work, and National Museum Act 1961*
2. *Ancient Site Artifact, Piece of Art Work, and National Museum Act 1961 (Revision 1987)*
3. *Revolutionary Council Declaration, Issue No.189, 1972*
4. *Revolutionary Council Declaration, Issue No. 308, on the Fine Arts Department 1972*
5. *The Fine Arts Department regulation on Benefit Management and Construction Control in the Ancient Sites of the Fine Arts Department 1992*

The Fine Arts Department under the Ministry of Education plays important roles in conserving the national heritage including those historical buildings in the Lanna region which are considered religious such as, the *wat* and its components, religious remnants and remains, as well as the city walls, moats, ancient sites and historic buildings, naturally historic sites and landscapes. There are two local offices in the Northern region, the 7^{th} division for Nan, Lampang, Payao, and Prae province, and the 8^{th} division for archeological sites and national museums in Chiang Mai, Chiang Rai, Lamphun, and Mae Hong Son. The offices take action for the historical buildings registered under the acts and controls for the operation made by the Fine Arts Department.

- The Religious Affairs Department under the Ministry of Education is also important for the conservation of arts, especially for those found in monasteries which are under the control of the head of the monks in each temple. This department has been established so as to conserve and protect the arts from being distorted by misunderstanding or ignorance. There are acts and controls for the operations as presented in the following:

1. *Clergy Act 1962*
2. *Clergy Declaration on the Control of Artifacts and Pieces of Art Works in Monasteries 1960*
3. *Ministerial Regulation, Issue No.2 1968, following the Clergy Act 1962*

The Religious Affairs Department under the Ministry of Education also plays an important role in the Lanna region since the majority of historical buildings here are considered religious buildings. The *Wat* or temples which can include both large and small scale buildings are arranged according to Buddhist architecture comprising a *vihara* (ordinary hall), *ubosottha* (assembly hall), library, *hor klong* or *hor rakhang* (drum tower or bell tower), *stupa* or *chedi*, and the *kuti* (monk's residences). The Lanna Buddhist architecture is made of different kinds of building materials.

None of the conservation projects in religious places or buildings are completely controlled by the Fine Arts Department, except those which are registered as a Royal *wat* or the province's most important monasteries, which get special care in conservation by the Fine Arts Department.

- The Department of Treasury under the Ministry of Finance is in charge of not only bank notes or coins, but also the conservation of the sites, such as moats, city walls, and ancient cities which are located in the area of the Treasury's land. There are acts and controls for the operation in the following:

1. *Treasury Land Act 1975*
2. *Ministerial Regulation 1976,* following *Treasury Land Act 1975*

- The Department of Public Works, Town and Country Planning under the Ministry of Interior is responsible for urban planning and can control conservation by specifying the areas that should be conserved, as well as controlling the buildings and structures. There are acts and controls for the operations in the following:

1. *Country Planning Act 1975*
2. *Country Planning Act (Revision 1992)*
3. *Construction Control Act 1979*
4. *Ministerial Regulation, Issue No.28 1991*
5. *Revolutionary Council Declaration, Issue No.295, on the Highway 1972*
6. *Code of Laws on Real Estate 1954*

- The National Environment Agency under the Ministry of Natural Resources and Environment controls not only the pollution in the environment, but also the cultural environment. The act which was created in 1987 provides important guidelines to conserve the cultural environment. There are acts and controls for the operations as listed below:

1. *Support and Maintenance of Environment Control (Revision 1978)*
2. *Art and Cultural Environment Conservation Guidelines 1987*

- Private organizations

- The Arts and Culture Conservation Board within the Association of Siamese Architects under the Royal Patronage protects, takes care of, and announces news about conservation from collected data. The Board focuses on the historic buildings reported on the list, together with giving awards for excellent architecture so as to promote and support conservation done by local authorities or their owners. Some of them are governmental offices which cannot be demolished, and some belong to the private sectors, in which case, the law cannot take any action. Their existing conditions and original patterns are partly preserved. Western conservation concepts are not adapted.

- The Society for the Conservation of National Treasure and Environment (SCONTE) announces and provides news and information for the study of art and culture conservation.

- The Special Project on Archaeology and Fine Arts (SPAFA) of the SEAMEO/UNESCO helps South East Asian countries with regional conservation and workshops.

- The National Committee of International Council on Monuments and Sites, ICOMOS Thailand, works with an advisory committee for the conservation of architectural and cultural heritage (http://www.icomosthai.org/).

- The Siamese Association, the oldest organization for the arts since the reign of King Rama VI, provides knowledge for the study of the arts.

There are other organizations who work for this field although they are not well-known, such as conservation clubs in schools, colleges, universities, and some organizations of the department which work for the conservation of each province (National Environment Agency 1987, p.51-56). Private collectors also work for conservation in each province on mostly unlisted historical buildings. For the historical buildings which have not yet been listed, many of them are worth being conserved. Most of them are owned by private sectors. These types of buildings, like historic houses, shophouses, as well as some religious buildings are scattered in every province. They tend to get demolished, repaired, or changed without the right manuals or guidelines. In such cases, their existing conditions and original patterns are only partly preserved. Western conservation concepts are not introduced or adapted. Sometimes, retrofitting is done so as to prolong their use. Governmental organizations cannot play a role in the conservation of these types of buildings.

To sum up, Thailand has no typical guidelines or principles for architectural heritage management or controls for each specific site. There are only regulations and acts which are under the control and support of both governmental and private organizations whose staff are skillful in the different aspects of conservation.

4. The architectural heritage conservation guidelines

Appropriate tools for architectural heritage conservation includes not only the laws or acts, but also the guidelines which have been developed in each area, by organizations who aim at conservation, such as those who work for palaces and monasteries, private trusts, and local organizations. Architectural conservation guidelines are generally intended for use by architects and building surveyors although they can be useful for anyone who deals with heritage buildings. The guidelines are intended to help architects, building surveyors and private certifiers make good decisions about heritage buildings and places, by highlighting commonly occurring problems and offering solutions that have been achieved in similar situations. Being aware of the heritage issues is the key to the solution of the problems. Most historical buildings are unable to comply with current building regulations. This does not necessarily mean that they are unsafe or unhealthy. In most cases, historic buildings can be upgraded to meet the intention of current building regulations. The challenge is to do this without losing the qualities which give the buildings their heritage significance (Australia ICOMOS Conservation Guidelines for Building Surveyors, 2002, p.5).

a. ICOMOS, International Scientific Committee for Analysis and Restoration of Structures of Architectural Heritage (ISCARSAH)

ISCARSAH has issued a document entitled, “Recommendations for Analysis, Conservation and Structural Restoration of Architectural Heritage (2003)” which can be divided into two parts. The recommendations are intended to be useful for all those involved in conservation and restoration problems, but are not meant in any way to replace specific knowledge acquired from cultural and scientific texts. The recommendations presented in the complete document are divided into two sections: 1) the principles, where the basic concepts of conservation are presented, and 2) the guidelines, where the rules and methodology that a designer should follow are discussed. A summery of both parts is presented below:

- ISCARSAH Part I – Principles: 1) General criteria; Conservation, reinforcement and restoration of architectural heritage require a multi-disciplinary approach. The value and authenticity of architectural heritage cannot be assessed by fixed criteria because the respect due to each culture requires that its physical heritage should be considered within the cultural context to which it belongs. 2) Research and diagnosis; Usually a multidisciplinary team, chosen in relation to the type and scale of the problem, should work together from the beginning – i.e. from the initial survey of the site and the preparation of the investigation programme. The structures have to be stabilized during excavation when knowledge is not yet complete. 3) Remedial measures and controls; Therapy should address root causes rather than symptoms. Adequate maintenance can limit or postpone the need for subsequent intervention. Safety evaluation and an understanding of the historical and cultural significance of the structure should be the basis for conservation and reinforcement measures. No actions should be undertaken without demonstrating that they are indispensable.
- ISCARSAH Part II – Guidelines: 1) General criteria; A combination of both scientific and cultural knowledge and experience is indispensable for the study of all architectural heritage. 2) Acquisition of Data: Information and Investigation: The investigation of the structure requires an interdisciplinary approach that goes beyond simple technical considerations because historical research can discover phenomena involving structural behaviour while historical questions may be answered by considering structural behaviour. Therefore, it is important that an investigating team be formed that incorporates a

range of skills appropriate to the characteristics of the building and which is directed by someone with adequate experience. 3) Historical, Structural and Architectural Investigations; Survey of the Structure, Field Research and Laboratory Testing, and Monitoring. Monitoring can also act as an alarm bell. As a general rule, the use of a monitoring system should be subjected to a cost-benefit analysis so that only data strictly necessary to reveal progressive phenomena are gathered.

b. Preservation Briefs: Technical Preservation Services (TPS)

There are a number of practical heritage conservation guidelines such as the “Preservation Briefs” which were issued by the U.S. Department of the Interior, National Park Service Cultural Resources – Heritage Preservation Service. They are useful to help home owners, preservation professionals, organizations, and government agencies preserve and protect the architectural heritage by providing readily available materials--guidance pamphlets and books, videos, and a Web home page on preserving, restoring, and rehabilitating historical buildings. “Technical Preservation Services (TPS)” is dedicated to the improvement of the quality of work on historical buildings by promoting their long-term preservation and fostering the responsible use of both traditional and innovative techniques in their care and maintenance. Buildings comprise more than 78,801 listings in the U.S. National Register of Historic Places, nearly 71% are historical buildings houses, schools, city halls, social halls, churches, libraries, courthouses, stores, barns, factories and mills, hotels, armories, and train depots. Historical buildings represent America's democratic, spiritual, and educational ideals, and also serve to document commercial success from over two centuries. Unfortunately, building materials (masonry, wood, and architectural metals) are all subject to damage, decay, and loss over time. With ongoing preservation, however, the historical buildings that define the neighborhoods, towns, and cities will survive for future generations to use and enjoy. Most federal and state government organizations and many local historical districts have adopted “The Secretary of the Interior's Standards for Rehabilitation” as developed from the “Technical Preservation Services”. They also utilize the guidance contained in the TPS publications, such as the “Preservation Briefs” series, on the treatment and care of historical properties (http://www.nps.gov/history/hps/tps/briefs/presbhom.htm).

TPS gives technical consultations provided for work involving many of the nation's most significant historical properties, including national historic landmarks, prominent federally-owned buildings; and state and privately-owned properties. The first “Preservation Brief” was published in 1975. Since then, over 40 have been added to the series. More than 2 million copies of the “Preservation Brief” are in print and 44 illustrated parts are integral to the list of titles given below:

01: Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings
02: Repointing Mortar Joints in Historic Masonry Buildings

03: Conserving Energy in Historic Buildings
04: Roofing for Historic Buildings
05: The Preservation of Historic Adobe Buildings
06: Dangers of Abrasive Cleaning to Historic Buildings
07: The Preservation of Historic Glazed Architectural Terra-Cotta
08: Aluminum and Vinyl Siding on Historic Buildings: The Appropriateness of Substitute Materials for Resurfacing Historic Wood Frame Buildings
09: The Repair of Historic Wooden Windows
10: Exterior Paint Problems on Historic Woodwork
11: Rehabilitating Historic Storefronts
12: The Preservation of Historic Pigmented Structural Glass (Vitrolite and Carrara Glass)
13: The Repair and Thermal Upgrading of Historic Steel Windows
14: New Exterior Additions to Historic Buildings: Preservation Concerns
15: Preservation of Historic Concrete: Problems and General Approaches
16: The Use of Substitute Materials on Historic Building Exteriors
17: Architectural Character - Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character
18: Rehabilitating Interiors in Historic Buildings - Identifying Character-Defining Elements
19: The Repair and Replacement of Historic Wooden Shingle Roofs
20: The Preservation of Historic Barns
21: Repairing Historic Flat Plaster - Walls and Ceilings
22: The Preservation and Repair of Historic Stucco
23: Preserving Historic Ornamental Plaster
24: Heating, Ventilating, and Cooling Historic Buildings: Problems and Recommended Approaches
25: The Preservation of Historic Signs
26: The Preservation and Repair of Historic Log Buildings
27: The Maintenance and Repair of Architectural Cast Iron
28: Painting Historic Interiors
29: The Repair, Replacement, and Maintenance of Historic Slate Roofs
30: The Preservation and Repair of Historic Clay Tile Roofs
31: Mothballing Historic Buildings
32: Making Historic Properties Accessible
33: The Preservation and Repair of Historic Stained and Leaded Glass
34: Applied Decoration for Historic Interiors: Preserving Historic Composition Ornament
35: Understanding Old Buildings: The Process of Architectural Investigation
36: Protecting Cultural Landscapes: Planning, Treatment and Management of Historic Landscapes
37: Appropriate Methods of Reducing Lead-Paint Hazards in Historic Housing
38: Removing Graffiti from Historic Masonry
39: Holding the Line: Controlling Unwanted Moisture in Historic Buildings
40: Preserving Historic Ceramic Tile Floors

41: The Seismic Retrofit of Historic Buildings: Keeping Preservation in the Forefront
42: The Maintenance, Repair and Replacement of Historic Cast Stone
43: The Preparation and Use of Historic Structure Reports
44: The Use of Awnings on Historic Buildings: Repair, Replacement and New Design (http://www.nps.gov/history/hps/tps/briefs/presbhom.htm)

c. The Madison Historic Preservation Manual: Madison Georgia

Many cities and regions have developed manual for conservation practice, as illustrated by the example of Madison. An excellent heritage conservation guideline book is, "The Madison Historic Preservation Manual, a Handbook for Owners and Residents," prepared by William Chapman of Athens Georgia, for the Madison Historic Preservation Commission and the City of Madison, Madison Georgia (1990). Madison is a unique city and one widely recognized for its outstanding historic architecture and its overall aesthetic and environmental qualities. First listed on the National Register of Historic Places in 1974 (with further expansion of the list in 1990), Madison stands as an unequaled reminder of the character and quality of 19th- and early 20th-century life in Georgia.

The city has recently been faced with a number of new threats to its longstanding character. In response, the mayor and city council in 1987 passed an ordinance establishing the Historic Preservation Commission. This Commission was charged with identifying historic properties and districts and it was recommended that they should be officially designated by the mayor and city council. In 1989, after scheduled public hearings and opportunities for comment by property owners and other interested citizens, the Commission made its first recommendation. Under the terms of the ordinance, all owners, residents, or business occupants of properties within the Madison Historic District are required to make an application to the Historic Preservation Commission prior to undertaking any major change to their property. Changes to building interiors or routine maintenance, such as repainting, roofing in a similar material, or repairs, do not require an application. All buildings, whether they are "historic" or "non-historic," are considered if they are part of the historic district. The Preservation Manual is designed to help owners or occupants of buildings within the historic district in making decisions about appropriate changes. It is meant to be as inclusive as possible and touches upon most of the issues facing owners and the Historic Preservation Commission, when considering changes to both historic and non-historic properties within the Historic District.

Madison's manual is divided into five chapters, each of which addresses issues and problems in a slightly different way. Chapter 1 is an overview of Madison's history, providing a general historical context for appreciating historic properties and assessing their relative significance. Chapter 2 is a geographical description of the town; it sets out the characteristics that distinguish the town as a whole today, such as street patterns, landscape treatments, street plantings, and even patterns of building types and materials. Chapter 3 is directed more specifically at owners. It attempts to introduce owners or occupants to ways they can better understand their own properties, as a basis for later decisions. Chapter 4 constitutes the actual "Guidelines". These include guidelines for new construction, guidelines for substantial changes to existing buildings, requirements to be considered for a demolition permit, and specific suggestions for elements such as fences, signs, or other changes. Finally, Chapter 5 is a set of recommendations for maintenance and ongoing care. While not addressed specifically by the ordinance, long-term maintenance is really the key to preservation. This last chapter is offered as a series of suggestions rather than as a set of requirements. The manual also includes a copy of the Madison Historic Preservation Commission Ordinance, as well as the by-laws of the Commission for the conduct of its meeting and for initiating designations. The list of properties and their designations, for example, as historic, non-historic, (less than 50 years old, but of distinguished character or quality), intrusions (properties that detract from the character of the historic district), or as empty lots (undeveloped property), are also appended. In addition, there is a copy of the Secretary of Interior's "Standards for Rehabilitation," a document that serves as overall guidance for the Commission's decisions and ties the Commission's choices to national standards. A bibliography and list of further readings, and an illustrated glossary can also be found. The manual serves as a useful aid in helping owners reach their own decisions about their properties. Neither the ordinance nor the Commission is concerned with "freezing" Madison in time. That the town will continue growing and changing and that owners or occupants will have their own changing needs and tastes goes without saying. The manual is a basic outline for understanding Madison's enduring qualities, and guidelines and suggestions for helping owners and occupants to contribute to the city's overall character.

d. The Conservation Guidelines for the Court Street Historic District, the City of Cincinnati.

“The Conservation Guidelines for the Court Street Historic District, the City of Cincinnati, Department of Buildings and Inspections,” is based on an analysis of each block in the district (http://www.cincinnati-oh.gov/cdap/downloads/cdap_pdf3683.pdf). The analysis shows that the buildings on Court Street shared certain architectural characteristics. These are noted in the analysis section of the guidelines and are intended to serve as a general guide to anyone contemplating changes to their property. Conservation guidelines are used by owners, architects, contractors and the City’s Historic Conservation Board (HCB) when owners in historic districts decide to make changes to the outside of their buildings. They are not rigid sets of rules, but rather a guide on how to make improvements in the district which are compatible with its character. Guidelines give building owners advice on how to undertake work in the district, and they give the Historic Conservation Board a way to determine whether proposed work is appropriate. The guidelines set broad parameters within which district changes should occur while maintaining ample opportunity for designing creativity and individual choices and tastes. If an improvement is proposed within the Historic District, a Certificate of Appropriateness (COA) must first be obtained from the Historic Conservation Board. This is in addition to a building permit though there is no additional fee. The following kinds of work do not require a COA:

- interior work such as plumbing, wiring, plastering; and
- ordinary repair and maintenance which does not result in an exterior change.

The following points are of extreme importance:

- The guidelines do not require that an owner make improvements.
- The guidelines do not force an owner to "take the property back to the way it was."
- The HCB may modify certain guidelines, as appropriate, in cases of economic hardship. The Board must approve the proposal, even if it does not meet the guidelines, when the owner demonstrates a) that there is no "economically feasible and prudent alternative" which would conform to the guidelines, and b) that strict application of the guidelines would deny the owner a reasonable rate of return on the property, and would amount to a "taking of the property without just compensation."
- The guidelines, and the legislation which set up the Board, are geared toward negotiating solutions which will give the owner substantial benefit without causing substantial harm to the district. The Board may grant approval, set conditions, or waive certain guidelines as "trade-offs" to aid negotiations.
- Any applicant who disagrees with a Board decision may appeal the decision to the city council. In the five years or so that the Board has reviewed proposals in historic districts all over the city, no one applicant has ever appealed. This indicates the overwhelming success of the negotiation process.

The Conservation Guidelines for the Court Street Historic District are composed of an introduction, analysis, rehabilitation and alteration, additions, new construction, site improvements, and demolition.

e. Guidelines for Conservation Rossland, British Columbia and other guidelines.

“Guidelines for the Conservation of Rossland, the City of Rossland, British Columbia, Canada,” provide unique guidelines for conservation which is unique. The city, first discovered by two prospectors from the nearby Dewdney Trail, is the site of the Le Roi mine which made the claim that started the gold rush in Rossland in 1890. It was sold to Colonel Topping in lieu of a $12.50 recording fee. He then turned around and sold it to a Spokane company for $30,000. They began to develop the mine and the town was born. In 1898 the Le Roi mine was sold to the British American Corporation for just over three million dollars. They recommended that the property owner gather as much information as possible regarding their property and proposal (e.g. legal description, drawings and surveys) and meet with City staff to discuss their proposal. Rossland's Heritage Development Guidelines are divided into

12 separate documents, which are: materials, windows, doors, porches, details, roofs, additions, new construction, site features, colour, signs, and the glossary.

At present, there are many websites which provide conservation guidelines, by both governmental and non-governmental organizations. Most are useful for the conservation architect, building contractor or planner, such as the Getty Conservation Institute (http://www.getty.edu/conservation/publications/pdf_publications), and the International Institute for Conservation -Canadian Group (http://www.cci-icc.gc.ca/publications/newsletters/news35/canada_e.aspx).

5. The architectural heritage in Northern Thailand

Geographically, northern Thailand may be divided into two parts: the lower north and the upper north. Of the two, the latter is culturally more distinct, whereas the lower north has an architecture and culture similar to that of its central region neighbors. The upper north, on the other hand, which includes the nine provinces of Tak, Lampang, Lamphun, Prae, Nan, Payao, Chiang Mai, Chiang Rai and Mae Hong Son, possesses a unique culture and architecture known as Lanna (Chaichongrak, et al. 2002, p 99). Some historical texts indentify eight provinces as being located in the Lanna region—Lampang, Lamphun, Prae, Nan, Payao, Chiang Mai, Chiang Rai and Mae Hong Son.

Within the Lanna cultural heritage group, the Lawa and the Mon were known as pioneers. Their stories have been handed down through legends and myths. The *Tai yuan*, or *khon muang* is the majority along with several minority groups, such as the Shan (also known as the *Tai yai*), found in Mae Hong Son, Chiang Mai, Chiang Rai, Lampang, and Tak, and the *Tai leu* (also known as the *Tai yong, Tai khoen*), of Nan, Payao, Prae, Chiang Rai and Chiang Mai. Historical studies indicate that the earliest center of Lanna culture was the thirteenth-century city of Yonok Chiang Saen, located in the northern part of Chiang Rai, Muang Hiran Ngoen Yang (Promsao, 1996, p.9). Lanna developed into a kingdom under Phaya Mengrai of Chiang Saen in the later part of that century. This mainstreams the spread of Lanna culture, the culture of the *Tai yuan*, or *khon muang,* from the early times of Chiang Saen, Chiang Rai, and Chiang Mai to many communities in the area due to voluntary and forced migration occasioned by war over many centuries.

The Shan had settled in present-day Mae Hong Son, specifically in the Mae Sariang and Pai areas, long before it became a province of Thailand. Some were refugees from wars in the Shan States of Burma and others came with British timber companies or as traders; The *Tai leu* are descendants of people who migrated from Chiang Rung in Sib Song Pan Na over the past few centuries (Chaichongrak, p. 99).

The area has also been settled by hill tribe minority groups—Hmong, Mien, Lahu, and Lisu who have migrated from the mountains of neighboring countries (Promsao, p.9). Because of the vast area of the northern regions, the population of many different tribes, variations of topography, climate and ways of life, northern vernacular architecture varies greatly in details. This is most apparent in the rural areas (Eiam-anant 1997, p.269).

a. Physical setting

Geographically, the northern region is a mountainous area situated several hundred meters above sea level; therefore, the climate is cool and rainy. The land in general is fertile. Wood, the most widely used material for structure, walls and shingle roof tiles, is abundant (Eiam-anant, p.269). The topography of Lanna is a mixture of mountain ranges, hills, valleys and plains. From the three major mountain ranges, the Daen Lao Mountain range, the north and west Thanon Thongchai Mountain range, and the Phi Pan Nam Mountain range, flow the main rivers of the north and central regions, the Ping, the Wang, the Yom, the Nan, the Yuam, the Pai and the Kok, and they are these rivers which have been at the heart of the agrarian society of Lanna.

As water is the most important factor for existence in an agricultural society, the selection of a site for permanent settlement is primarily based on the availability of a reliable water source and a fertile area suitable for planting, such as a river plain or valley (Chaichongrak, p.100).

It was, therefore, in such places that the ancient Lanna settlements were located. The geographical conditions also created a local agricultural technology: *the muang fai* (weir and channel irrigation systems) by which water from distant sources at higher elevations was brought to the lower-lying rice fields. An outstanding characteristic of these Lanna villages and houses is that they were situated in an extensive area of greenery which created a shady and tranquil atmosphere.

The physical pattern of the Lanna village, whether in a river plain, in a valley, or even on a hillside, was a cluster of houses sub-divided into smaller groups; each group consisted of houses close together sharing a small yard. The village had a main thoroughfare with paths leading to the particular groups of houses. It also had a square, an open area where the village pillar was enshrined. The fields of the villagers were in the same area. Surrounding the village, between the houses and the fields, was a community forest, *the pa phae* (Goat Forest), which served as a fire and wind break and a place where villagers could gather forest products. At the point between the village and the community forest was *the hor sua* (spirit house), which was believed to protect people in the village from evil and keep them in peace and happiness. Beyond the community forest was the village's main planting area. In those villages where the fields were far away, shelters were built in the rice fields for those who needed to stay over during certain phases in the rice growing cycle. Beyond the fields was *the pa ton nam* (headwater forest), which protected the source of the streams as well. People were aware of the importance of their headwater forests. They cut only the timber they needed for their houses, realizing that maintaining the local ecological system was vital for the survival of the community.

In each village, apart from the houses, there was a village pillar or the sacred and auspicious tree, the spirit house, the fields, the community forest and the headwater forest. The other essential element of Lanna culture was the monastery, temple or *wat.* The village monastery might have been located in the center of the village or it may have been on high land within convenient walking distance. One monastery was frequently shared by more than one village (Chaichongrak, p.105).

b. Communities

Generally, a settlement begins with a house and grows into a group of houses with the development of transportation, trade, and exchange. As the community expands, its appearance and form also change. Nowadays, Lanna communities, *Tai yuan*, Shan and *Tai leu*, can be classified according to their size and importance: 1) Urban communities are large towns and important centers such as Chiang Mai with extensive links to other urban towns. 2) Intermediate communities are midway between an urban and rural community and may be situated along main roads. 3) Rural communities are small villages remotely located from an urban city, where agriculture is the main occupation. This type of community has often preserved more of its local identity than those of the other two types and is thus a source of data about beliefs, religion, customs and traditional production.

Despite differences in scale, the three types share similar components including the community center and the same types of public buildings which make up the community and the house. The center of a typical urban community is a square where the city pillar or shrine is located. Nearby might stand the mansion of the governor, as well as an important monastery. There is also a large reservoir to store rainwater. Groups of buildings are located along the main road, and minor roads run from the main road to other building groups, some of these lanes curving with the topographical features of the area. Normally the spirit house of the village, which is believed to be the abode of ancestral spirits, is located at the edge the community. This shrine is generally a wooden house supported by six posts built in the shade of a large tree and surrounded by a boundary fence. Offerings are made on a regular base. In an urban community, apart from residential houses, there are houses which have been adapted to serve as shops and buildings constructed as shops.

The layout of a rural community is generally similar but on a smaller scale. There is an open square in the centre where the village pillar is enshrined and it is also where traditional ceremonies and public activities are held. There is a spirit house at the edge of the village and a small village monastery.

In order to appreciate Lanna architecture, the best sources are to be found in the monastery and the house. Typically, the house stands in its own yard. In the front, there is a spirit house. Near the house is a granary, pens and coops for animals, and storage sheds. Behind the house are the bathing area, a vegetable pot, and a shrine to the ancestral spirits. In the yard there will be one or more wells, depending on the owner's needs. Trees create an impression of coolness and tranquility (Chaichongrak, p.107). Lanna architecture comprises houses, dwellings of various types, shophouses, markets, factories, storage houses and public buildings for different activities i.e. *salas* (rest pavilions) *sala karn pariens* (preaching halls), *ubosathas* and *viharas*, etc (Eiam-anant, p.269).

The North is also home to many tribal people who retain their ways of life and culture. These are expressed in their tribal languages, costumes, culture, architecture, ceremonies and ways of living. Accordingly, the building of public places such as *salas, ubosotthas, viharas* and others differs depending on the topography, beliefs and preferences of each tribe. As for dwellings, the houses, storage houses, animal houses and barns are characterized according to each family's functional requirements, as well as to conform to each tribe's own way of living.

Architectural characteristics are generally observable from town planning and zoning, architectural styles, structures, decorative elements, landscaping and interior decorations. For northern vernacular architecture, zoning conforms to the sloped, mountainous land which requires a suitable irrigation system, such as dams which were made to transfer water for the community. Community and farmland locations are found both on slopes and flat lands. Architectural style of both residential and public buildings such as *ubosotthas, viharas*, and houses of merit-making are gabled with high pitch and low-sheltered eaves. The eaves are distinguishably long due to the cold, mountainous areas of the upper northern provinces and have less openings than solid walls. Decorative elements are simple; however, religious buildings are exceptionally well-decorated especially on roof, walls, and building bases (Eiam-anant, p.269).

Vernacular architecture and historic buildings in Lanna are collected and recorded by many scholars and professors in Thailand. They can be categorized as: Buddhist temples, houses, and shop houses. However, vernacular designs which are not permanent structures in the Lanna cultural groups, Lawa, Mon, *Tai yuan*, Shan (*Tai yai*), *Tai leu* (*Tai yong, Tai khoen*), and the hill tribe minority groups are not included in this literature review.

c. Buddhist temples

- Lanna temples: Buddhist temples in Lanna differ from those in Central Thailand in their sizes and proportions. The Lanna monasteries are much smaller and simpler. In addition to the *ubosatha* (assembly hall) and the *vihara* (preaching hall) that have walls, there are also open *viharas,* which are unique.

The floor plan of the *ubosatha* and *vihara* adds gentleness to the form, and is echoed in the roof and its multiple layers. A fine example of a *vihara* with four walls of brick and mortar is *vihara* Lai Kham in *Wat* Phrasingh in Chiang Mai province. Another beautiful *vihara*, with wooden walls, is that of *Wat* Prasat, located near *Wat* Phrasingh. Fine examples of open *viharas* are the *vihara* Nam Taem at

Wat Phra That Lampang Luang and the *vihara* Chamadevi at *Wat* Pong Yang Kok, both in Ko Kha district of Lampang province.

The sizes and proportions of most Lanna *viharas* and *ubosottha*s are on a very human scale. Their architectural decoration, found on the corner pieces, the tops of posts, and the pediments, are mostly in beautifully carved wood. In urban monasteries, the carved wood may be gilded and decorated with glass mosaic in the Lanna style, while at rural monasteries, the carving depends on the skill of the artisans, and designs generally differ from one locality to another (Chaichongrak, p.110).

The sizes and proportions of most Lanna *viharas* and *ubosathas* also slightly differ from province to province. This we call "local-craftsmanship distinctiveness" or *sakol chang,* but mostly they rely upon the same philosophy, beliefs and physical layout.

- Shan Temples: The outstanding architectural characteristic of Shan temples is their multi-tiered roofs. Those with double surmounted roofs, each with a triple-layered roof are called *chettabun* and those with triple surmounted roofs, each with a four-layered roof, are called *yon saek*. For very important edifices in which a presiding Buddha image is enshrined, the roof is of three, five, seven, or nine layers. Delicate roof decorations add grandeur to the architecture. Originally, the eaves, the pediments, and the roofs were decorated with wooden fretwork; more recently, a zinc-tin alloy has been used.

Monastery structures generally include the *ubosottha,* the *chedi*, and the *vihara,* although some monasteries do not have an *ubosottha* and, accordingly, the ordination of monks would not be possible there. The *vihara* can have many functions. Usually, it is used as a preaching hall, but it may also be partially partitioned to provide space for a museum, the *kuti* (living quarters for monks), or a Buddhist school. Most are rectangular in plan and are generally left open and screened off only in those areas where privacy and security are needed, such as for museums or monks living quarters. The floor is divided into different levels reflecting the varying functions, with the highest level, being reserved for the presiding Buddha image and being adorned with various decorative designs. The impressively painted columns in a Shan *vihara* also serve to demarcate certain areas (Chaichongrak, p.114).

Figure 1 & 2:

Lanna temples: *vihara in Wat* Buparam (left) and *vihara in Wat* Pan Tao in Chiang Mai (right) (taken by Vitul L., 14/3/02 & 16/3/02)

d. The houses

Lanna houses can be divided into two types of construction materials. The division is based on the physical appearance of the house as well as the materials: the *reun mai ching* (the hardwood house, or the *ruen krueng sab*) and the *ruen mai bua* (the bamboo house, or the *ruen krueng pook*), (Chaichongrak, p.118).

The Lanna house can also be divided into specific types for each minority group. They demonstrate different planning and construction techniques i.e. *Tai lue* house, Shan house, and *Tai yong* house. The house can also be divided depending on the status of the owner, for example, some belong to the community's leading citizens, the noble and the governor. This type is distinguished by its fine craftsmanship and most noticeable by style and decoration for example the *ruen kalae* and the *khum* (the residence complex of northern kings and royal families).

Some definitions follow:

- The *ruen kalae*: which have elegantly carved wooden decorations at the gable top. For the most part, it is a twin house, the smallest type having one bedroom in each part. There are two basic floor plans which differ in the location of the staircase: in one, the staircase is parallel to and against the front of the house and is covered by the roof; in the other, the staircase is at right angles to the house platform. The area in the big twin house is used for sleeping, separated by a corridor connecting the front part of the house to the back called a '*chan hom*'. The front part of the sleeping room is a guest hall called *toen*, which is behind the front platform where there is a water shelf and a staircase. The back of the house comprises the kitchen, the back platform, the water shelf and the back staircase. The planning of the front part is similar to the twin gabled house. The *ruen kalae* has long roof eaves, walls slightly sloping outward at the top, and minimal openings. The structure is wood with wooden walls, roofing materials are wooden tiles or thatch, jointing is done with wooden dowels and interlocking joints, therefore, skilled carpenters or craftsmen are required for building. The *ruen kalae* is a characteristic of the houses in Chiang Mai, Lampoon and those mostly belonging to wealthy people such as the royal families of the North, the governors or landlords.
- The more modest type of *ruen mai ching*, which may be either a single or twin house, has no *kalae*. These houses, owned by ordinary people, are influenced by the *kalae* house. The Gabled House (*Tai lue* house) is comprised of one house built on high stilts for dwelling and another storage house built on high stilts with solid walls. The area under the house is used for buffalo stables and storage for agricultural tools. Both houses are gabled with long eaves extended to cover the cooking house (kitchen or *ruen khrua*). Roofs are covered with single wooden tiles (*pan kled*), or for some houses they were exchanged for

corrugated zinc sheets. Walls are generally solid with minimal openings. The front part of the house is open for good ventilation making it suitable for the hot climate. This front hall is a multi-purpose area for receiving guests, family living, dining, and can be adapted as a guest sleeping area. Adjacent to this area is a Buddha shelf which is intended to be seen by visitors. This Buddha shelf is made by extending part of the wall into a niche, which is a special characteristic of this type of house. Near the front hall in some houses, there is a terrace called a *"chan"* extending to the eaves, which is used for airing the agricultural produce such as garlic and nuts. The kitchen house is beside the front hall with the exposed front platform. A small part at the side is a shelf for water containers, the small earthenware jars or the decanters to keep drinking water, and there is always a long bench in this area for resting and greeting passers-by. Around this platform are placed plants and flower containers and on one side is the staircase. The house always has bamboo grid fences or hedges in between the house and the road. This type of house belongs to the upper northern provinces i.e. Mae Hong Son, Chiang Rai, Phayao, etc.


Figure 3 & 4:

Ruen kalae at Chiang Mai Cultural Center, Chiang Mai University (left) and gingerbread house at Soi Wiang Beao in Chiang Mai (right) (taken by Vitul L., 10/4/02 & 11/4/02)

- The Shan House is often identified as the Lanna house because it looks similar to the Gabled House (*Tai lue* house). Both are wooden framed houses raised high off the ground with rather low eaves. However, the Shan house in the north of Thailand is in fact significantly different from the *ruen mai ching* or *ruen kalae*, especially with regard to the roof, which has many levels and extended eaves on all sides. The plan of the Shan homestead is of two types: a single house standing in a yard of 1,600-2,400 square meters enclosed by a fence, or a cluster of two or three, or perhaps four of five houses in one yard. The former type belongs to a family of means who have been settled for two or three generations. The latter belongs to families that have settled more recently, when less land was available. There may be a large house shared by a big family or many houses. Some houses have separate granaries, while others have a granary at the rear of the house protected by the extended rear eaves. This type of granary is just a very large “basket” that can store enough rice for a family for a year. Some houses have as many as three such “baskets”. Each house has its own well. Shan houses in urban and in rural communities can be divided into three types: the residential house, the shop house and the shop. The size and function of the residential house will vary according to the owner’s needs and financial status. The two main architectural differences are the single- and double-gabled house.

- The Gingerbread House is the wooden house of later period brought by the westerners who came to the North for commerce and forestry in Thailand. Therefore, this type of house is found scattered throughout the northern region, which is abundant with forests. In the present time they are still found in Lampang, Chiang Mai, Chiang Rai, Mae Hong Son, Tak, and Kampangpetch. The planning is in western style with bedrooms, guestrooms, living room, working room and kitchen. There is generally a front portico and balconies as important elements of the house. They are built mainly in 2 stories with either opened or walled ground floor. Roofs are hipped, gabled, and gabled-hipped, covered with cement tiles. Eaves are extended to shade all sides with ventilation under the eaves. Over the doors and windows are openings for ventilation which are beautifully decorated with carved and cut wood to lessen the heaviness of the roofs as well as for aesthetic reasons. Rooms are high-ceilinged for good ventilation. The elaborate decoration as mentioned above is similar to that found on gingerbread and is the origin of the name ‘Gingerbread House’.

e. Shophouses

A shophouse serves two functions, dwelling and commerce; therefore, the location must be adjacent to the road for the buyers’ convenience. The front part for commercial use is elevated from the ground not higher than 3 steps, while the other section of this part is adjacent to the living area with internal corridor and stairs. For some houses, the commercial and the living areas are situated under the same roof by extending the eaves from the residential part which is 2-storey. For some, the commercial area is underneath the living area. The house always faces the road with its long side and has a shared corridor along this side for the buyers’ convenience. This corridor is sometimes used for displaying goods. The entrance for the living area is clearly separated from the commercial area. There are both one-storey and 2-storey shophouses. Roofs are covered with corrugated zinc sheets or tiles and the walls are made of wood planks. The doors and windows are decorated with horizontal or 45-60 degree-slanted wood pieces, and has carved and cut wood decorations for openings. Roofs are gabled, hipped or hip-gabled. Originally shops were simply ordinary houses selling a few goods. However, as commerce increased, some houses on main routes were modified to serve as shops below and houses above or alongside.

The shophouse can be either a single or double-gabled house. The additions for sales and storage are usually on one side, thereby, separating them from the front staircase and platform to preserve family privacy. If the street is on one side of the house, the roof can be extended to cover the shop. However, if the street is at an end of the house, a separate single-gabled building only slightly raised above the ground is built next to the house. The structure and materials of the main house and the addition are the same: a wooden framework and roof structure, with a roof of large eaves. Some buildings are built primarily as shops. Rural shops are usually one-storey, row houses or the modified ground floors of single houses, in which the proprietors live above in the house part. The front is always left open. Urban shops are usually two-storey wooden buildings having three ‘rooms’ (i.e. four posts across), each measuring 3.50-4.50 meters in width. The front forms the shop, and the rear a kitchen. On the upper floor are a storage room and a bedroom, with a protruding balcony on the street side, which shades the shop entrance during the day.

Figure 5 & 6: Shophouse on Rajadrumnorn Road Chiang Mai (left) and shophouse in Sankampang district in Chiang Mai (right) (taken by Vitul L., 5/3/02 & 1/4/02)

The front of the shop is closed at night using a series of hinged panels which open and close in accordion fashion. There are three rooms on the upper floor, with the middle room having a door onto the front balcony while the other two rooms have windows. The door and windows are flanked by slatted windows, giving the front of the building a distinctive appearance. The roof style has been influenced by the Central Thai house, but the details such as doors, windows, and the carving and design of balustrades show the inspiration of Shan architecture. Nowadays, good examples of Shan shops are rare, but some can be found in Mae Hong Son province. The framework of the building and its roof, floor, and walls are made of wood, while the roof is corrugated iron or tiles.

f. Other structures

In northern Thai villages, as elsewhere in the kingdom, the houses are usually grouped together in the same area while the fields are often located some distance away. People have to walk quite far to go back and forth between their home and the fields. During the planting and harvesting seasons, this is not convenient, so a field shack is essential. Looking across the rice fields, one can see many such field shacks which lend beauty to the fields. Villagers who live far away from their fields and need to stay in them for long periods build more permanent field shacks. Field shacks or *tieng na* are raised high off the ground and have no walls, but simply a low balustrade.

Barns or *chang*, for animals like cows and buffaloes used to be an essential part of a farmer's life, because after a long day's work, they need secure shelters. The barn is thus another important small-scale structure within the compound of a Thai house. Normally, barns are located near the house, within sight for safety. The architecture of these open buildings is simple: the posts may be simply rough tree trunks stripped of their bark standing on a tamped earth floor. The gabled roof with awnings most frequently has a bamboo framework with a thatch of large dipterocarp leaves. The barns are also used to store implements and the large mortar and pestles for husking and polishing rice may also be set up there.

There are two kinds of rice granaries called *long khao*: one is separate from the main house, the other is attached. The latter is simply the space beneath the eaves which are extended almost to touch the ground and are supported by posts. The rice is stored in a large basket. Separate granaries are like small houses; they are elevated high off the ground with the ridge of the roof parallel to that of the house. In some, the rice granary is completely enclosed within wood-framed walls, and stands on a hardwood floor capable of withstanding a significant amount of weight. The walls may be either hardwood or bamboo boards, with the wall studs on the exterior. Some granaries have low walls. The space beneath the storage chamber may be used for feeding pigs and chickens or for storing farm implements.

Figure 7 & 8:

Rice granaries at or *long khao in* Sankampang district (left) and field shacks or *tieng na* at Maejam district in Chiang Mai (right) (taken by Vitul L., 3/2/02 & 1/5/02)

Chapter 3

Historic building conservation in Northern Thailand

For this study, Lanna comprises the eight provinces of Chiang Mai, Chiang Rai, Lamphun, Lampang, Prayao, Prae, Nan, and Mae Hong Son, which have some characteristics, especially the ethnicity and architecture in common.

1. Lanna customs and old structures

a Demolition and relocation of historic buildings

Traditionally and locally, the demolition of historic or old buildings, including the selling of wood or construction materials, especially when the owner of the building has passed away, has continuously been done over time. It is believed that the money from selling these things and donating the proceeds to temples can bring "*boon*" to the owner, as is mentioned in Chapter 2, section 1 c. However, "*bu ra na pa ti sung khorn*" (reconstruction and renovation) in Thai contexts is mostly used for religious buildings, along with "preservation" which can be used in general, with any building, but seems like a new practice to the locals. In addition, although renovation, reconstruction, and conservation are mostly used altogether, they are managed differently from place to place and from time to time. According to the field surveys, several concepts and methods regarding renovation, reconstruction, and conservation are as follows:

The demolition and relocation of old buildings which no longer serve normal purposes was the normal Lanna custom. Whereas the relocation of historic buildings for conservation can be categorized into three groups:

- Demolition of privately owned historic buildings when the owners have died, then selling the construction materials and donating the proceeds to temples due to traditional beliefs that it can bring "*boon*" to the owners. The buildings which are still in good condition may be demolished then relocated to other *wats* as a donation, examples include the *vihara* of *Wat* Suan Dok in Chiang Mai which used to be the old residence of the governor (the grand *khum*), the *vihara* of *Wat* Chetuphon in Chiang Mai which used to be the residence (*khum*), and the *vihara* of *Wat* Chiang Man in Chiang Mai which used to be the hall of the residence of Phra Chao Kawilorotsuriyawongsa, the governor.
- Relocation of privately owned historic buildings for institutes, foundations, and conservation organizations include, for example, Chiang Mai University and the Rajabhaj Universities.

- Relocation of religious historic buildings (*wat* and its components) for institutes, foundations, conservation organizations or the private sector are, for instance, Muang Boran (the ancient city in Samut Prakarn), Chiang Mai Culture Centre then constructs the new building on the old land as a donation for temples as "*pha ti kam,*" (http:www.onab.go.th/mean/detail14 .html office of national Buddhism).

Demolition and relocation of historic buildings is complicated as it requires skillful craftsmen or *salar*, along with architects and engineers to carefully monitor every process. First, the measurement of historic buildings needs to be done, then a plan of the buildings is drawn up. There is also the survey and examination of the damaged parts which need special care. It is also necessary to survey carefully, in case there are any "holy *yan*", small pieces of textiles which are believed to be sacred on the main pole of the building to protect the residents. There is also the ceremony to beg for pardon "*khor khama*" from the ancestors of the house. Then all the wooden parts of the building are sprayed, as moisture can help remove them. Skillful craftsman can estimate the right amount of water and time (about 20 minutes), which is appropriate, as too much or little water can cause damage to the wood. Then the roof is removed carefully as the old baked tiles or *din khor*, can easily be cracked due to long use and the effects of weather. Next, the entire structure of the roof is removed. This process is not very difficult because it is only fixed to stick with the gable by a dowel, then the overall part can be removed or re-fixed. After that the overall wooden walls and panel are removed, followed by the floor. When the roof structure, i.e. purlines, beams, and rafters, is removed it is necessary to mark each component to prevent confusion when relocating. Finally the poles are removed. However, water should be poured onto the hole of each pole before removing. Each pole should be marked or numbered as well for relocation.

b Reassembling historic buildings

After removing each part of the building, they should all be washed, but not brushed as the wood can be damaged. Then an area for re-assembly is prepared, following the original plan. The next step is to place the poles in a traditional ceremony held on an auspicious day and at a time of prosperity for the residents. Traditionally, the gable of the house faces the north or the south, with the bedroom on the east and the kitchen on the west. Then the roof structure is carefully moved. The pipe for the drainage system is also laid at this step. After that the floor is done, followed by roofing and the four wooden walls and panel are placed altogether. When the building is complete, there is another ceremony on an auspicious day for the residents to start a new life in the new house with prosperity.

c Ceremonies and beliefs about historic buildings

In Northern Thailand houses, members of families mostly have activities inside the house, then there are many ceremonies, beliefs, taboos, or the dos and don'ts for the residents to follow so as to prevent the "*khud*" or the taboos which cannot be accepted by members of the same community because "*khud*" is considered to be disastrous. Hence, ceremonies and beliefs have continually been practiced so that the residents can live happily and peacefully. Ceremonies and beliefs are undertaken, for example, to place the altars for the Buddha images and ancestors who protected the house and its residents, and also for the teachers. This is a way to teach young members to pay respect to the elders and to appreciate with gratitude those who passed away. In the main bedroom, there is the main pole which is believed to be the place of the guardian spirit. On important occasions like New Year's Day, Song Kran's Day, Buddhist Lent, or when there is a newcomer, including an in-law, as well as when one of the residents has to leave the house, it is necessary to come and tell this main pole so that the guardian spirit will protect them. In the same areas, there is also the joss house which is separated from the house. It is also believed to be a place of the ancestors, like in some areas where there is kept an altar on the same side of the bed. For the daughter's room, it is not allowed for other people who are not relatives to enter. There is also the belief that a couple who is not married cannot be together. If this belief is broken, the man has to beg for pardon at the altar of ancestors at the woman's house. If they do not do this, it is believed that the woman will be cursed (Relocation of historic building 2006, p 21-32).

The kitchen is also an area of many beliefs. For example, when a child is sick, a ceremony is performed to pay respect to the rice cooking container as it is believed that it contains a guardian spirit who will protect children. When the child has to go out, the parents have to tell the guardian spirit as well. The ceremony involves sticky rice, the member's main dish, along with flowers. The ceremony is performed by the elder. There are also the don'ts in the kitchen, for instance, do not step on or walk over the stove, do not use utensils when singing or dancing, do not eat before the parents, and do not tell other people about dreams in the kitchen.

There are also other beliefs, like not sleeping at the door or on the north or west side, not stepping on the pillows, washing the feet before going to bed, not hanging or placing clothes on the roof, the fence, or at night, and more. These beliefs and ceremonies are practiced and taught as they are very important for all families and are believed to bring them prosperity, happiness, wealth and good fortune.

Figure 9 & 10:

Buddha image and *vihara* during conservation project at *Wat* Seang Khao Noi, Pasang, Lamphun (taken by Vitul L., 3/4/07)

2. List of historic buildings

a. The Fine Arts Department’s list

In the northern region, there are two local offices for the Fine Arts Department under the Ministry of Education, which include the 7^{th} division whose office is in Nan, and the 8^{th} division which is located in Chiang Mai. They are responsible for the conservation of historic buildings in Lanna which can be categorized as declared and undeclared under the government gazette. The types and number of historic buildings of each province are shown in Table 2.

Figure 11:

Vihara Lai Kham in *Wat* Phrasingha, Chiang Mai, registered historic building (taken by Vitul L., 23/6/06)


Figure 12 & 13:

Wat Jomklang (left) and *Wat* Phra That Doi Kongmu (right) in Mae Hong Son, registered historic buildings (taken by Vitul L., 15/6/07)


Figure 14 & 15:

Chedi, vihara, *ubosottha*; religious place and building at *Wat* Chiang Man, Chiang Mai, registered historic buildings (taken by Vitul L., 3/7/03 & 7/11/01)

Table 2: Historic places and buildings under *the Ancient Site, Artifact, Piece of Art Work, and National Museum Act 1961*, Fine Arts Department (from the field survey)

Province	Number of historic places and buildings under Act 1961
Chiang Mai	The declared government gazette 1. Religious place and building (*wat* and its components) 65 ea 2. Religious remnant and remains 39 ea 3. City wall, moat, ancient site and remains 5 ea 4. Historical building - ea 5. Naturally historic site and landscape - ea The un-declared government gazette 1. Religious place and building (*wat* and its components) 35 ea 2. Religious remnant and remains 2 ea 3. City wall, moat, ancient site and remains 5 ea 4. Historical building - ea 5. Naturally historic site and landscape – ea
Chiang Rai	The declared government gazette 1. Religious place and building (*wat* and its components) 29 ea 2. Religious remnant and remains 6 ea 3. City wall, moat, ancient site and remains 5 ea 4. Historical building 2 ea 5. Naturally historic site and landscape 1 ea The un-declared government gazette 1. Religious place and building (*wat* and its components) 67 ea 2. Religious remnant and remains 72 ea 3. City wall, moat, ancient site and remains 22 ea 4. Historical building 3 ea 5. Naturally historic site and landscape 2 ea
Lamphun	The declared government gazette 1. Religious place and building (*wat* and its components) 9 ea 2. Religious remnant and remains 4 ea 3. City wall, moat, ancient site and remains 1 ea 4. Historical building 1 ea 5. Naturally historic site and landscape - ea The un-declared government gazette 1. Religious place and building (*wat* and its components) 67 ea 2. Religious remnant and remains 3 ea 3. City wall, moat, ancient site and remains 6 ea 4. Historical building - ea 5. Naturally historic site and landscape 2 ea

Lampang	The declared government gazette 1. Religious place and building (*wat* and its components) 27 ea 2. Religious remnant and remains 3 ea 3. City wall, moat, ancient site and remains 3 ea 4. Historical building - ea 5. Naturally historic site and landscape – ea The un-declared government gazette 1. Religious place and building (*wat* and its components) 8 ea 2. Religious remnant and remains 1 ea 3. City wall, moat, ancient site and remains - ea 4. Historical building 1 ea 5. Naturally historic site and landscape – ea
Payao	The declared government gazette 1. Religious place and building (*wat* and its components) 16 ea 2. Religious remnant and remains 1 ea 3. City wall, moat, ancient site and remains - ea 4. Historical building - ea 5. Naturally historic site and landscape – ea The un-declared government gazette 1. Religious place and building (*wat* and its components) 3 ea 2. Religious remnant and remains 4 ea 3. City wall, moat, ancient site and remains 1 ea 4. Historical building - ea 5. Naturally historic site and landscape – ea
Prae	The declared government gazette 1. Religious place and building (*wat* and its components) 9 ea 2. Religious remnant and remains - ea 3. City wall, moat, ancient site and remains - ea 4. Historical building 1 ea 5. Naturally historic site and landscape – ea The un-declared government gazette 1. Religious place and building (*wat* and its components) 6 ea 2. Religious remnant and remains - ea 3. City wall, moat, ancient site and remains - ea 4. Historical building - ea 5. Naturally historic site and landscape – ea
Nan	The declared government gazette 1. Religious place and building (*wat* and its components) 25 ea 2. Religious remnant and remains - ea 3. City wall, moat, ancient site and remains 1 ea 4. Historical building 1 ea 5. Naturally historic site and landscape – ea

Nan	The un-declared government gazette 1. Religious place and building (*wat* and its components) 14 ea 2. Religious remnant and remains 1 ea 3. City wall, moat, ancient site and remains - ea 4. Historical building - ea 5. Naturally historic site and landscape – ea
Mae Hong Son	The declared government gazette 1. Religious place and building (*wat* and its components) 7 ea 2. Religious remnant and remains - ea 3. City wall, moat, ancient site and remains - ea 4. Historical building - ea 5. Naturally historic site and landscape – ea The un-declared government gazette 1. Religious place and building (*wat* and its components) 9 ea 2. Religious remnant and remains - ea 3. City wall, moat, ancient site and remains - ea 4. Historical building 1 ea 5. Naturally historic site and landscape – ea

It can be seen that the Fine Arts Department puts emphasis on religious places and buildings, as many of them were surveyed and listed, while only a few non-religious historical buildings and architecture were listed. From the survey and study, the conservation projects for historical buildings done by the office of the Fine Arts Department in Chiang Mai and Nan during 1997-2007 were for 39 religious buildings (Fine Art Dept. 2006) and none for non-religious buildings due to the limited personnel and budget. Official contractors such as Chae-fa, Por Vor Chor Likit-kransrang, and Sor Boonmeerith are named.

b. Religious places and buildings

The Religious Affairs Department under the Ministry of Education is responsible for the conservation of historical buildings as religious places and buildings (the *wat* and its components), religious remnants and remains. From Table 3, the number of Buddhist places and buildings (the *wat* and its components like the *vihara* or ordinary hall, *ubosottha* or assembly hall, *hor tri* or library, *hor klong / hor rakhang* or drum / bell tower, *stupa, chedi*, and the *kuti* or monk's residences) is shown in column 1. The royal *wat* or the province's most important monasteries, which get special care in conservation, is shown in column 2. The *wats* in the Muang district or urban area which are undertaken in traditional conservation are in column 3, and the *wats* which are registered in the Fine Arts Department Gazette are shown in column 4.

Wats in the Muang district are undertaken in the traditional conservation way, "*bu ra na pa ti sung khorn*" (reconstruction and renovation). In Thai context, it is mostly conservation according to Thai philosophy which means it has been reconstructed and renovated many times by the public and the head of the monks of each temple. However, wrong methods of conservation to preserve and protect the architecture are normally found.

Table 3: Historic buildings as religious places (from the field survey)

Province	Number of religious places			
	Wats	Royal *wats*	*Wats* In Muang district	In the Gazette
Chiang Mai	1085	4	107	100
Chiang Rai	856	2	160	96
Lamphun	357	2	153	76
Lampang	635	2	166	35
Payao	411	1	119	19
Prae	282	1	81	15
Nan	387	2	95	39
Mae Hong Son	120	1	33	16
Total	4133	15	914	396



Figure 16, 17 & 18:

Religious places, wooden and masonry libraries in Lamphun: *Wat* Baan Sam (left), *Wat* Seang Khao Noi Nua (middle), *Wat* Pang Bong (right) (taken by Vitul L., 8-14/12/04)


Figure 19 & 20:

Royal *wat* at *Wat* Phra That Haribhunchai, Lamphun (taken by Vitul L., 2/12/00)

Figure 21:

Vihara in *Wat* Baan Ko, Wiang Nua district, Lampang (taken by Vitul L., 19/7/06)

Figure 22:

Government house or grand *khum*, historic building in Nan, listed by the Association of Siamese Architects and also in the gazette (taken by Vitul L., 24/11/05).

c. The Association of Siamese Architect's historic building list

The Arts and Culture Conservation Board of the Association of Siamese Architects under the Royal Patronage has shown concern over the historic buildings for the best conserved buildings which have been on its list since 1982 so as to promote building conservation. Many more organizations have paid more attention to this list. The numbers of these types of historic buildings are as follows:

Table 4: The Association of Siamese Architect's historic building list (from the survey)

Province	Number of listed historic buildings
Chiang Mai	18 ea (4 were in gazette)
Chiang Rai	1 ea
Lamphun	2 ea
Lampang	7 ea (3 were in gazette)
Payao	None
Prae	2 ea (1 were in gazette)
Nan	3 ea (3 were in gazette)
Mae Hong Son	1 ea

Figure 23 & 24:

Vihara in *Wat* Phra That Changkum (left) and *vihara* in *Wat* Pumin (right), historic buildings in Nan, listed by the Association of Siamese Architects and also in the gazette (taken by Vitul L., 24/11/05).

d. The local and government historic buildings

The Department of Public Works, Town, and Country Planning, the local municipalities, and the authorized building users are responsible for controlling the conservation of their historic buildings and structures that should be conserved, as well as other structures like bridges and monuments. See Table 5.

Table 5: Unlisted government historic buildings and structures (from the field survey)

Province	Government historic buildings (estimated)
Chiang Mai	1. Government house and *khum* 10 ea 2. Government office, hospital, institute, bank, museum 10 ea 3. Other building and structure 10 ea
Chiang Rai	1. Government house and *khum* 10 ea 2. Government office, hospital, institute, bank, museum 5 ea 3. Other building and structure 5 ea
Lamphun	1. Government house and *khum* 5 ea 2. Government office, hospital, institute, bank, museum 5 ea 3. Other building and structure 5 ea
Lampang	1. Government house and *khum* 10 ea 2. Government office, hospital, institute, bank, museum 10 ea 3. Other building and structure 5 ea
Payao	1. Government house and *khum* 5 ea 2. Government office, hospital, institute, bank, museum 5 ea 3. Other building and structure 5 ea
Prae	1. Government house and *khum* 5 ea 2. Government office, hospital, institute, bank, museum 5 ea 3. Other building and structure 5 ea
Nan	1. Government house and *khum* 5 ea 2. Government office, hospital, institute, bank, museum 5 ea 3. Other building and structure 5 ea
Mae Hong Son	1. Government house and *khum* 5 ea 2. Government office, hospital, institute, bank, museum 5 ea 3. Other building and structure 5 ea


Figure 25 & 26:

The Forestry Dept., unlisted government historic building and structure in Lampang (taken by Vitul L., 17/2/07)

e. Universities, foundations and institutes / private collectors (the privately-owned located and relocated historic buildings)

Chiang Mai University, Rajabhaj Universities, Muang Boran (the Ancient City in Samut Prakarn) and the Chiang Mai Cultural Centre play roles in the relocation of historic buildings for conservation in Lanna. This can be categorized as relocated privately-owned historic buildings when the owners passed away, or the unwanted and relocated religious historic buildings, called *pha ti kam* (when they are unwanted).

Table 6: Relocation of historic buildings (from the field survey)

Province	Number of relocated historic buildings
Chiang Mai	10 ea (1 was in gazette, 1 was listed)/ 5 ea private collection
Chiang Rai	1 ea
Lamphun	2 ea
Lampang	None
Payao	None
Prae	1 ea private collection
Nan	None
Mae Hong Son	None

Figure 27 & 28:

Kalae houses, the relocated historic buildings in Chiang Mai University (taken by Vitul L., 9/5/03 1/3/02)

Figure 29:

Phra Tamnak Darapirom, MaeRim district, Chiang Mai, the located historic buildings by Chulalongkorn University (taken by Vitul L., 18/05/06)

f. The locally-owned historic buildings

The field survey found types of unlisted historic buildings as follows:

Table 7: Unlisted private historic buildings (from the field survey)

Province	Number of unlisted historic buildings (estimated)
Chiang Mai	1. House 80 ea and *khum* 10 ea 2. Shophouse 40 ea 3. Non-Buddhist religious buildings 10 ea
Chiang Rai	1. House 10 ea and *khum* - ea 2. Shophouse 10 ea 3. Non-Buddhist religious buildings 5 ea
Lamphun	1. House 20 ea and *khum* 5 ea 2. Shophouse 20 ea 3. Non-Buddhist religious buildings – ea
Lampang	1. House 60 ea and *khum* 5 ea 2. Shophouse 50 ea 3. Non-Buddhism religious buildings 5 ea
Payao	1. House 5 ea and *khum* - ea 2. Shophouse - ea 3. Non-Buddhist religious buildings 5 ea
Prae	1. House 5 ea and *khum* - ea 2. Shophouse 10 ea 3. Non-Buddhist religious buildings – ea
Nan	1. House 10 ea and *khum* 8 ea 2. Shophouse 15 ea 3. Non-Buddhist religious buildings 1 ea
Mae Hong Son	1. House 5 ea and *khum* - ea 2. Shophouse 15 ea 3. Non-Buddhist religious buildings – ea


Figure 30 & 31:

Shophouses in an urban area in Mae Hong Son (taken by Vitul L., 24/6/07)

3. Historic building conservation classification

According to the field surveys, several concepts and methods regarding renovation, reconstruction, and conservation have been applied to historic buildings. The main conservation classification in Northern Thailand is as follows:

a. Historic places and buildings under an *the Ancient Site, Artifact, Piece of Art Work, and National Museum Act 1961*, Fine Arts Department's list (Table 2)
b. Historic buildings as religious places, The Religious Affairs Department (Table 3)
c. The Association of Siamese Architect's historic building list (Table 4)
d. The local and the government historic buildings (Table 5) Universities, foundations and institutes / private collectors (Table 6)
e. Unlisted private historic buildings (Table 7)
f. Reconstructed building

The reconstructed buildings include those reconstructed with some old or existing materials, or totally from new materials, but based on the original designs or patterns. Reconstruction is mostly used for art and cultural conservation, or for business. Reconstructed buildings are not considered historic, and are not conserved. An example of reconstructed buildings are the imitated *vihara* at *Wat* Lai Hin in Lampang, the Oriental Daradhevi Hotel in Chiang Mai, the imitated Grand *khum* in Lampang in Muang Boran (the Ancient City in Samut Prakarn).

Figure 32:

Reconstruced building resembling the grand *khum* in the Oriental Daradhevi Hotel in Chiang Mai (taken by Vitul L., 19/3/07)

Figure 33 & 34:

Reconstructed building resembling rice granary or *long khao* (left) and pavilion or *sala* (right) in Sankampang district, Chiang Mai (taken by Vitul L., 14/6/02)

4. Historic building types

Historic buildings in the eight provinces of Lanna can be categorized as residential and non-residential buildings owned by local organizations and private sectors, religious and non-religious buildings, of Buddhism and other religions, and shophouses. These groups of buildings are also categorized by their origins, architecture, construction materials and methods. In terms of "conservation", the buildings that are at least 50 years old are considered historic, and the buildings of more than 100 years old can be labeled as an ancient site registered under *the Ancient Site, Artifact, Piece of Art work, and National Museum Act of 1961* which are worthy of being conserved. At present there are 374 listed historic buildings in Northern Thailand which are listed as ancient sites by the Fine Arts Department. There are 34 historic buildings listed by the Association of Siamese Architects. There are estimated 1023 unlisted historic buildings. And 19 historic buildings conserved following relocation. The categories of architecture that are conserved are as follows:

a. Houses and *khums*

- Houses can include wooden houses and vernacular architecture. The materials are locally found and they are built by local people. But for *khum*, it includes only the residential buildings of a governor or person from the high hierarchy. This type of residence was developed from Western architecture along with traditional Thai architecture. Houses and *khums* include, for example,

  - Lanna Ancient Houses Museum at the Center for the Promotion of Arts and Culture, Chiang Mai University
  - *Ruen Kalae* and *Tai lue* house at the Chiang Mai Cultural Center
  - Local owned houses, especially those of the *Yong* people in Lamphun, *Tai yai* in Mae Hong Son, and *Tai lue* in Nan
  - Big Vernacular wooden houses such as the Ban Pong Nak House and Ban Sao Nak House in Lampang
  - Wooden *khums* which are located in some provinces

- Wooden and masonry houses are mostly built in the traditional style. The buildings are made of both wood and brick by local people. Examples of wooden and masonry houses are:

  - The residences of foreigners in Lanna, British Borneo co., Ltd. Ben's Compound, Wayruwan House
  - Luang Yoanthakarn's residence
  - Wooden and masonry *khums* which are located in some provinces
  -

Table 8: Number of houses and *khums* as historic buildings (from the field survey)

Province	Wood houses				Wooden and masonry houses			
	A	B	C	D	A	B	C	D
Chiang Mai	-	5	40	7 (5P)	-	3	40	-
Chiang Rai	-	-	5	-	1	-	5	-
Lamphun	-	1	15	2	-	-	5	-
Lampang	-	1	30	-	-	-	30	-
Payao	-	-	5	-	-	-	-	-
Prae	-	-	5	(1P)	-	-	-	-
Nan	-	-	5	-	-	-	5	-
Mae Hong Son	-	-	5	-	-	-	-	-
Total	0	7	110	15	1	3	85	-
Province	Wood *khums*				Wooden and masonry *khums*			
	A	B	C	D	A	B	C	D
Chiang Mai	-	1	5	-	-	1	5	-
Chiang Rai	-	-	-	-	-	-	-	-
Lamphun	-	-	3	-	-	-	2	-
Lampang	-	-	-	-	-	-	3	-
Payao	-	-	-	-	-	-	-	-
Prae	-	1	-	-	-	-	-	-
Nan	-	-	6	-	-	-	2	-
Mae Hong Son	-	-	-	-	-	-	-	-
Total	0	2	14	0	0	1	12	0

Wood houses and *khums* = 148 / Wooden - masonry houses and *khums* = 102

A = Registered historic buildings

B = Listed historic buildings

C = Unlisted historic buildings

D = Relocated historic buildings

Figure 35:
Wooded house in Pasang, Lamphun (taken by Vitul L., 14/12/04)

Figure 36 & 37:
Khums in Lamphun - *khum* Chao Yodraung (left) and Hangna-Chao (right) (taken by Vitul L., 14/12/04&25/12/04)

Figure 38 & 39:

Wooden & masonry *khums*: *Khum* Chao Rajchabutha in Chiang Mai (left) and Chao Sampan thawong in Lamphun (right) (taken by Vitul L., 3/7/05 & 4/12/04)

b. Urban buildings and government buildings

Urban historic buildings are mostly built in the traditional and/or western or colonial style and are about 50-80 years old. They are not reconstructed anymore. They were made of wood and brick by local people and people from the central region of Thailand and foreigners like the Chinese or Vietnamese. Examples of urban historic buildings are the city hall, post office, hospital, bank, school, police station, train station, and prison. This also covers the museum and culture centre as their adaptive reuse. The non-Buddhist religious historic buildings like the church and mosque are also included in Table 9.

Table 9: Number of urban buildings and non-Buddhist religious buildings (from the field survey)

Province	Urban buildings				Non Buddhist buildings			
	A	B	C	D	A	B	C	D
Chiang Mai	-	1	10	-	-	1	10	-
Chiang Rai	3	1	5	-	-	-	5	-
Lamphun	-	1	5	-	-	-	-	-
Lampang	1	2	10	-	-	-	5	-
Payao	-	-	-	-	-	-	-	-
Prae	1	(1)	-	-	-	-	-	-
Nan	1	(1)	5	-	-	-	1	-
Mae Hong Son	-	-	5	-	-	-	-	-
Total	4	5	40	0	0	1	21	0

A = registered historic buildings
B = listed historic buildings
C = unlisted historic buildings
D = relocated historic buildings

Figure 40:

Urban building, Tobacco Company in Chiang Mai (taken by Vitul L., 1/2/02)

c. Shophouses

Shophouses are a form of building that was developed from vernacular architecture along with Chinese commercial buildings. They can be both wooden and masonry buildings which were built by local people as well as foreigners including the Chinese and Vietnamese. The areas where shophouses are found in Lanna are as follows:

Chiang Mai: Wat Ket area, the area of Lao Jow alley to Wichayanond street, Klang Wiang area, the area along Charoen Muang Road, and Toung Siao area
Chiang Rai: The old downtown and urban area
Lamphun: The area of Inthayongyot to Charoenrat Road, as well as the urban area, Pa Sang area, Pak Bong area
Lampang: The area of the Chinese market, Kao Jao area, Thip Chang to Boonyawat Road, Prasarn Maitri to Chatchai Road, Charoen Muang Road and the area nearby, Charoen Prathet Road
Payao: The old downtown near Kwan Payao
Prae: The old downtown and urban area
Nan: Sumon Dhevaraj Road and urban area
Mae Hong Son: The area of Klang Wiang Community to Singhanat Bumrung Road

Examples of shophouses which are considered historic are as follows:

- A Wooden shophouse which belongs to Liao Choon Li Shop, comprised of two-stories in Muang District, Chiang Mai
- A Masonry shophouse which belongs to Anusarn Co.,Ltd., comprised of two-stories in Muang District, Chiang Mai

Table 10: Number of wooden and wooden and masonry shophouses (from the field survey)

Province	Wooden buildings				Wooden and masonry buildings			
	A	B	C	D	A	B	C	D
Chiang Mai	-	-	20	1	-	2	20	-
Chiang Rai	-	-	5	-	-	-	5	-
Lamphun	-	-	15	-	-	-	5	-
Lampang	-	-	20	-	-	-	30	-
Payao	-	-	-	-	-	-	-	-
Prae	-	-	5	-	-	-	5	-
Nan	-	-	10	-	-	-	5	-
Mae Hong Son	-	-	15	-	-	-	-	-
Total	0	0	90	1	0	2	70	0

A = registered historic buildings B = listed historic buildings
C = unlisted historic buildings D = relocated historic buildings

Figure 41 & 42:

Wooden shophouses in Lamphun (taken by Vitul L., 11/2/05)

Figure 43 & 44:

Wooden shophouses in Lampang (taken by Vitul L., 17/2/07)

d. Religious buildings

There are a vast number of religious historic buildings, religious remnants and remains. From the numbers and figures shown in Table 10, 4,133 *wats* are found in Northern Thailand, but there are only 396 *wats*, or 17.91%, which are registered in the Fine Arts Department Gazette. It is therefore estimated that the other 3,224 *wats* or 12,896 buildings, or more than 82% of *wats* in Lanna, need to be surveyed and conserved.

Table 11: Percent of historic buildings as religious places

Province	Number of religious place		Percentage		82.09%	
	Wats	Gazette	Gazette	17.91%	*Wats*	Buildings
Chiang Mai	1085	100	9.22	239	846	3384
Chiang Rai	856	96	11.22	188	668	2672
Lamphun	357	76	21.29	79	278	1112
Lampang	635	35	5.51	140	495	1980
Payao	411	19	4.62	90	321	1284
Prae	282	15	5.32	62	220	880
Nan	387	39	10.08	85	302	1208
Mae Hong Son	120	16	13.33	26	94	376
Total	4133	396	17.91	909	3224	12896


Figure 45 & 46:

Chedi and *vihara* at *Wat* Seang Khao Noi, Pasang, Lamphun (taken by Vitul L., 17/2/07)


Figure 47 & 48:

Chedi and *pratu khong* at *Wat* Puong Sanuk in Lampang (taken by Vitul L., 17/6/05)



Figure 49, 50 & 51:

Religious historic buildings and structures after the renovation project was done by local *salar* and the head of the monk: *vihara* terrace with bright blue terracotta (left), newly built giant Buddha image (middle) *and naga* main staircase (right - old abandoned staircase which is underneath and a newly built staircase which is above) at *Wat* PhraThat Doi Kham, Maehea in Chiang Mai (taken by Vitul L., 06/09/07)

Chapter 4

Historic buildings conservation and investigation

Architectural conservation involves preservation and maintenance of buildings or structures of the past, which have historical and architectural significance. It is a process which leads to the prolongation of the life of cultural heritage places and for their utilization now and in the future. In the past few years, many historic buildings in Northern Thailand have been conserved while others have been adapted to become premises for a museum, bank, restaurant, information centre or a tourist attraction. Many religious historical buildings (i.e. *vihara, ubosottha)* have been conserved in the Lanna way. This dissertation is about the continuum of change in architectural conservation in Northern Thailand today.

Before undertaking building conservation, it is important to engage the service of a conservation architect, building contractor or planner with a broad understanding of the field. This is to ensure that any action carried out during the conservation work is properly performed and is in accord, not only with the building requirements, but within the scope of contemporary knowledge of the subject. This Chapter deals with the common problems of historical buildings and conditions, including building materials and their common problems or defects, mainly wood, brick and plaster.

The process of investigating old buildings can range from the brief and inadequate to the opposite extreme of being almost endless and superfluous. Obviously the aim is somewhere in between. The conservation architect is faced with a balancing act to achieve conservation goals, requirements, and to meet available budgets. Practical experience demonstrates again and again that insufficient research and planning leads to projects running over budget and to poor conservation practice.

Northern Thailand, Lanna, is one of the unique regions that has many historic buildings which are of immense architectural and historical value. It is believed that there are more than 1,500 historic buildings built before1957 throughout the provinces of Chiang Mai, Chiang Rai, Lamphun, Lampang, Payao, Prae, Nan and Mae Hong Son which are worthy of preservation and conservation. Unfortunately building conservation is a fairly new practice. Northern Thailand faces a range of problems in dealing with the issues of historic buildings. First, the philosophy and organization for conservation in the past has been altered. Second, the present legislation, management, control and guidelines on historic buildings are not sufficient or suitable to protect such buildings from being demolished and destroyed. There are presently acts, declarations, regulations and enactments which show some aspects of building conservation even though it is felt that their application and formulation are restricted and not intended to address the question of heritage conservation extensively. With the country's current rapid development in which the practice of demolishing historic buildings has become the norm, none of these pieces of legislation is comprehensive enough. Third, there are no suitable systems for discovering and recording historic buildings. Recording systems are quite important in building conservation, particularly among other things to register the building locations, functions and owners; to classify buildings according to their functions; assist the authorities in keeping a record of the buildings for future research and funding; and to measure building defects and assess remedial measures. Finally, there is a lack of technical knowledge in repairing and maintaining historic buildings. This is a major problem because almost all conservation jobs involve both repair and maintenance stages requiring an understanding of and diagnoses of building defects.

In Thailand, under *the Ancient Site Artifact, Piece of Art Work, and National Museum Act 1961,* only a few historical buildings or monuments aged at least 100 years old can be listed or gazetted by the government through the Fine Arts Department in the Ministry of Education to give protection and encouragement for preservation and conservation. At present, there are 374 buildings which have been gazetted. Only 6 of these buildings are non-religious examples of Lanna architecture. Most of the gazetted places are owned by the Religious Affairs Department, even though there are many privately owned buildings which are of architectural and historic value. Some examples of historic buildings in Lanna worthy of listing and preservation include traditional Lanna houses, prisons, government offices both institutional and commercial, residences, schools, railway stations, hotels and guest houses, and monuments.

A large number of building surveys and inspections were undertaken for this study. These included structural surveys, building condition and defects analysis, and investigation of selected buildings built before 1957 throughout Northern Thailand. Each building was studied externally and internally following permission from its occupants or owners. The main purpose of the surveys and inspections was to study the common building defects or problems and to determine the proportion of building conditions. However, most of the buildings shared some common building defects or problems. It was found from the study that sometimes one building shared 3 or more common building defects, depending on its location, age, building materials and changes in use. There are many common building defects or problems, such as fungal stains or harmful growth, peeling paint, defective plastered renderings, poor installation of building equipment, defective rainwater goods, decayed floorboards, cracking of walls, erosion of mortar joints, penetration of dampness through walls, roof defects, insect or termite attack, and unstable foundations.

1. Common problems of historic buildings

a. Roof – materials and structure

- Ageing original roof materials, missing, broken pieces, decay, defects, and cracks – wooden shakes, baked tiles, cement tiles, ceramic tiles

- Degradation of wooden roof structure and items, broken pieces, discoloring parts, fungus stains and harmful growth, insects or termites
- Sinking or tilted roof caused by differentiated structure settlement or failure
- Failure of purlines or rafters of roof structures
- Fungus stains and harmful growth, insects or termites attacking the wood on purlines or rafters of roof structures
- Leaking roof causing water stains on roof structures


Figure 52 & 53:

Ageing and leaking roof problems in historic buildings, shake wood roof or *pan kled* at *Wat* Baan Ko, Lampang (left) and baked tiles at *Khum* Chao Buriratana Keawmungmaung, Chiang Mai (right) (taken by Vitul L., 19/7/06 & 1/2/02)


Figure 54 & 55:

Sinking and leaking ceiling in the *vihara* in *Wat* Seang Khao Noi, Pasang, Lamphun (left) and termites attacking at *Wat* Baan Ko, Lampang (right) (taken by Vitul L., 17/2/07 & 19/7/06)

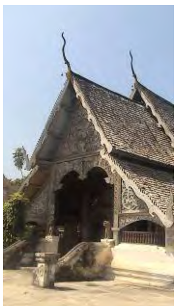


Figure 56, 57 & 58:

Failure on wooden structures of historic buildings in the *vihara* in *Wat* Baan Ko, (taken by Vitul L., 19/7/06)

b. Ceilings

- Sinking or damaged ceiling
- Failure of ceiling structures
- Fungus stains and harmful growth, insects or termites attacking the ceiling

- Leaking roof causing water stains on the ceiling, moisture contents, swelling and shrinking

c. Wood partitions and structure
- Missing or un-matching original material wood species and characteristics, broken pieces, decay, defects, cracks
- Failure on wooden structures caused by subsided columns
- Failure on wooden member joints, moisture contents, swelling and shrinking
- Fungus stains and harmful growth, insects or termites attacking the wood
- Additional propping supports to reinforce the failure of wooden parts

d. Masonry walls
- The deterioration of historic brickwork, stone, laterite, and architectural terracotta
- Fungus stains and harmful growth on masonry
- Rising damp through the wall, moisture content on the wall and water penetration resulting in dampness
- Erosion of cementitious products i.e. mortars, joints, plaster and natural cement, mold cement, concrete including alkali-aggregate reactivity, salt crystallization, scouring action of winds, the disintegrating effects of wall-growing plants and other forms of mortar deterioration
- Defective plaster rendering mostly on the external walls
- Vertical and diagonal cracks of structural instability on the walls and leaning walls
- Rainwater causing defects

Figure 59 & 60:

Deterioration, defective plastered wall of the *vihara* in *Wat* Chedi Luang, Chiang Mai (taken by Vitul L., 4/6/06)

Figure 61 & 62:

Cracks of historic brickwork in the *vihara* in *Wat* Baan Ko, Lampang (taken by Vitul L., 19/7/06)

e. Floor

- Decayed floorboards caused by surface abuse
- Cracks of structural instability on the foundation

Figure 63:

Cracks on the floor of historic building, *vihara* in *Wat* Baan Ko, Lampang (taken by Vitul L., 19/7/06)

f. Foundations

- Unstable foundations, differentiated ground settlement

Figure 64:

Differentiated ground settlement of historic buildings, wooden library in the pond in *Wat* Pang Bong, Lamphun (taken by Vitul L., 8/12/04)

Figure 65:

Differentiated ground settlement of historic buildings, investigation pit for the foundation of the *vihara* in *Wat* Baan Ko, Lampang (taken by Vitul L., 9/8/06)

Figure 66, 67 & 68:

Damaged openings and frames of historic buildings, *vihara* in *Wat* Baan Ko, Lampang (taken by Vitul L., 19/7/06)

Figure 69:

Missing or un-matching painting and coating material, *vihara* in *Wat* Seang Khao Noi, Pasang, Lamphun, (taken by Vitul L., 17/2/07)

g. Openings – Doors and windows

- Damaged openings
- Failure of structures
- Fungus stains and harmful growth, insects or termites attacking the openings

h. Architectural painting and coatings

- Missing or un-matching original material architectural painting and coating, gold lining, *Lacca* coating
- Peeling paint on plastered walls, columns and other areas caused by dampness, wind and sunlight and common mechanism deterioration
- Un-matching types of paints - a lime wash, emulsion, oil-based, tar, bituminous and oil-bound water paint

i. Architectural elements, glass, gold, and wood decorations

- Missing or un-matching original materials of architectural glass, gold, wood, and mold cement
- Architectural elements and decorative deterioration
- Architectural glass, gold, and wood decorative deterioration

Figure 70, 71 & 72

Un-matching decorative glass, gold, and wood elements on *nah bun* in *Wat* Ubosottha, MaeHea, Chiang Mai (left), missing moulded cement on *nah bun* at *Wat* Koklang, Pasang, Lamphun (middle), and original materials and decorative elements deterioration on *nah bun* in *Wat* Prasart, Chiang Mai (right) (taken by Vitul L., 6/4/04, 5/7/06, 1/2/06)

2. Building investigation

a. Investigation report for historic buildings and structures

Investigative processes in the field and in the laboratory were reviewed for each group of materials and associated systems. Surveying, measuring, and recording has a number of functions which can affect the selection of techniques, scale, and degree of detail required. Recording historic buildings or structures is done for the future just in case by some unfortunate chance they happen to be badly damaged or even destroyed in a disaster, then having sufficient information to restore them or at least to record them for future generations. Such records may require a very high level of accuracy and great detail.

The building survey and measurement of a structure in order to prepare conservation contract documents will convey our intentions and requirements to contractors, trades or crafts workers. Measurements may also be required for structural survey records to establish the current state of a structure so that any changes which occur with the passage of time, or because of external forces acting upon that structure, can be detected. These techniques include the use of tell-tales, micrometers, and strain gauges to record and measure the magnitude of structural movements, cracks, bulges and other distortions.

Investigation reports are usually prepared in anticipation of the work required to rectify any identified building defect: hence, they are best conducted as part and parcel of the documentation for these works. A poor understanding regarding the extent and nature of the building’s defects would render an inappropriate approach and scope of repair work being carried out during the conservation project - leading to disagreements and substantial costs implications amongst building owners, clients and contractors. Reports are undertaken to identify and record the building’s defects through the means of photographic and digital documentation prior to any conservation work. The survey is usually carried out by a conservation architect. It requires in-depth analyses of the building’s defects, probable causes and the proposed methods and techniques of building conservation. Normally, data and information obtained from the Investigation is analyzed, documented and presented in a technical report: which is used for preparing project briefs, building specifications and the bill of quantities.

As building conservation often involves various remedial works and building repairs, a thorough identification and recording of the building’s defects is integral in determining the appropriate conservation methods and techniques to be employed. Sometimes investigation reports involve historians, architects, conservators, structural engineers, mechanical and electrical, and quantity surveyors. Occasionally, the expertise of microbiologists, chemists, archaeologists and geologists are also sought. Recording and documenting are the basic components of the investigation of the building’s conditions, defects and their causes. The conditions and nature of the existing building materials should be well captured in both photographic and digital forms for purposes of such documentation. Existing building materials whether timber, stone, brick, plaster, metal, glass or concrete, should be fully examined and documented. The same goes for the condition of roof structures, floors, doors, windows, footings and foundation. Architectural ornaments that have been broken or missing from the past should also be noted. The exact locations of all the building's defects, all spaces and elements should be marked clearly and plotted onto floor plans, sections and elevations. For cross-referencing purposes, windows, doors, and rooms should be coded. The report should contain the following information:

- Historical background and cultural attributes of historical buildings
- Architectural detail drawing and significance of historical buildings
- Building condition, defects and their causes documented or detailed by way of explanation
- Proposed methods, techniques of building conservation and recommendation for scientific studies or further tests to be carried out

It is essential to recommend in the investigation report the proposed scientific studies and tests to be carried out prior to any conservation work. Such recommendations are important as they provide additional information that can lead to solving related building problems or defects. Common studies required during the conservation works include microbiological studies to identify plant species, dispersion agents, control ranking and chemical fungicides; archaeological studies to trace buried or hidden remnants; and the study of relative humidity to gauge the local environmental conditions. Some examples of laboratory tests required are the brick test to analyze the compressive strength and level of porosity; timber analysis to identify timber species, grading and group strength; salt tests to detect the salt levels and the percentage of total ions; and paint analysis to classify paint types as well as color schemes. All data and analyses generated from the scientific studies and laboratory tests should be presented in separate reports.


Figure 73 & 74:

The site investigation pit for foundation of *Khum* Chao Buriratana Keawmungmaung, Chiang Mai (taken by Vitul L., 15/4/02)

To be effective, investigation surveys should take a multidisciplinary approach including in-depth knowledge in conservation as well as related fields in order to correctly assess the building's defects, determine their causes, and propose restoration methods. Relevant scientific studies and laboratory tests are equally important as the results would provide a sound basis for decision-making in the conservation works to follow. Callous incidences of improper diagnoses of building conditions, and the resultant ineffective remedial measures, may pose unnecessary threats to the heritage structures and raise concerns over public safety. It is imperative, therefore, to invest adequate resources in conducting the investigation survey, also called ‘dilapidation survey’ prior to any conservation project. The dilapidation survey report, once completed, serves as an indispensable archival resource for future reference and cyclical building maintenance programs to follow.


Figure 75 & 76:

The site investigation on roof and structure of the *vihara* in *Wat* Baan Ko, Lampang (taken by Vitul L., 9/8/06)

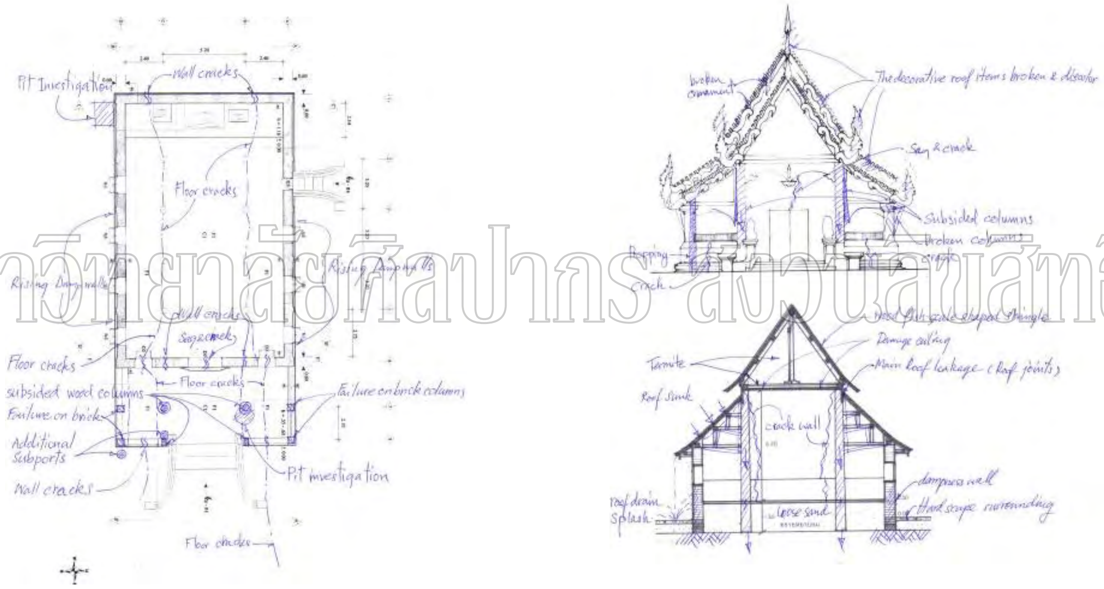


Figure 77: Investigation record and plan, elevation and section of the *vihara* in *Wat* Baan Ko, Lampang (sketched by Vitul L., 5/10/06)

b. Investigation report for future use

Recording as a precautionary measure against future disaster is usually best carried out by means of stereo photogrammetry. The entire structure can be recorded by stereo pairs of photographs with all appropriate measurements and scales in the drawings, photographs. Technical data on the digital recording, including focal length, must also be carefully noted and stored. Great care must be exercised in the architectural details of an appropriate scale since this affects the number of photographs which will be required and hence the degree of detail which will be recorded. For practical purposes, it is recommended that the scale should be no smaller than 1:50. A scale of 1:25 is a common choice. The ideal feature of this type of recording is that once the stereo pairs are taken they can simply be stored in an appropriate archive. They do not have to be immediately processed and converted into drawings.

c. Investigation report for contract use

Probably the most common use of investigating and recording techniques is in the preparation of contracts. Practical experience shows that combinations of photographs, hand measurements, and drawings can be compiled into photo-drawings which are reproducible. The prints from these reproducible recordings present the contractor with the best combination of various forms of data to explain exactly what is required and exactly where. Digital photographs on site using electronic prints are then cut and mounted to produce composite images. These are then reproduced by scanning and printing on plain paper. Drawings and specification notes are added and then the whole photo-drawing is ready for reproduction.

Details which are of special interest can be photographed to a much larger scale to produce transparencies to include as photo-drawings. Some architects use rectified photography to produce images which are reproduced to predetermined scales and with perspective distortion eliminated or minimized with the use of perspective-corrected lenses, rising and tilting front cameras, or by subsequent rectifications of the images. Such surveys with annotated photo-drawings from an ideal basis for contract documents with a minimum of interim steps can lead to the production process.

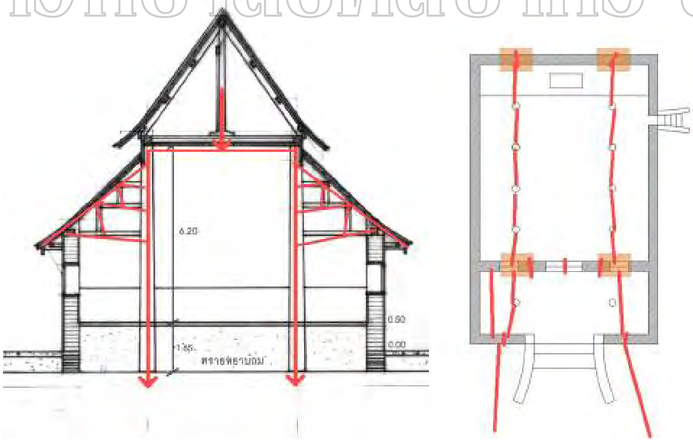


Figure 78:

Structural investigation record on wall and floor cracks of *vihara* in *Wat* Baan Ko, Lampang (sketched by Vitul L., 5/10/06)

d. Structural investigation report

Annotated photo-drawings or photo-mosaics make ideal structural survey records. Additional information is required on the progressions of cracks and of the directions of movements which caused the cracks to open. It is important that the cracks' dimensions are measured in the direction of the movement. When looking at a crack one simply draws a series of parallel lines in these directions linking matching profiles and this gives the direction of the movement. Structural signs of localized crushing associated with the cracking should also be closely examined since these reveal where masonry masses are being pushed together and where others are being pulled apart.

e. Access to structural investigations

Effective investigations of the exteriors of buildings are largely dependent on the type of access which the conservation architect has to the actual surface of the building. At the lowest and most inaccurate end of the scale are the surveys of high areas which depend on a visual inspection from the ground. For better results, the architect involves much use of high powered binoculars. For the most effective inspections, the investigator must be able to actually touch the surface of the building. Indeed in some cases, such as pediment-faced buildings, it may be necessary for the architect to "sound" every single wooden item in certain critical areas. This requires a small hammer to test the soundness of each part. In order to have this close access it is necessary to use hydraulic platforms, crane-ladder trucks, or scaffolding.

Although it is very expensive, scaffolding provides the most secure and satisfactory means of carrying out investigations. However, it must be properly designed for the job to give safe and close access to all surfaces without the investigator having to lean out or swing dangerously from stages which are just too far away from the surface to be inspected. All too often, the investigator has little choice in the matter but is pressed to use a scaffold which has been erected for another purpose, such as for repairing a roof.

Figure 79 & 80:

Scaffolding for investigation in *Wat* Pong Sanuk, Lampang (taken by Vitul L., 17/6/05)

Figure 81, 82 & 83:

Platforms and ladders for investigation in the *vihara* in *Wat* Baan Ko, Lampang (taken by Vitul L., 9/8/06)

Investigations may be conducted from crane-ladder trucks which may sometimes be capable of reaching suitable heights. However, it might limit access to some parts of the building. To prevent the accidental dropping of tools and measuring equipment, surveys must be carried out with great care. Crane-ladder trucks can also crash into the side of the building causing structural damage and even knocking fragments off so that they fall, with great risk to life and limb.

f. The investigation tool

Conservation architects develop their equipment and material so that they carry them on the site, up the scaffolding or crane-ladder trucks. The following items might be regarded as standard equipment:

- Drawings or prints of photo-mosaics upon which to mark information on defects. The drawings should be conveniently folded or printed on separate sheets which require minimal folding
- A notebook or notepaper - pens and pencils
- A clip board to provide a firm support for the drawings or prints.
- Clips and rubber bands to assist in holding down the drawings or prints in the wind
- A digital camera with multi-zoom lenses
- A pocket microscope preferably with a magnitude for measuring objects in the field of view
- A pair of powerful binoculars
- A hammer and screwdrivers
- Measuring tapes and folding rods
- Polyethylene bags with zip-lock seals and screw-top plastic vials for collecting samples
- Scalpels and other small tools for taking samples and plastic bags and vials to record the site, location, and date
- Permanent marker for writing on plastic bags and vials to record the site, location, and date
- Swiss army knife - assorted tools depending on the nature of the structure but probably including a heavy rubber mallet, a small thin steel pry-bar with a nail-lifting slot, a long thin bladed screwdriver with an impact resistant handle, a pair of pliers with cutters, and a small pair of tin-snips or sheet metal shears
- A laptop computer may also be taken on site in some instances. Standardized formats for surveys can be used with laptop computers which can be taken on site so that data can be entered directly

The above list is not an exhaustive one but the investigator will require a large bag to contain all this material. When the investigator is working from scaffolding, the large bag should be hauled up separately by rope. If the investigator climbs ladders with the bag slung from a shoulder, there is a risk of the bag catching in a projection and causing the investigator to be pulled off the ladder.

Chapter 5

Lanna building materials

Building projects differ in complexity, duration and deterioration according to their raw materials. It is important in these studies that a standard scientific approach be employed. The conservation architect, building contractor, planner or conservation scientist adopts and adapts tests and standard procedures which have been developed for other purposes. Such tests and procedures may be primarily oriented toward new materials rather than old materials which may be required to conserve their cultural and historical values rather than simply replacing them.

This process is not without its problems, and in fact a number of methods developed in recent years by Western practitioners have subsequently been found to have been unreliable or inadequate for application in Northern Thailand. The examination of historic mortar is such an example of this problem. In a paper entitled "Chemical Techniques of Historic Mortar Analysis," the Canadian conservation scientists, Costain and Stewart (1982, p.127), reported in their studies on the problems of improving analytical techniques for studies on historic mortars. They concluded that while the majority of the current tests provided somewhat unreliable results, some provided results which were totally misleading or simply incorrect.

The following chapters of this dissertation have been dedicated to each of the major categories of traditional building materials for Lanna, Northern Thailand. Each subject is examined and discussed according to its physical structure and behavior. This is followed by a study on the sources of the raw materials, processing and manufacturing. Each subject is completed by a section on appropriate conservation techniques and materials. Specials techniques of examination and testing of the materials alone and in systems are discussed in the accompanying text. Most of the historical buildings in Northern Thailand use local building materials wherever they were readily available. The building materials can be grouped into six categories:

- Wood and Timber: Timber has long been used by local builders in building construction. It is the most useful material available for wall, floor, roof and other structural framing. All timbers can be classified into softwoods and hardwoods depending on the characteristics of their grains, weight and moisture content. In general, timbers either of softwoods or hardwoods have a moisture content of between 12 to 15 percent in their seasoned state. Normally, a well-dried timber has a moisture content of 12 percent. If the moisture content of the wood exceeds 20 percent, fungal rotting, insect infestation and termite attack can eventually take place. This could lead to structural failure. Therefore, before timber is used for building construction, it is important for the material to be seasoned and dry. The primary aim in seasoning timber (either of air or kiln drying) is to render the timber as stable as possible. Timber increases in strength as it dries. The life of timber can be prolonged by means of preservation treatments, usually by means of fungicidal preservation, flame-proof protection or water-repellence application.

- Masonry: Stone and brick masonry is the next main category of material used in Lanna buildings. Brickwork has been used in many historic buildings in Thailand. Some buildings have exposed brick walls and others are plastered and painted. Old bricks are slightly different than modern bricks. The texture of modern bricks looks closer and smoother, and the edges are straighter and sharper compared to the old materials. Color and size are also different. Brick may decay through the weathering process which includes effects from sulphurous smoke from a polluted atmosphere, water penetration through small holes and openings of the brick as well as mortar joints; and dampness in walls that have not been protected in locations near a river. Brick may deteriorate due to harmful vegetation and also mold or fungal growth that accumulates in the brick surface. Brick can also decay due to cracks caused by structural movements. Such structural movements may come from building foundations when the subsoil is compressed through the decades or centuries followed by wall deflections due to the foundation weakness or an uneven loading distribution from above the wall structure.
- Cementitious products: Cementitious materials were commonly used in mortars and plasters. They tend to deteriorate over time. Plaster normally contains lime, sand and water; and sometimes natural fibers or chopped up animal hair to give it tensile strength. Mortars, plaster and natural cement, molded cement and concrete are used widely in decorative panels, ceiling linings, and internal walls. Causes of deterioration include salt attack, direct exposure to driving rain, condensation, evaporation, air pollution, aerosols, capillaries, thermal stresses, vegetal causes, insect attacks, animals and human activities. Cementitious products may become cracked due to either shrinkage or movement in the substrate. Shrinkage usually occurs early in the life of the building but substrata movement is often the reason for failure in historic building situations.
- Roofing materials: Most of the early historic buildings in Northern Thailand, Lanna, used wood framing and baked tiles for covering permanent local building materials. Some important religious buildings used ceramic tiles. Later, houses and shophouses used cement tile
- Architectural glass: Glass materials were used in religious buildings
- Architectural painting and coating: Gold lining, *Lacca* coating, painting and coating were also used mainly in religious buildings.

Understanding the nature of the building materials and the accurate diagnosis of defects is most important for the care and conservation of historic buildings. This is because historic buildings are, like older people, vulnerable to all sorts of failures. Therefore, in order to tackle the problems, conservation architects, building contractors or planners should first become familiar with the building materials in common use before going deeper into the proper techniques of preservation. Common building materials will be discussed as well as the causes of decay in each of the materials subject.

1. Wood and timber

Any approach to the problem of restoring or repairing an old wooden building or other structure must be systematic. First, the nature of the structural system and the species of woods which were used for the various structural elements must be examined. Some woods were chosen for their durability, while others were simply used because they were readily available. The knowledge of where the structural timbers were obtained and what species they are, can lead to a greater understanding of what is wrong with them. Finally when we have this knowledge, and only then, can we proceed to design and specify appropriate treatments (Weaver 1993, p.13).

Wood is susceptible to several agents of deterioration. The major causes of deterioration are moisture in the tropical rainy climate, ultraviolet light, insects and micro-organisms. It has been observed that severe damage results from prolonged neglect of protective measures. These problems are really serious and require urgent intervention. The application of appropriate water-proof materials and wood preservatives are the most efficient methods for conservation of wooden buildings (Aranyanark 1997, p. 511). Wood is probably the oldest structural material since it is in some respects ideal for building purposes. It is light but very strong for its weight. It is easily accessible and relatively easy to work. Wood was an integral part of houses, temples, palaces, offices, and almost every kind of traditional architecture. Carved decorations have always been popular for Thai style buildings. Wood carved into decorative patterns adorns windows, doors and gables (Aranyanark, p. 512).

Figure 84 & 85: Villagers preparing timber for local conservation in *Wat* Baan Ko, Lampang (taken by Vitul L., 28/10/06)

Today, with the shortage of timber and desperate struggles to preserve the ever-shrinking forests in Thailand, it is hard to comprehend just how wonderful those Northern Thailand forests once were. In the 1960s, log exports were banned and subsequently major public reforestation sites set in motion, which totaled 6,000 ha/year in the 1970s. The government then encouraged the growth of village plantations and plantations owned by private industrial companies, such as the Forest Industry Organization. In restoration work, timber is imported from Myanmar and Lao for such projects. Having knowledge about the quality and quantity of the resource and the almost astronomical production quantities that are needed, it becomes much easier to comprehend the standard use of masses of oversized timbers.

a. Wood species and characteristics

In order to understand how the wood has behaved, and is behaving, in an old structure it is necessary to know which species were used and their properties. Usually the selection of one type of wood against another was dependant upon the most readily available and hence most economical species. Large timbers are heavy and were hard to move over primitive roads, if waterways were not available. In the past, in Northern Thailand where there was an abundant forestry, timber was frequently found very close to the user. In any text of this nature, space is limited—too limited to include all the details of the physiology and chemistry of wood, but a brief summary is as follows: wood is a natural polymeric or macromolecular material composed of the following substances: 40-50% of cellulose, 25-35% of hemi-cellulose, 20-30% of lignin, and extractives, time of year, and other variables. Minerals such as silica, calcium, potassium, and phosphates may comprise 0.3-3.0% of the wood substance (Weaver, p.18). Wood is made up of bundles of fibers which run lengthways along the trunk. These fibers are more or less well defined according to the species, and form the grain. The fibers can be close and compact or loosely bound together forming hard and soft woods, respectively (Aranyanark, p.511).

In tropical hardwoods, the lignin content is frequently higher and the wood is correspondingly more rigid and less resilient. The timber industry considers woods as being either softwoods or hardwoods. Softwoods are derived from coniferous trees such as pines and firs. The structure of the wood is formed of cells of various sizes and shapes. Hardwoods and softwoods have cells of distinctly different natures and arrangements or distributions which make it possible to identify the various species (Weaver, p.18-19). Thailand lies entirely within a tropical and monsoonal climate region. Therefore, the forest is composed principally of hardwood trees. Hardwood is derived from a type of deciduous or broadleaved trees. The conducting tissue in hardwoods consists of vessels or pores. The vessels can be seen in the transverse section as holes in characteristic patterns, and in the longitudinal section as long, thin furrows. The cells in these woods are large and quite noticeable. The hardwood is not always so hard. The strengthening tissue of hardwood consists of fibers. The important strength characters of hardwood are usually dependent on the wood fiber construction (Aranyanark, p.511). The hardwoods commonly used for wooden buildings in Thailand are as follows:

- *Afzelia xylocarpa Craib - ma ka mong*
- *Balonocarpus heimii King*
- *Chukrasia velutina Wight & Arn.- yom hin*
- *Cotylelobium melanoxylon Pierre - kiem*
- *Diospyros mollis Griff - ma kleng*
- *Dalbergia oliveri Gamble - ching chang*
- *Dalbergia cochinchinensis Pierre - pra yoon*
- *Dipterocarpus obtusifolius Teijsm - heang*

- *Dipterocarpus tuberculatus Roxb. - pao yang na*
- *Hopea odorata Roxb. - ta kieng tong*
- *Hopea ferrea Pierre - ta kieng hin*
- *Pterocarpus sp. - pradu*
- *Pentacme siamensis - rung*
- *Shorea obtuse Wall. Shorea siamensis Miq.- rung*
- *Sindora sp. Sindora siamensis Teijsm.– ma ka tae*
- *Tectona grandis (Teak)- sak*
- *Teminalia mucronata Craib & Hutch.- ta beake*
- *Xylia kerrii Craib & Hutch. - dang*

Among the many kinds of wood available in Thailand, *Tectona grandis* or teak has long been widely used. The teak tree is native in the tropics of Asia. This wood is similar in coloration to the black walnut, being mainly a yellowish-golden brown. The color and durability of the teak is dependent largely upon the locale of the tree. The weight per cubic meter is 576.69 – 640.61 kg. Its specific gravity is 0.642 (Aranyanark, p.512). Actually, teak is not as hard as other types of hardwood. It yields easily to the will of the carver who may impress in it the nervous cut of the chisel. Teak stands fairly well under the exposure of the atmospheric agents, but in the long run, when exposed outside, although protected by a coat of wood finish, it is damaged by the rain. In addition, teak's texture contains such toxic chemicals as *methyl anthraquinone, lapacol, tactual* and *dehydrotectol*, so it also has the advantage of not being susceptible to attacks by termites, beetles and fungi. The natural resistances of certain hardwoods arise from the accumulation of natural preservatives in the wood. Several woods were reported to contain toxic chemicals, e.g. the *Rung* tree or *Pentacme siamensis*, *Shorea obtuse Wall* and *Shorea siamensis Miq.* The amount and distribution of such chemicals vary considerably from tree to tree of a given species. These substances prevent or retard decay development. The ancient craftsmen were wise enough to utilize durable woods. They also used only the heartwood of well seasoned timbers (Aranyanark, p.512).

b. Wood moisture content, swelling and shrinking

When a tree is felled the wood has a moisture content averaging from 60 to 100%. Water at this point is contained in the cell walls (bound water) and in the lumens or central spaces within the cells (free water). The free water may be lost without any dimensional changes taking place in the wood. When all the water from the lumens has gone, the wood is described as being at the "fiber saturation point" which varies from about 24 to 32%, depending on its species. As the moisture content is lowered still further for use in buildings or furniture, shrinkage occurs in the wood. Wood is an anisotropic material which means that it does not shrink equally in all directions. Shrinkage tangential to the growth rings is largest; then only about half as much as that radially, and finally, only negligibly in length (Weaver, p.19).

These differences in shrinkage rates mean that certain cross sections of timber are less dimensionally stable than others, the most stable being the "quarter sawn" or "edge grain" sections where the growth rings are perpendicular to the length of the tree. The least stable sections are the “flat sawn” or “tangentially sawn” where the long sides are tangential to the growth rings. The latter tend to cup with their outer edges curling outward. Wood in service constantly tends to adjust its moisture content to reach a balance with the ambient relative humidity. This balanced state at a certain ambient relative humidity is referred to as the equilibrium moisture content or EMC. For new construction, wood moisture contents are normally selected as follows: 25% for rough exterior carpentry work, 15% for general joinery work, and 12% for furniture, doors and paneling. For restoration and repairs the existing moisture content of the wood to be repaired may be even lower than 8%. Conservation architects usually prefer to store the wood which will be used for restoration and repair work in the building in such a way that the old and new woods come to the same or a similar EMC before the work is carried out (Weaver 1993, p.19).

In addition, wood had normally been treated with wood finishes to protect its surface against mechanical, physical, and chemical influences or to enhance the natural beauty of the wood. Oil and waxes are used traditionally for this purpose. Surface coatings usually aim at reducing the rate of swelling and shrinking by minimizing the exchange of moisture into or out of the cell wall structure of the wood. Common traditional wood finishes are mineral oils, resin, shellac, paints, varnishes, and *lacca*, or lacquer. The cheapest and most common wood finish used is mineral oils mixed with red pigments – red oxide. The most effective wood finish used is *lacca* coating. Important wooden artifacts have usually been coated with several layers of lacquer. Thai lacquer is made from the sap of the *Rak* tree or *Melanorrhoea usitata*, which under suitable conditions solidifies, and becomes a hard material of great strength capable of being polished and carved. It had long been used as a protection and watertight covering for wood in Lanna. Hardened *lacca* film is hard and flexible at the same time, and exhibits excellent resistance to weathering. The natural color of lacquer is black, but it can be modified by the addition of various pigments, such as *mercuric sulphide,* or *arsenic sulphide*, for decoration. However, lacquer exposed outdoors generally deteriorates due to the ultraviolet radiation and the solar heat. It changes color and looses luster. Long periods of exposure cause scaling or flaking. When cracks are present the wooden materials start to decay, and this is why red pigmented oils (red oxide) are used. The pigment protects the wood from the effects of ultraviolet light. See more details on *lacca* coating, architectural painting and coatings in this chapter.

c. The causes of wood deterioration

Wood is a remarkably resilient material with great strength in relation to its density. Wood may be light and soft or hard and dense. Some are difficult to cut even with a sharp chisel and some will not float in water. The woods that were traditionally used in Lanna buildings often deteriorate swiftly due to a wide range of causes. As an organic material, wood is susceptible to being disintegrated and destroyed through attack by several natural agents of deterioration. The locality and conditions of storage and use largely determine the nature of the deterioration. The presence of moisture in too large a quantity usually causes deterioration. Deterioration of wood in buildings is a common problem in the structure, finishes and furniture.

Wood is susceptible to changes in relative humidity and extreme variations in temperature. The rate of wood degradation is accelerated when artifacts are continuously exposed to fluctuation in atmospheric conditions. Much wood deterioration is a direct result of high humidity what is sometimes caused by poor maintenance or poor ventilation. Fluctuation in relative humidity causes damage because the wood is constantly expanding and contracting. Outdoor sunlight also affects the deterioration of wood due to the ultra-violet break down of the outer surface of the wood substances. The surface fibers become friable and actually disintegrate but the fiber underneath stays sound. Mold or micro-organisms only attack wood above certain moisture content. Otherwise, insects attack all wood but need moisture.

In Northern Thailand, artifacts facing the south and west deteriorate faster than those facing the north and east. During the rainy season, they are overwhelmed by monsoons from the south. Therefore, the south and southwest-facing surfaces show a much greater degree of deterioration than other surfaces. The physical, chemical, and mechanical factors may be important in the deterioration of wood in historical buildings. The factors may be grouped as follows:

Physical, chemical, and mechanical factors

- Problems related to the wood itself, growth-related defects
- Problems related to the seasoning or drying process, the conversion process from the log to the dimensioned timber
- Problems related to the fluctuation in relative humidity or moisture content on the wood
- Problems related to the failure of the wood fibers under load or stresses, inadequacies in original structural design
- Abrasions from foot and vehicular traffic or work processes and repeated wear from hardware
- Photodegradation of the wood surface caused by exposure to sunlight and ultraviolet radiation

In Lanna, the wood bio-deterioration factor is a major group with causes ranging from bacteria at the smallest end of the scale up to large mammals and even trees.

First, microbiological deterioration of wood is attributable to fungi, bacteria, algae, and lichens. Microbiological action on wood is a cause of numerous undesirable circumstances, for instance, loss of water repellency, loss of strength, discoloration, etc. Decaying fungi disintegrate the cell walls and thereby change the physical and chemical characteristics of the wood. The normal color of the wood is more or less modified. Microbiological activities often darken and disfigure the exterior surface of the wood. The decomposition of the wood by micro-organisms usually causes shrinkage, warping and cracking. Thus, the strength and density of the wood is reduced. The wood is friable, light and falls to powder under pressure.

Microbiological deterioration factors

- Bacteria: Bacteria may thrive on wood in anaerobic conditions under water. They attack the pit membranes of those pits located between the wood cells. By destroying them, they can open up the cell structure to water penetration, thus causing wood to become waterlogged and liable to further degradation. However, normally the bacteria do not cause major degradation of the wood (Weaver, p.23).
- Fungi: Architectural structures and wooden artifacts exposed out of doors are most prone to micro-organism attacks because they often become wet. Decay is most common in wood found to be in direct contact with soils or in locations where moisture collects and cannot readily evaporate. It is also prominent in wood exposed (unpainted) to the weather. The common decay usually proceeds when the moisture content rises.

Fungi and bacteria, when present on wood, have a direct effect on the chemical composition of cell walls and are the cause of discoloration, softening, and loss of weight in the infected wood. Microbiological deterioration of wood conditions take place where there exists a source of infestation, a suitable food supply of nontoxic wood, a suitable temperature, sufficient moisture, and a source of air, as in the case of fungi, or when the wood is submerged in water, as in the case of bacteria.

- Molds: Molds are in fact types of fungi which are visible as dry colored powder deposits on the surface of the wood that is under attack. Most of these represent only a superficial growth on the surface which can be removed by brushing, shallow planning or sanding. The most important feature of the presence of mold lines is the fact that they signal that the moisture content of the wood is high; therefore, an attack by more damaging fungal species could occur.

Insect deterioration factors

Wood in service in Northern Thailand may be attacked by a wide variety of insect species at various points in their life cycles. The species include beetles, termites, carpenter ants, and carpenter bees. Their life cycle consists of four main stages which are: 1) the egg stages including the time to hatch which may take a period of several days; 2) the larva or larval stage—the egg hatches into a larva which usually involves at least three instar stages; 3) the pupa—the last instar stage where the larva molts and changes into a pupa; and 4) the adult where the exoskeleton hardens and the pupa becomes a fully grown adult.

The actual insects responsible for the damage often remain invisible, or are not seen by the casual observer. In the absence of the actual culprits, the investigator uses the following evidence to commence the identification process: 1) the form of the frass or wood boredust and excreta; 2) the diameter of the exit holes or flight holes bored by the young adult insects as they emerge onto the surface of the wood; 3) the form of the galleries or tunnels; and 4) the presence or absence of frass in the galleries or tunnels. The most serious damage to timber is usually caused by species of insects in three orders: *Coleoptera* (beetles), the *Isoptera* (termites), and the *Hymenoptera* (ants and bees).

- *Coleoptera* (beetles): Powder-post beetles, this group of insects infests wood under a wide range of conditions. They attack softwoods as well as hardwoods, and green logs as well as seasoned wood. The larvae of these insects bore through wood for food and shelter, leaving the undigested parts of the materials in the form of a fine powder. Since the larvae work in the inner portion of the wood, considerable damage has already occurred before it is discovered.

Figure 86 & 87:

Damage caused by *Coleoptera* (beetles) in *Wat* Baan Ko, Lampang (taken by Vitul L., 28/10/06).

Figure 88 & 89:

Coleoptera (beetles) galleries or tunnels underneath the main structure in *Wat* Baan Ko, Lampang (taken by Vitul L., 28/10/06).

Figure 90: Damage caused by *mord* or *Heterobostrychus aqualise* or wood-borer, in the *vihara* in *Wat* Ubosottha, MaeHea, Chiang Mai (taken by Vitul L., 6/4/04).

Amongst the most important families of wood-tunneling larvae are the *Lyctidae* and *Bostrichidae*. The species *Minthia rugicollis* (walker) of the family *Lyctidae* or true powder-post beetles causes extensive damage to wood products with a high starch content. The attack by these insects reduces the wood to a fine, flour-like powder and they repeatedly reinvest in the same wood time and time again, so long as the wood continues to furnish adequate food for the larvae. The larvae create a honeycomb in the wood when the attack is severe, usually leaving little trace of sound wood and a thin outer shell. The timbers which are known to be susceptible to attack by *Minthia rugicollis* (walker) include: *bamboo, Bombax, Hevea brasilensis (Muell.Arg.), Acacia spp., Bombax, rattan* and *bamboo etc.*

The major *Bostrichidae* beetles, or "*Mord*" in Thai, include the *Heterobostrychus aqualise* or wood-borers, *Dinoderus minutus Fabricius* or bamboo-borers, *Apoleon edax Groh.,and Stromatium longicorne.* These insects are important pests in southeast Asian countries. Great damage is done by the larvae which bore their galleries into the wood. Wood species susceptible to *Heterobostrychus aqualise* and *Dinoderus minutus* are *Cassia spp., Terminalia spp. - ta beake, Dipterocarpus tuberculatus Roxb.- pao yang na, Shorea obtuse Wall - rung, Pterocarpus sp.- pradu, Xylia kerrii - dang, Bombax, rattan* and *bamboo*.

- Isoptera (termites). The most important group of insects injurious to wood are termites. The ground dweller termites or subterranean termites usually attack wood which is in direct contact to the ground or adjacent to crevices in masonry or concrete, through which they travel to reach their food. They have a fixed nest from which the workers move out in search of wood and to which they return with their spoil. They build the earth like runways over brick, stone and concrete foundations to reach the wood. They require a constant supply of moisture for their existence. The presence of subterranean termites in wood may not be discovered until the more seriously attacked pieces of wood begin to show definite evidence of failure. The common species are *Coptotermes havilandi* and *Coptotermes gestroi* (Weaver 1993, p.32). The wood-dwelling termites are entirely wood inhabiting never entering the ground, and require no moisture other than that which they can derive from the wood itself. At the time of swarming, the alates or winged reproductive, enter the wood directly from the air. From there they begin to excavate galleries in the materials. Infestation is frequently overlooked especially in the early stages of the attack. The major species are *Coptotermes* domestics, *Coptotermes Thailandis,* and some *Glyptotermes spp* (Aranyanark 1997, p.516).
- *Hymenoptera*: ants, including carpenter ants, and bees are seen in the northern areas of Thailand, and can completely destroy large parts of timbers in old buildings. The carpenter ants do not eat the wood but excavate large chambers for their colonies in timbers while they feed elsewhere. The galleries have a clean "sandblasted" appearance and no frass remains in them. All the frass is ejected and forms large piles of coarse "sawdust" beneath the wood that is under attack. Carpenter bees such as *Xylocopa virginica Drury* attack softwood. Attacks typically consist of large cleanly cut holes over 10 mm in diameter in exterior timbers in well lit areas such as barge boards and fascias.

Behind the large holes, lie 150-200 mm long horizontal galleries, about 25 mm below the surface.

Plant deterioration factors

Plants can damage wood in a number of ways including: by discoloration; by retaining moisture or preventing the drying of the wood; by abrasion, for example, as branches are blown back and forth by the wind; and by expanding and splitting, for example, when seeds germinate in cracks in old timbers and then the growing tree stem splits the surrounding timber. The following list is arranged in order of size:

- Algae—a sign of high moisture content
- Lichens—a sign of high moisture content
- Mosses—a sign of high moisture content
- Small Plants—a sign of high moisture content
- Bushes and shrubs—moisture retaining and mechanical damage
- Tree—moisture retaining and mechanical damage

Algae and lichens are densely found on exposed and unprotected wood. Their growth is always associated with moisture retention. It was observed that the number of these micro-organisms was found to be the greatest during the rainy season. Algae grow rapidly in a humid atmosphere of about 70% RH. They produce spores for reproduction and distribution very quickly as soon as conditions of humidity and temperature are favorable to their growth. Algae grow easily and develop under even the simplest conditions; only moisture and sunlight need be present. Their presence not only darkens and disfigures the exterior surface but also weakens the wood on which they grow. Certain algae produce organic acids of numerous types such as citric acid, oxalic acid and gluconic acid. These acids are harmful to wood and other building materials. Lichens can also produce lichenic acids and organic acids which are responsible for the decay of wood. The growth of mosses, ferns, and liverworts retain moisture in the wood and accelerate other microbiological activities. Their presence is an indicator of wet conditions in the wood.

Animal deterioration factors

Animals damage wood in the following ways:

- Birds—woodpeckers primarily boring into wood searching for insect larvae. Consequently, hollow structures may “fool” woodpeckers and cause them to attack wood which does not actually contain insects.
- Rodents and small mammals—this type of damage is usually caused by chewing to gain access to building interiors for food or nesting.
- Large mammals—this type of damage is usually caused by cribbing or biting which is typical of horses, and licking or the use of the building structure as a scratching post as is done by cows.

The major factors of deterioration in wooden buildings involve many other unexpected causes. The tropics have proven to be a severe environment for both organic and inorganic materials. Moisture is the prime agent in tropical areas. The ultraviolet rays are powerful enough to disintegrate the surface of wood. Insects and micro-organisms often cause extensive damage. These problems are actually quite serious and require professional intervention by conservation architects, building contractors or planners. The application of appropriate materials and wood preservatives are the most efficient methods for the conservation of wooden historic buildings.

2. Masonry

Masonry is used in the construction of walls. It is a heavy form of construction that derives its strength from its mass. It is an art or trade of buildings in various types of materials mainly stone, which has been universally practiced since ancient times. Among the ancient Khmer, stonework was generally squared and fitted; no mortar was used to bed the units and spread the load. Ancient examples of masonry composed of immense irregular blocks of stone laid together without mortar have been found throughout Southeast Asia.

Masonry may be divided into two broad categories called rubble and ashlar. Rubble is composed of irregular and coarsely jointed quarried or field stone. Ashlar is made up of carefully worked stones set with fine, close joints. Either kind of masonry may be laid with mortar; however, when laid without mortar, it is called dry masonry. In modern-day industrialized countries, the work of finishing stones, formerly done with hand tools, is usually performed by machines. The term masonry is often extended to apply to work in brick and tile. Types of materials used in masonry can be divided into the following categories:

- Stones composed entirely or partly of acid-soluble carbonates or chalky material. The correct term for these is “calcareous.” The group includes limestone, marble, calcareous sandstones, and sand lime bricks. The use of calcareous sandstones is found in Phayao and Chiang Rai.
- Stones composed of acid resistant materials such as quartz or silica and silicate compounds. This group includes granite, andesite, most types of sandstone, and a whole range of hard, dense stones which the building trade groups as “granite” but which in fact are not granite. Included in this latter group are gabbro, gneiss, syenite, diorite and laterite. Laterite is used in Lamphun, Chiang Mai and Chiang Rai.
- Architectural ceramics. This large group of acid resistant fired-clay products includes bricks and architectural terracotta. It is generally used in many provinces.
- Water-soluble or water-sensitive masonry materials. Examples of these materials are adobe, clay block, terre pise, cob, sod, and alabaster. They are rarely used in historic buildings.

- Cementitious products: Included in this group are lime and gypsum mortars, “natural cements,” lime and gypsum plasters and stuccos, and Portland cement. It is widely used, and is one topic of this study, following Masonry.

Thus, being roughly classified, depending on the masonry materials or potential substrates and what matter binds them together or causes them to adhere to the substrate, the selection of appropriate processes can then be made on the basis of proper knowledge.

Historically, it was found that brick and laterite have been extensively used in Northern Thailand since the era of Haribhunchai. Brick, limestone, calcareous sandstone and other masonry categories were generally used for religious buildings and architecture. Then, during the era of Lanna, brick and laterite were also used, mostly in religious buildings as well, such as for the *vihara* and *chedi.* In this study, bricks, architectural terracotta and various cementitious products are focused on and analyzed.

a. Laterite

Laterite is a surface formation in hot and wet tropical areas which is enriched with iron and aluminium and developed by intensive and long lasting weathering of the underlying parent rock. Nearly all kinds of rocks can be deeply decomposed by the action of high rainfall and elevated temperatures. The percolating rainwater causes the dissolution of primary rock minerals and decrease of easily soluble elements such as sodium, potassium, calcium, magnesium and silicon. Laterites consist mainly of the minerals kaolinite, goethite, hematite and gibbsite which form in the course of weathering. Moreover, many laterites contain quartz as a relatively stable relic mineral from the parent rock. The iron oxides, goethite and hematite, cause the red-brown color of laterites. Laterite is found and used extensively as a building material in Chiang Mai, Chiang Rai and Lamphun. It comes in various sizes and shapes.

b. Brick

The brick that was commonly used in Lanna architecture is called “*din kee*”. Fired or burned bricks have been used on a large scale for buildings since at least the early Haribhunchai period. It can be said that the greatest stimulus to the steadily increased use of fired brick all over Lanna at the end of the thirteenth century and all through the seventeenth and eighteenth centuries was the rapid growth of monasteries and cities. The increasingly dense populated centers and the bigger and better buildings had one feature in common—the need of more fire and vermin-resistant construction. The process to produce *din kee* is described as follows:

- Clay selection: Clay, the principal material in fired bricks, is composed of a mass of fine particles derived from the erosion and chemical breakdown of igneous rocks. The most common clay minerals are kaolinite, illite, montmorillonite, and chlorite. The crystals of these clay minerals typically have a finely layered structure which enables them to absorb water and consequently to expand upon wetting. Montmorillonite is particularly noted for the latter characteristic. Often when clays are dug straight from the ground they are found to be too "plastic." This means that while they can be readily molded and formed with the hands or in molds, they shrink severely upon drying and can warp, twist or crack. Worse still they may not dry completely before being fired and as a result may generate steam and explode in the kiln destroying all the ceramics around them.

To reduce plasticity, sand may be added to the clay. Early Lanna brick-makers often used a mixture of about 30% sand to 70% plastic clay. This in turn raises the firing temperature necessary to produce good quality bricks. Then a small quantity crushed limestone for example may be used as a flux to lower the melting points of the silica in the sand and the silicates in the clays. Some excellent mixtures of clay and sand occur naturally and are ideal for the manufacture of fired bricks. These naturally occurring mixes are called "brick-marls". A second source of "ready-mixed" clay and possibly some sand are the so-called "brick shales". Shales are rock which has been formed naturally in the earth's crust by heat and pressure from mud or barely consolidated mud known as "mudstone."

- Clay gathering: The selected soil should be put into water, the longer the period of time, the better the soil. Then the gravel and sand will be picked out. The next steps in early brick manufacturing were digging the clay then "weathering" or laying the lumpy clay mass out in the open to break down and crumble. "Tempering" was the next step and involved mixing the clay with ash, sand and water. At first this was done crudely, and often ineffectively, by hand.
- Brick molding: The wooden mold which is used to set the shape of the brick must not bend when it touches water or moisture. It must be about 5-10% bigger than the brick as the brick shrinks when all moisture evaporates due to the heat from sunlight. The standard sizes used for construction of Lanna architecture are 20x30 cm. and 15x29 cm. However, there is no specific or typical form as it is dependent on the artisans and workers' decision. According to the field study at *Wat Ton Gwen*, the use of brick at each level was quite different as there were pieces of roof tiles inserted in between those levels before the walls were covered with mortar. The size was very big, in comparison to bricks that are used at present. The size varied because of different molds and ingredients used at the time.

From the time of the ancient Lanna civilization up until the nineteenth century, and in some instances even into the twentieth century, bricks were molded by hand, by single or double wooden molds with increasing production needs.

- Brick drying: After the molding or extrusion process, the bricks usually had to be laid out to dry. In the earlier or more primitive process they were laid out under rough shelters made of scraps of wood and with straw thatch roofs. Some might lay them out in the sunlight so that the moisture would evaporate. This would take about 3-5 days in the summer and 7-8 days in other seasons. However process is not recommended during the rainy season.
- Brick trimming: The dry bricks would then be trimmed into the same shape and size before they were put into the stove.
- Brick burning: All bricks were put into rows, mostly about 4x6x1.6 m. apart. Then the husk would be laid both between and on the rows of bricks, about 7-10 cm thick. The husk was always added when it was ready to burn. This process would take about 15 days. Wood could also be used instead of husk, however, it is unlike husk which can be burnt with bricks in any open area. To use the wood as fuel, it had to be added under the kiln. This would take about 2-3 days, and the brick which was burnt with wood would be harder than that which was burnt with husk.

Different firing temperatures and improperly or incompletely mixed clays all lead to color variations, even in single bricks. The variation and irregularities of form tend to give bricks that were created in the earlier times a distinctive character and charm. The colors of early bricks varied greatly because their makers had a limited idea of the chemical process which controlled the colors. The normal brick colors of red or orange are derived from the iron compound, ferric oxide, which is about 5-6 % of the clay content. The presence of lime produces cream, yellow, or greenish bricks; magnesia and alumina produce buff bricks. Ferrous oxide can produce colors ranging from green to black and manganese may produce brown or even purple colors.

Figure 91: Typical *din kee* 15x29 cm, Chiang Mai (taken by Vitul L., 4/11/05)

c. Architectural terracotta

The term “architectural terracotta” or burnt clay is used to distinguish the masonry material used to form and decorate buildings which have been and still are used primarily in domestic ceramics and in sculpture. Architectural terracotta is a ceramic material which might be described as a close cousin to the more humble clay brick and clay tile. Terracotta used in Lanna architecture is either glazed or unglazed depending on different processing and manufacturing. It is used in building for masonry, floor tiles, roof tiles and cading tiles. It comes in various sizes and shapes. Unique terracotta in Lanna architecture has its own unique green color or glaze which is called *Celadon.*

Celadon is a green earthen ware whose color is due to its glaze made from ashes of burnt wood. It is baked in the kiln under 1260-1300° C. The creation of *celadon* dates back to about 2,000 years ago by the Chinese. It was inherited by the people of Sukhothai in Thailand where the main production of *celadon* is now at the district of Sawankhaloak. *Celadon* was found in Chiang Mai as King Mengrai, the first King of Lanna, was a friend of King Ramkhanhang of Sukhothai. Thus, the art of making *celadon* was taught to the Lanna people as well. In addition, Chiang Mai is a good source of the black clay filler which is used for *celadon*, as opposed to Lampang where the white clay filler is found. Hence, the terracotta of Chiang Mai and Lampang are different. *Celadon* was one significant construction material of the Lanna kingdom, especially used for religious buildings and residences of the hierarchy people. Although *celadon* was not commonly used, it can well reflect the local wisdom and technology as well as the craftsmanship of the Lanna people.

In the mid twentieth century, architectural terracotta was used to finish and decorate the facades of many shophouses and typical buildings in Lanna. The popularity of terracotta gradually ceased as builders moved to the use of reinforced concrete, glass, and steel. Today, there is generally a limited understanding of what terracotta is, or was, how it was made, how it was fixed to concrete or structures, how it behaved or misbehaved, and how it could be preserved. Failures of terracotta have been publicized in some quarters but often with little understanding of the reasons for such failures.

d. Bricklaying and bonds

The strength of the brick masonry depends upon the cohesive qualities of the mortar and upon the bond. The bond consists of various systems of overlapping the individual bricks from course to course and connecting the inner and outer faces of the wall with “through-bricks” or “bond-bricks.” The walls of historic buildings are nominally 22.5 to 32.5 mm. in thickness, being multiples of the width of a brick plus one or more joints. With an enormous number of variations in historic buildings in Northern Thailand, bricks might average between 27.5 to 32.5 mm. in length (the stretcher face) by 15 to 20 mm. in width (the header face) by 5.3 to 7.5 mm. in thickness.

Typical bonds found in Lanna were variations on stretcher bonds. The usual bond was the “running bond” and “running header bond” in which stretchers or headers in all courses overlapped in such a way that there were continuous vertical joints but there were pieces of roof tiles or small bricks inserted in between those vertical joints. Some stretcher bonds were built with an improved strength by laying “bond” bricks diagonally into triangular recesses formed by clipping off the back corners of adjacent stretchers.

e. The deterioration of historic brickwork

Historic bricks in Northern Thailand tended to be relatively soft and porous. Although this might at first be thought to cause problems of durability, generally the pore and capillary diameters were well in excess of what is known today to be the critical limit of 1 um or below. Paradoxically it is the higher strength, denser bricks with the pore diameters of 1 or 2 um or less, which have been found to deteriorate most rapidly. Failures in historical brickwork usually occur for one or more of the following reasons:

- The original bricks were under fired and tended to crumble when exposed to moisture.
- The brickwork has been saturated with water for long periods, usually from leaking roofs.
- Prolonged water saturation flushes out the mortar, and the brickwork loses its cohesion and strength.
- Water-soluble salts form in or just below the brick surface as sub florescence or crypto florescence. Repeated cycles of hydration and dehydration of the salt crystals in the surface pores then lead to the crumbling or exfoliation of the brick surface. The cause may be associated particularly with prolonged saturation from a leaking roof and rising dampness from soils containing large quantities of soluble salts.
- Acid precipitation and air pollution may accelerate the deterioration of brickwork by dissolving the lime or calcium carbonate from mortars and depositing water-soluble salts.

Figure 92 & 93:

Deterioration of historic brickwork which has been saturated with water for a long period on the *vihara* wall in *Wat* Chedi Luang, Chiang Mai (left) (taken by Vitul L., 4/6/06) and brickwork which has been crushed out with the structure load on the *vihara* wall in *Wat* Baan Ko, Lampang (right) (taken by Vitul L., 19/7/06)

There is a second form of deterioration which is associated with poor maintenance and restoration. The principal forms are as follows:

- When old pointing fails, rather than using the original type of lime mortar again, the misguided conservator may use a mortar which is based on ordinary Portland cement. This change is based on the false assumption that if the mortar is denser, harder, and less permeable, it should be better. If the bricks expand, lime mortar will compact but Portland cement-based mortar will not. In the latter case, the result will be the crushing and spalling of the edges of the brick. If the bricks shrink, lime mortar will stretch somewhat but still adhere, whereas the cement-based mortar may either break away leaving a crack for water to penetrate into the masonry, or worse still, the cement-based mortar will pull the face clean off the original brick. Portland cement-based mortar may contain sulfate impurities which will cause salt contamination of the adjacent brickwork, leading to crumbling and exfoliation of original brick.

- When rainwater leaks have occurred apparently through the brickwork, attempts may have been made to treat the brick surface with paints and/or water-repellent coatings. In some cases these coatings may have caused the retention of water within the brickwork with consequent problems from water-soluble salts. A complete loss of the surface can result from changes in permeability caused by accumulations of such coatings or by the transformation of such coatings caused by reactions with ultraviolet radiation, atmospheric pollutants, and other chemicals.

3. Cementitious products

Cementitious is a term meaning relating to a chemical precipitate, especially of carbonates, and having the characteristics of cement. There are groups of cementitious products used in building construction in Lanna architecture. It can be used as a mortar or binder, plaster, stucco or cement materials for masonry, structure works, and decoration. Most of them are lime mortars and natural cements.

Lime, typically limestone or chalk, is composed primarily of calcium carbonate. Burning (calcination) converts it into the highly caustic material *quicklime* (*poon dib)* or calcium oxide, CaO and, through subsequent addition of water, into the less caustic (but still strongly alkaline) *slaked lime (poon sook), hydrated lime* or calcium hydroxide, $Ca(OH)_2$. The process is called *slaking of lime*.

Slaked lime is most suitable for ancient sites because it is easy to get and is available in Lanna, as well as that it does not shrink too much, is flexible, and porous. Thus, it can release moisture and the air can flow through. In addition, *hydrated lime* is not very salty, hence, it does not decay easily because of moisture. But the preparation process is complicated and takes time, from 3 months to 36 months, and it also needs a large storage area. (It takes time to totally slake). Even though organic additives can make it workable, there may be some undesirable tints occurring when the organic additive evaporates. Its permeability is due to its porous nature, thus the building will be too humid and not comfortable for living. It cannot bear a very heavy weight.

Organic binder additives and a chemical compound of carbon with oxygen, hydrogen, nitrogen, sulfur, and other elements, were traditionally derived from animal and vegetable sources often producing a high cohesion and binders that were less expensive, more stable substitutes for the natural organic compounds. The most commonly found aqueous binders for mortar and plaster are *nam nung kwai* (proteinaceous glues obtained from the boiling and filtering of collagen from the skin of the buffalo) and to a lesser extent, sugarcane, *ma fan*g rubber, *bong* rubber, mucilaginous solutions of complex organic acids and calcium, magnesium, and potassium. Soluble mineral silicates such as sodium silicate (waterglass) and potassium silicate have also been used as inorganic binders, and are especially well-suited for exterior masonry surfaces.

a. Mortars

An old masonry wall is comprised of two things: the masonry units whether they are of brick, stone, or laterite; and the joints between the units. Bricks, stones, and laterite are laid in the mortar and the units are arranged and overlapped in various patterns so that the wall is both strong and resistant to weathering. The various ways of arranging the bricks or stones to provide single or double skins in veneer patterns are called bonds and coursing. The actual appearance of the joint itself is determined by color, texture, and profile. Color and texture are controlled by the mortar materials used in the joint, while the profile depends primarily on a need to waterproof the joints and a desire on the part of the builders to produce decorative effects. Frequently, the joints of old masonry are not the actual binding mortar in which stones or bricks are bedded but a secondary application of mortar known as pointing.

However, when masonry joints are without a binder, the construction cannot be strong. But the use of a binder in and of itself doesn’t solve the problem completely. Mortar is also necessary to be used together with a binder so that binder meets many more qualifications for different types of construction. The type of mortar depends on the type of binder. For example if soil is used as the binder, the mortar is known as *sor din* or mud mortar, which is found in ancient remains or archeological sites, and if the mortar is mixed with plaster, it is known as *sor poon* or lime mortar. Both mud mortar and lime mortars are found in Lanna construction.

- The *Sor din* or mud mortar which uses soil as the main ingredient is called *puek din*, and is found in archaeological sites and ancient remains of more than 700 years old, such as at *Wieng* Kum Kam and *Wat* Ton Gwen. For this type of mud mortar, clay was used as the main ingredient mixed with limestone, sand, sugarcane juice, and water. This type of mud mortar was very thick, as it was necessary to make sure that the bricks would stick together so that the building did not collapse.
- The *Sor poon* or *patye poon* or lime/gypsum mortar which uses minerals as the main ingredient is called *puek poon*, and is found in the Lanna period. This type of mortar was more durable than the mud mortar. *Sor poon* mortar demonstrated the local wisdom of using lime or gypsum minerals in some areas.

Mortar in old buildings can be characterized by three main ingredients: lime or gypsum, aggregate (sand of various grain sizes, shapes and colors) and hydraulic substances (which may or may not be present). Historic mortar mixes varied a lot in their minor constituents but were remarkably similar otherwise. Some typical historic mixtures are:

- Slaked lime and sand at a ratio of 1:2 along with sugarcane mucilaginous solutions (Chiang Mai mixture)
- Slaked lime and sand at a ratio of 1:2.2 along with *nam nung kwai* (Chiang Rai mixture)
- Slaked lime paste and sand at a ratio of 1:1.25-2 along with *nam nung kwai* (Nan and Luang Prabang mixture)

b. Plaster and natural cement

Slaked lime is the main material for natural cement used in Lanna architecture as stated under the topic of Mortar. The preparation process of natural cement to be used as stucco plaster cement and masonry plaster cement is similar to mortar, that is to slake lime for 6 months when preparing it for *poon charp* or *patye poon* or fiber cement used for *Torchis* stucco plaster cement, and 36 months when preparing it for *poon satye* or *patye phet*, an extra strong structure or plaster cement. There are types of *poon* used in Lanna architecture as described in the following:

- *Poon charp* or *patye poon* or fiber cement is for stucco plaster cement and masonry plaster cement. *Poon charp* is composed of one part fresh and well-burnt lime, slaked lime, and one part of soft sand, along with an organic additive with a ratio of 0.01 part *nam nung kwai,* 0.005 part sugarcane and 0.005 part *Bong* rubber as mucilaginous solutions.
- *Poon satye* or *patye phet* is an extra strong structure or plaster cement. *Poon satye* is composed of one part fresh and well-burnt lime, slaked lime, and one part sharp sand, 1/4 part natural fiber like straw, along with an organic additive with a ratio of 0.02 part sugarcane as mucilaginous solutions and 0.02 part *nam nung kwai*.

Poon charp and *poon satye* are used, not only with walls and ceilings, but also with the surface of buildings which are covered with masonry to protect the masonry surface from heat and moisture, the main causes of deterioration. Filler is also a necessary ingredient. Either soft sand or sharp sand is added into the *poon* to protect it from shrinking or cracking when water or moisture evaporates. However, the sand must be washed so as to remove the salt. In addition, natural fiber is also necessary to help strengthen *poon* so it can stick better.

Poon charp is utilized in the following way: The slaked lime is separated into two parts. The first part is to mix with sand at a ratio of 2:5 to paste the inside layer and another proportion of 1:3 to paste the outside layer. The slaked lime which is mixed already will be kept in an iron bucket to seal it and keep out any air which can cause the slaked lime to solidify. The second part of the slaked lime is used for the surface, so the process for preparation is more complicated. That is, the slaked lime is made into balls 10 cm in diameter then they're put outdoors so that the sunlight can remove any moisture. This takes about one day. Next, the slaked-lime balls are crushed, together with *sa* or straw-fiber paper until the paper is mixed into the slaked lime. After that, this *poon* is kept in a plastic bag in the iron bucket filled with water. This takes at least two weeks, or can be up to two months.

The slaked lime must be mixed with *nam nung kwai* along with sugarcane juice. The slaked lime used for the inner and middle side is mixed with sand at a ratio of 2:5 and the proportion for the surface is 1:3. The thickness of plaster should be 9-20 mm. The slaked lime may shrink, so water should be added so that it does not dry easily.

Figure 94:

Plaster cement or *poon charp* mixing with natural fiber and organic additive at Prao, Chiang Mai (taken by Vitul L., 12/6/05)

After applying plaster three times, the surface is covered again with crushed slaked lime which has already been mixed with glue. After the surface is plastered, it will then be glazed. The thickness of this crushed slaked lime is only 2-3 mm and is done in an area where the sunlight cannot reach. Water should be added into the slaked lime every hour then changed to every 3-4 hours. The slaked lime which is mixed in the bucket can be used for only one day.

The slaked lime which turns into plaster will gradually become solid because of the CO_2 which affects the CaO and becomes $CaCO_3$. This side effect is called carbonation, and can take from 1 to 100 years, depending on the thickness of the slaked limed.

Today, the hydrated lime which is manufactured and packed in bags has had impurities removed and cannot simply be used, for example, in mixture with a ratio of 1:2 with sand like in the old mortars. It is necessary to add a small amount of Portland cement or some other pozzolanic medium to replace the missing ingredients and highly desirable hydraulic characteristics. The conservator must also be careful that the Portland cement does not contain sulfates or other impurities which can cause stains and efflorescence in the new masonry. For this reason conservators usually specify non-staining white Portland cement or sulfate-resisting Portland cement.

c. Molded cement

Poon pun, *poon tum*, or *poon nam mun* are all names for the cement used for molding architectural reliefs or sculptures. The *poon* which is mixed and pounded is called *poon sod* which is a soft, spongy substance, and it must be used immediately before it hardens and becomes calcium oxide. In the Lanna mix, oil is always used and called *poon nam mun*.

Molded cement is important for building ornaments. It has been found in Haribhunchai and Lanna architecture, mostly in the walls, posts, door frames, bases, and *chedis*. The brick, stone, laterite, or wood surface needs to be prepared before the molded cement is placed. Terracotta and glass may also be used along with molded cement. *Poon pun* is a one of the Fine Arts of sculpture found in high-reliefs, bas-reliefs, or three-dimensional figures (Suksawat, 1998, p.12). In Lampun, caste cement molds are utilized for this purpose which is called *poon lor.* For *poon tum*, the cement is soft and can be shaped into different figures, even for small parts. However, it will become solid very fast, so it must be used quickly. The ingredients of *poon pun* are as follows:

- Fine slaked lime is composed primarily of calcium carbonate. After burning, calcination makes the highly caustic material quicklime, or CaO. Then some water is add to make it less caustic $Ca(OH)_2$. This takes about 15 days. Some materials which can be used to substitute are crushed shells or red lime.
- Fine sand is round river sand from a mature stage of the river. The particles of soft and plastering sand are between 0.05 mm and 1.00 mm. This helps the cement solidify. The materials which can be used to substitute are stone dust and red sand stone dust.
- Natural fiber is, for example, manila rope, pineapple fiber, newspaper, some types of paper, cotton, wool, etc. These materials are torn up before they are used along with other ingredients. Natural fiber makes the cement stickier.
- Organic binder is traditionally derived form animal and vegetable sources which produce high cohesion but less expensive and more stable and stickier, especially when it is mixed with ingredients like shellac, rubber from trees like *rak or pradu*, *nam nung kwai*, sticky rice, sugarcane juice, sugar, etc. In the North of Thailand, pure tung oil, sticky burnt sugar, sugarcane juice, *ma fang* rubber, *bong* rubber, are all popularly used.
- Additive color is from natural sources like *Chad* which causes red, *rong* which causes yellow and other plants which give different colors.

Ingredients for molded cement include:

- General formula: lime, fine sand, fiber and glue = 5:2:1:2
- Thai formula (for exterior parts): lime 3 kg, fine sand 1.5 kg, natural fiber 100 kg, boiled sticky rice 200 g, *nam nung kwai* and brown sugar 150 g.
- Chinese formula (for interior and detailed parts): lime 3 kg, pine oil powder 200 g, pure tong oil 900 g.
- Foreign formula: cement can be used instead of lime.

After considering which formula should be chosen, mix all ingredients altogether and pound them in the mortar, then add some glue, boiled sticky rice, water, and lime and pound again until the mixture becomes a sticky paste. Thai cement must be kept carefully, avoiding moisture and air for at least one week. The longer it is kept, the more sticky it becomes. On the contrary, Chinese cement cannot be kept for a long time as it will become solid.

The surface for molded cement can be brick, stone, laterite, wood or a surface covered with cement. The *glone* or the model is prepared before it is coated by *satye*, sticky cement, or *tuak*, cement mixed with glue from cattle skin and sugar. In the Chinese formula, sesame oil is mixed with lime then it can be shaped into different figures.

- For brick surface, it needs to be pounded as the cement works properly on a rough surface. Then the *glone* is coated, followed by preparing the *tuak*. If the brick at the surface is not burnt at the right temperature, the molded cement can crack easily.
- For fine and hard store surfaces, *glone* is coated with cement. Then *tuak* is used to stick on the store, followed by molding.
- For a laterite surface, as it is rough, it can stick with cement very well. However, if it is not hard then it can crack easily when there is moisture.
- For coated surface, whose previous surface may be brick or stone, this directly relates to molded cement. In other words, if the surface is not coated well, the molded cement can be damaged easily.
- For wooden surface, it is coated before molding. However, if the wooden structure is deteriorated, the molded cement will be damaged as well.


Figure 95 & 96:

Cast cement mold for *poon lor* in *Wat* Seang Khao Noi, Pasang, Lamphun (left) (taken by Vitul L., 17/2/07) and molded cement in *Wat* Koklang, Pasang, Lamphun (right) (taken by Vitul L., 5/7/06)

d. Concrete

Portland cement was first manufactured in Thailand in 1913. It was introduce in Northern Thailand around 1918 when the railway reached Lampang and 1921 when a railway to Chiang Mai was completed. Modern cement and construction has since spread all over Lanna.

e. Other forms of mortar deterioration

In historic buildings, mortars are usually found to have deteriorated for one or more of the following reasons:

- The removal of carbonates from the lime by prolonged penetration of the masonry by large quantities of rainwater which is usually acidic. Mortars are thus reduced to wet sand and fragments of deteriorated mortar with little or no cohesive, compressive, or adhesive strength.
- The crumbling of the mortar caused by the expansion of clay minerals included in the original mix and later subjected to long periods of wetting. Clay minerals often have clay, loam, and organic material which can cause them to crumble.
- The crumbling of the mortar caused by the presence and growth of masses of crystals of anionic salts such as chlorides, sulfates, and nitrates.

Figure 97 & 98:

Deterioration of plaster and mortar and a damaged mural painting caused by leaking roof allowing for shrinkage in masonry units in the *vihara* in *Wat* Baan Ko, Lampang (left) (taken by Vitul L., 19/7/06), deterioration of repair plaster which is brittle and breaking away at *Wat* Ubosottha, MaeHea, Chiang Mai (right) (taken by Vitul L., 6/4/04)

Occasionally deteriorating mortars are found to be repaired mortars which have been made with unsatisfactory mixes. Typically these cause failures because they contain too much Portland cement and no lime. Associated problems are as follows:

- Joints will open and admit water because the mortar is inelastic and fails to allow for shrinkage in the masonry units.
- The edges of the masonry units are shattered by the hard mortar which will not compress when the units expand.
- Thin feathered edges of hard mortar may be brittle and break away, opening joints to water penetration.
- Sulfate impurities from ordinary Portland cement may damage the adjacent units and cause the joint to fail through loss of adhesion.
- Adhesion may be lost because of a reliance on the use of synthetic resins for the bonding of a repaired mortar followed by the "re-emulsification" of the resin when exposed to water. Many "bonding agents" are based on droplets of synthetic resins which are held in suspension in water. These are often but erroneously described as "emulsions." Certain resins may be suitable only for use inside

buildings where they will not be exposed to water. If exposed on the exterior of a building, when they get wet, the solid resins may return to solution, lose all strength, and even be washed away and when the resin breaks down in rainwater, the mortar patches fall from the face of the building.

- The use of “dead” mortars which have been allowed to partially heal or harden, rather than throwing them away and making a new batch, the inexperienced mason adds water to make them “workable.” This problem often occurs when workers are being asked to use lime/cement mixes which to them are unfamiliar. Improperly handled, such mixes crumble as they dry. When only small areas of mortar repair work are being called for in various locations, there is often a tendency for the mason to mix too large a batch and then to try and stretch the use of that batch beyond its usefulness.

4. Roofing materials

Roofing materials are important character-defining features of historic buildings. Most historic roofs in Northern Thailand are covered with baked terracotta tiles or ceramic tiles. Some of them have been changed to modern baked tiles or ceramic tiles or even asbestos cement tiles. However, historic roofing material, such as wooden shingles, baked tile, or cement tile, should be retained or replaced by matching material whenever possible. The following are some typical historic roofing materials with some of their qualities:

- Wood roofs were generally popular in Lanna but are now expensive. New preservatives can extend the life of shingles up to 30 years, however, are not appropriate for many simple buildings and religious buildings.
- Baked tiles were very popular in many types of buildings. These roofing materials are still manufactured.
- Cement tiles are a common roofing material for houses and shophouses dating back not over 75 years. Most of them are locally made but the use is obsolete in the construction industry.
- Ceramic tile was favored for temples and religious buildings. It is expensive but extremely long lasting. This should be used to replace damaged existing tile roofs. It may also be used for buildings of the appropriate style and period.

a. Wood roofs

Wood roofs are probably the most traditional in Northern Thailand. Wood roofs come in only shakes types called *pan kled.* Shakes are hand-split tapering pieces. They are usually 6 to 14 inches long, and of random widths. These are probably the earliest permanent roofing material in Lanna, though a few original shake roofs remain. Shingles are new in Lanna roofing material comparable to shakes, they are sawn rather than hand-split into 8 to14 inches lengths. Both shakes and shingles are hung on purline, usually with nails forming a hook on the purline. They should never be attached to solid decking, such as plywood, as they need to breathe. Wood roofs were once notoriously short-lived. But this is now less true. Shakes that have been traditionally made from hardwood and teak are also used. Both shakes and shingles can be pressure-treated with both fire retardant and wood preservatives. Wood roofs can be expected to last 20 years. The *vihara at wat* Bann Ko has lasted 50 years with five-year intervals of maintenances and few replacements.

b. Baked tiles

Baked tiles which were widely used for roofs in Lanna buildings are called *din khor*. Not only for the *vihara*, but also other baked tiles were more durable than that made from natural items, such as leaves, straw thatch roofs or wood roofs. Moreover, they are easier to repair and change as the old piece can be removed, then the new one is inserted from the inside instead. It is unnecessary to remove all tiles or repair on the outside of the building like when repairing roofs made of other materials. Fired or burned tiles have been used since the Haribhunchai period. All over Lanna, the process to produce *din khor* is similar to the following:

- Clay selection. Marls clay, the principal material in *din khor*, is composed of a mass of fine particles derived from the erosion and chemical breakdown of igneous rocks. Lanna tile-makers often used 100 % marls clay soaked in water for 24 hours.
- Clay pressing. Clay pressing is another form. The selected clay should be taken out from the water, any gravel and sand are removed and the clay is mixed with husk. The next step is pressing the clay by hand, or sometimes by grinder to make it stickier.
- Tile molding. The wooden block which is used to set the shape of the tile must not bend when it touches water or moisture. Some ash may be put onto the block so that the clay does not stick on the block. Then, that clay is put onto the block, and a wire is used to trim the rim of the clay. A wooden triangle tee which is wet is used to sweep away the extra clay out, and then remove the clay from the block. The molded-clay is then trimmed at its ends, and bent at certain angles which are very practical for placing on roof purlines. The standard sizes used for construction in Lanna are 11x22.5 cm. (12 cm 135 ea per 1 sq. m.) and 16x34 cm. (20 cm 87 ea per 1 sq. m.) when it was handmade, therefore, the molded-clay was very thin (only 3-4 mm.) Various types of ridge covers are added to accompany the *din khor.*
- Tile drying. After the molding or extrusion process, the tiles usually had to be laid out to dry. The blocked clay was laid out in the sunlight for about two hours or laid out under rough shelters made of scraps of wood or with straw thatch roofs for about two days. This process is not recommended during the rainy season.
- Tile burning. All tiles are put into rows in the 3.00x3.00 to 5.00x4.00 m. kiln, and then the wood is put between and on the rows of tiles. This

process takes about 30 hours. They are fired at the highest temperature until they become red or brown.

- Tile pieces are baked for about five days. Then it's necessary to wait for about ten days until they become *din khor* and can be used.

In the past, to prepare this type of roof, it was mostly done in an area nearby to the construction site because most *din khor* was used for the roof of the *vihara*. As it is fragile, it is inconvenient to transport because the tiles might crack.

Figure 99 – 114

Cement tile design, *Vaw* tile and drying process in local manufacture in Chiang Mai (taken by Vitul L., 8/12/04)

c. Cement tiles

Cement tiles were available in many shapes and sizes. The most distinguished were called *Vaw* (kite or diagonal shape) or called *vi bul shi* (trade name of a roofing manufacturer in Bangkok). It was the favored roofing material for houses and shophouses during the early 1900s in every province. The process to produce cement tiles was as follows:

- Cement mixes. Old slaked lime was suitable for making cement tiles for over 24 months. A big roller was used to crush slaked lime to a fine particle. In the wet mixture process known as *poon satye,* slaked lime and sand were mixed in the proportion of 1:2 to which sugarcane mucilaginous solutions or other organic binders were added together with carbon, oxygen, hydrogen, nitrogen, sulfur, and other elements. Soluble mineral silicates such as sodium silicate and potassium silicate have also been used as inorganic binders. These were especially well-suited for very low permeability for roofing tiles.
- Tile molding. A metal mold and block was used to set the shape of the pressed tile. Some ash was put onto the block so that the tile would not stick to the block. The metal mold and block was then pressed,

and the tile removed from the block. The molded-tile was then released from the block.

- Tile design. There are several types of ridge covers to accompany cement roof tiles. Some had a permeability rate of less than 10% with un-reversibility rainwater protection design for example: the following common types of tiles have been recorded:

  - *Vaw* small 20.5x30 cm. weigh 1.2 kg. (12.5 cm. 39 ea per 1 sq.m.)
  - *Vaw* big 25 x 36 cm. weigh 1.8 kg. (15 cm. 26 ea per 1 sq.m.)
  - Strait cut small 15 x 26 cm. weigh 1 kg. (18 cm. 74 ea per 1 sq.m.)
  - Strait cut big 20 x 27 cm. weigh 1.5 kg. (20 cm. 48 ea per 1 sq.m.)
  - Lotus 21 x 33 cm. weigh 1.5 kg. (13 cm. 36 ea per 1 sq.m.)
  - Honeycomb 20 x 35 cm. weigh 1.5 kg. (15 cm. 33 ea per 1 sq.m.)
  - Wave 19 x 31 cm. weigh 1.2 kg. (12 cm. 42 ea per 1 sq.m.)
  - Regulated 24 x 38 cm. weigh 2.5 kg. (30 cm. 16 ea per 1 sq.m.)

- Tile drying. After the molding or extrusion process, some tiles were usually laid out to dry under rough shelters, and then weathered about five days before used.

d. Ceramic tiles

Ceramic tile roofs are not common in Lanna. They were reserved only for use on the royal *wat* or main religious places. However, ceramic tile is an appropriate material for many important buildings. Ceramic tiles come in a variety of patterns. Most of them are molded and shaped in the same manner as local baked tiles and cement tiles with interlocking pantiles. They have a rough "S" shaped profile, with an interlocking "V" profile barrel or they are built with lips that overhang battens for secure fastening. Tile is a long-lasting material when properly maintained and can last indefinitely. Failure usually is the result of structural problems or a pin failure. When used for the royal *wat* or main religious places, the only color allowed is red, along with using the highest-grade materials.

Figure 115:

Wooden roofs of more than 60 years old in the *vihara* in *Wat* Baan Ko, Lampang (taken by Vitul L., 19/7/06)

e. Roof deterioration

Wood roofs, baked tiles, cement tiles, and ceramic tiles each have their own characteristic materials. The better the roofing material, the longer the roof will last. High quality roofing materials greatly extend the life of any roof. Roofing material is priced by squares. Prices are given both for materials and for labor. Often a cheaper material will require the same labor costs, so apparent savings on materials should often be reconsidered. Roofing problems can be the result of the failure of support systems. The decking, battens, and rafters should all be inspected. Sometimes the structural system is inadequate for the roofing material. Always consider the bearing capacity of your roof when considering a new or heavier roofing material. Roof slope is expressed in terms of the rise in Lanna which is around a 35-45 degree of run. The rise is important in choosing and applying materials. Wood would not be suitable for roofs with low rises. The relative rise should be carefully considered when selecting materials. Roofing problems of broken pieces are replaced in kind, changed as the old piece can be removed, and then a new one is placed. Therefore spare tiles should be kept in store for replacement. Hailstorms are main cause of roofing problems. Sometimes they could devastate the whole roof of every building in a village in only one storm.

Figures 116 & 117:

Cement tiles of more than 60 years old in the *vihara* in *Wat* Jaeson, Lampang (left) (taken by Vitul L., 10/2/08), tiles of one shophouse at Kad Kongta, Lampang (left) (taken by Vitul L., 24/10/05)

5. Architectural glass

The development of the use of colored glass for the *vihara* in Northern Thailand is somewhat hazy but it appears that the *vihara* built during the sixteenth century A.D. was decorated with colored glass at the pediment. It is also recorded that many *viharas* in Chiang Mai were employed with thin cut and colorful polished glass. The story of the development of glass in Lanna is not the scope of this work but from the field study the glass, called *kaew cheun* or *kra jok kriap*, was mostly used for the ornament of Lanna architecture, especially the *vihara* and *ubosotha*. It was used with wood and stucco and mostly at the pediment, gable shaped board, *ma tang mai*-main structure, the top of the pediment's poles, hexagonal posts at the front, and the main posts. *kaew cheun* was also widely used in other provinces in the northern area.

The earliest plain colored leaded glass used for decoration in Lanna was imported from England via Burma and can be dated with certainty to the 1900s. It was used to substitute *kaew cheun* as it was easy to produce. However, it was thick and hard to cut; thus, it seems not so neat for decoration.

To stick *kaew cheun* or *kra jok kriap* on carved wood or stucco, *lacca* or *rak samook*, which is made of rubber from the *melanorrhoea* tree and banana leaf charcoal, was used. Some may have used resin, rubber, and lime which when mixed were sticky and then the glass could be placed on the surface.

a. Glass materials and the manufacturing process

The main ingredient in all glass is silica which may be derived from sand, quartz, crystals, or flint. However, a temperature of about 3100°F (1704 $^{\circ}$C) is required to melt silica. Thus pure silica has only been used comparatively recently to form high temperature resistant glass (Weaver 1993, p.233). During the Lanna period, neither Siam nor Burma had furnace technology capable of reaching over 1200 $^{\circ}$C at that time. The Burmese discovered that if one mixed lime and soda with the silica, its melting point was lowered and it became cheaper and more practical to make glass. In fact, the melting point was lowered to 2700 $^{\circ}$F (1482 $^{\circ}$C), but the addition of metallic oxide such as lead oxide also caused the same effect of lowering the melting point, hence, the working temperatures still further. In these early formulae, soda ash was usually referred to as the “flux” and limestone as the “stabilizer”. A flux is any substance which can be used to lower the melting point of another material and reduce viscosity. Broken glass known as “cullet” can also be used to lower the melting point of a new mixture. Stabilizers such as calcium or magnesium oxide improve the chemical durability of the glass and prevent crystallization or disintegration of the glassy mass. Glass may be colored accidentally, for example, by the inclusion of small quantities of iron compounds, thus, the glass has a greenish color. Different states of oxidation produce different colors in glass. Other colored glass may be formed by mixing small quantities of mineral oxides with the silica and other ingredients. Colors in the glass may be of two basic forms, that is, when the metal oxides are dissolved in the glass, or when the metal is dispersed through the glass as minute particles in what are known as colloidal dispersions.

b. Glass types

Architectural Glass in Lanna may be classified into two types:

- *Kaew cheun* or *kra jok kriap* is glass which was cast onto a sheet of tin. *kaew cheun* was mostly used for the ornament of Lanna architecture, especially the *vihara* and *ubosotha*. *Kaew cheun* was also used as the ornament for sculpture as they are very colorful, mostly green, blue, white, yellow, and brown. *Kaew cheun* in Lanna was commonly manufactured in and imported from Burma, whose colored glass was produced from an ancient technique known since the early 1800s. *Kaew cheun* contains substantial amounts of lead oxide which was used as the flux, is characterized by high density, high refractive index (high luster), relative softness, and ease of working. They are placed on very thin pieces of tin. Although they crack, they still stick on tin. The Burmese also discovered the application of thin glass on a tin sheet which is called Ava or Amarapura or Angwa glass and Bagan glass. The formula consisted of potassium nitrate (saltpeter or gunpowder), *pag klong,* cullet, and natural glass sand. Then they were heated altogether like steaming rice, so it was sometimes called *kra jok houng* (steaming glass), and were placed on 1 mm piece of tin which was easy to cut. This type of glass was popularly used in central Thailand at the end of King Rama IV (1815) when the *kra jok houng* department was established. However, in Thailand, natural glass sand contained more iron oxide than in other areas, therefore, the glass quality and clarity were not suitable for use. For Lanna, glass for decoration came from Burma who produced two types of *kaew cheun* which were in thin pieces and done as balls for ceiling decoration. At present, *kaew cheun* is not produced even though it is needed for conservation.

- Plain colored glass is the leaded glass which is polished and beveled. The pieces of glass are set into lead strips of a cross section like the letters H, I, or C. These strips are known as "cames" which are made of lead and are subject to plastic deformation under load. Thus leaded glass work may be found sagging; then they are no longer properly supported and the glass may become loose. After 80-100 years the lead may be seriously brittle or corroded and harmful to the environment. Leaded glass was commonly imported from Western countries. The glass was known as "pressed glass". Small, often colored, panes were produced for windows, interiors, and screens. This type was actually made in a mold and was often highly decorated in bas-relief with designs as leaf and vine motifs, steamboats, Gothic tracery, and fine geometrical patterns. It was used in residential areas and shophouses in Northern Thailand.

Figure 118 & 119:

Kaew cheun, wooden decorative elements on *nah bun* of the *vihara* in *Wat* Pong Sanuk, Lampang (left) (taken by Vitul L., 17/6/05), *Kaew cheun* on *nah bun of the vihara* in *Wat* Ubosottha, MaeHea, Chiang Mai (right) - (taken by Vitul L., 6/4/04)

c. Glass deterioration

Glass can react with water or with aqueous solutions with chemical changes occurring first at the surface and possibly spreading right through the thickness of the glass. The seriousness of the deterioration depends particularly on the chemical constituents of the glass and the pH of the liquid. It is believed that water molecules diffuse into the glass and react with free oxygen atoms to form hydroxyl ions which then migrate out with the alkali cations from the glass causing what is known as “alkali extraction”. A hydroxyl is a radical containing hydrogen and oxygen. Radicals are fundamental atoms or groups of atoms which normally form parts of compounds but which remain unaltered during the compound’s ordinary chemical changes. Eventually all the alkalis are leached out and only separated silica layers remain; the glass becomes iridescent and loses transparency. The iridescence is caused by rays of light being reflected from thin alternating layers of air and weathered glass (Weaver 1993, p.235). Different forms of deterioration have been found on glass. As an example of the range of problems which may be encountered with any major sampling of architectural glass, and also a known typical defect include: un-weathered but not bright and shiny, half-pitted and half-weathered, and pitted and crusted.

Much *kaew cheun* and glass has been found severely damaged by exposure to air pollution in the presence of prolonged acidic moist conditions. The glass has high lead, calcium and/or magnesium oxide contents and/or high potash contents but generally has a different composition from those used in Northern Thailand art and architecture. The use of the former *kaew cheun* and glass in similarly polluted environments would of course result in similar health problems. The major problems from their use may be summarized as follows:

- The exposure of *kaew cheun* and glass which were not fired at sufficiently high temperatures and in which consequently mineral oxides may be liable to leaching in polluted environments with the associated formation of porous layers in the glass.
- Failure or collapse of the glazing structural system due to problems with lead cames or glazing bars; corrosion in iron or tin reinforcement and supports; failure of putties or glazing compounds; and rotting of wooden frames-all of which may be directly or indirectly related to exposure to acidic precipitation or air pollution.
- Alkali solutions, hydrofluoric acid, and phosphoric acid all actively attack and corrode glass and support systems. All of these substances are used in pediment cleaning formulations and could thus cause damage in localized pollutant spills, wind-born overspray, or contaminated runoff incidents.

Figure 120:

Plain colored (clear) glass on the main entrance of one historic house in Pang Bong, Lamphun (taken by Vitul L., 8/8/05)

6. Architectural painting and coating

Architectural painting and coating have had a long and continuous history in historic buildings. When the surface is finished, these materials provide protection as well as articulation and decoration for building materials including wood, brick, plaster and stucco. Although they are easily obliterated by continual changes in taste, and altered by environmental agents causing fading, darkening, and loss architectural painting and coatings remain fundamental in the traditional building materials. Northern Thailand developed their intelligence, traditions, materials, and skillful labors over the centuries. This involved the establishment of well-developed techniques which provided the necessary range of raw materials and tools to a builder and his apprentices for both the preparation and application of painting.

By the end of the nineteenth century however, technological changes led to the mass-production and marketing of “ready-mixed” painting materials and the establishment of large imported paint material businesses, thus, causing changes in the nature of the products as well as the trade. A broader range of synthetic resin painting and related coating became widely available. Despite these technological advances in the use of painting and coating, their use remained remarkably unchanged.

Traditionally, Lanna architectural painting and coating have three main developments as follows:

- Gold lining is to use *Jung Go*, the bronze mixed with metal like gold or copper, to envelop the *chedi* in order to appear long lasting golden and prevent deterioration.
- *Rak,* or *lacca* coating with or without gold foils is to decorate carved wood, especially for buildings for high-hierarchy people and temples. *Lacca* can also protect the wood.
- Painting is to easily decorate wooden and masonry buildings by using oil-based or water-based color. This method is not very hard or expensive, so it is generally used for most buildings.

a. Gold lining

Jung go is mostly used as a gold lining material to protect the *chedi*. Bronze, which is the main mixture of *jung go*, is collected mostly from people who donate it to make merit as *jung go* is for the *chedi*, a sacred place, such as at the *chedis* of Phra That Doi Suthep, Phra That Hariphunchai, Phra That Lampang Luang. At present, the *chedis* are at risk of collapsing. An earthquake or hard rain can make the soil at the base of *chedis* become soft and then turn to sludge; moreover, these circumstances along with additional moisture hastens the collapse as the cement becomes soft as mud. In addition, the floors around the *chedis* which are made of granite are too hard for humidity ventilation. Some *chedis* were covered by *jung go* twice for conservation. This can support the *chedis,* but they can still collapse if a natural disaster is very serious. Furthermore, there is also the lack of understanding by the local people about the right causes of the deterioration or collapse, and also the conservation. Such was the case at Phra That Phanom in North-Eastern Thailand, which collapsed 30 years ago, or the case of the *chedi* at *Wat* Pun On in Chiang Mai which collapsed in 2006.

b. *Lacca* coating

Lacca or rak coating with or without gold foil, needs skillful artisans who have to pay careful attention and devote much time to this method. The process starts with coating the *rak* in several thin layers until the surface becomes thick. After that the pieces of gold foil are put in place. This process needs much care so as to prevent a seam from forming between each gold foil. This process is done in an area where the wind cannot interfere. This method can help protect the wooden surface from deterioration caused by sunlight, rain, or insects such as termites.

Rak (*melanorrhoea*) can give natural rubber, called *lacca*. In Thailand, there are four types of *melanorrhoea,* which are the *melanorrhoea ustata, melanorrhoea laccifera*, *melanorrhoea pilosa,* and *melanorrhoea glabra.* The *lacca* has been used for more than 4,000 years to protect wooden surfaces, especially on the exterior sides which are exposed to the sunlight, wind, or rain. *Lacca* is also used to coat utensils for aesthetic purposes and making them durable. An example of this is the Chiang Mai lacquerware. Names and types of *lacca* are as follows:

- *Rak dib* is the liquid from the *melanorrhoea* which is originally white then becomes brown liquid when it comes out of the trunk.
- *Rak nam kliang* is *rak dib* mixed with other mediums or vehicles, used with *samook* to make the surface shiny.
- *Rak samook* is *rak nam kliang* mixed with *samook* or ash from burning weeds, banana leaves or with crushed soil. It is used for moulding, filling, and surfacing.
- *Rak klia* is *rak nam kliang* and ash from banana leaves. It is used for filling, and resurfacing.
- *Rak ched* is *rak nam kliang* which is boiled until it is sticky and then used with gold plates or covered on the surface.
- *Rak sai* is a type of rubber which when it is extracted looks like pure liquid and seems colorless, however, as it is used to mix with other *rak* it can change colors.

Samook is the filler which can be categorized accordingly:

- *Soft samook*, such as the white clay filler or clay filler which is then mixed with *Rak rak nam kliang* and used as a foundation.
- *Hard samook* such as the ash from burning weeds, charcoal from banana leaves, charcoal from straw, or lime (calcium hydroxide) mixed with *rak nam kliang* and used as a thick and hard foundation.

Figure 121 & 122:

Gold lining on *Chedi* Wat Pun On, Chiang Mai (taken by Vitul L., 2/7/07)

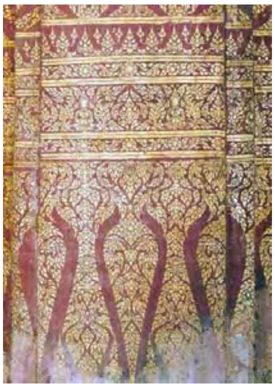


Figure 123:

Lacca or rak coating on the *vihara* wall in *Wat* Chedi Luang, Chiang Mai (left) (taken by Vitul L., 4/6/06)

c. Painting

Painting materials are composed of two basic components: the colorant and the medium or vehicle. These components individually and collectively determine the physical, mechanical, and chemical properties of the resulted paint systems as well as their application techniques. It is the function of the colorant to impart color, texture, and opacity or transparency to the system while it is the role of the medium or vehicle to provide initial fluidity during application, subsequent adhesion, and durability of the film. Pigments or colorants are the actual coloring materials used in dry powder form to impart color and opacity to the paint. They are finely divided coloring materials which are suspended as discrete particles in the medium or vehicle in which they are used.

In Lanna, pigments were obtained from a wide variety of mineral, animal, and vegetable sources often classified as organic and inorganic. The inorganic pigments include the naturally occurring earth clays such as the yellowish-brown crushed minerals. These materials in turn can be further burned to extend the range of colors. Organic pigments, composed of carbon with oxygen, hydrogen, nitrogen, sulfur, and other elements, were traditionally derived from animal and vegetable sources producing often highly colored pigments and dyestuffs such as lamp, vine or bone black, madder, carmine, and indigo. Sometimes used directly in a paint vehicle, dyes are more frequently transformed into paint pigments such as mineral oils, resin, shellac, and *lacca* (a natural organic red dyestuff) by precipitating them directly onto inert carriers such as aluminum hydrate or calcium sulfate.

The medium or vehicle is usually the liquid component of the paint system which acts as the carrier of the pigment allowing it to be applied to the surface and to contain the binging material thus giving the paint its cohesive and adhesive film-forming properties. The medium is often composed of two separate components: the binder or non-volatile portion and the solvent or volatile portion. The solvent aids in the initial application and penetration of the system. It later evaporates during the film formation such as in the evaporation of water from glue distemper paint or mineral spirits from oil base paints.

Paints traditionally used in Northern Thailand are classified by their medium either in terms of the vehicle, as in water or oil-based; or of the binder, such as *nam nung kwai*, mineral oil. Many natural substances derived from animal, plant, and mineral sources have been used as binders for traditional paints. Most natural binders are either aqueous or non-aqueous.

- The aqueous binders for traditional architectural paints are *nam nung kwai,* proteinaceous glues obtained from the boiling and filtering of collagen from the skin, bones, tendons, and cartilage of buffalo and fish. Additionally, they come from mucilaginous solutions of complex organic acids and calcium, magnesium, and potassium. Soluble mineral silicates such as sodium silicate (waterglass) and potassium silicate have also been used as inorganic aqueous binders, especially well-suited for exterior masonry surfaces.
- The non-aqueous binders were considered new material in Lanna because of their durability and water-repellent properties then in wide use. The most commonly employed of these is linseed oil from flax or nut. This type of oil possess the ability to form a solid, elastic film when exposed to the air in thin layers. Other types of oil such as fish oil, when combined with driers such as red lead, were often used as an inexpensive substitute. Plant and tree resins and exudates such as balsam, copal, and insect shellac were used alone or in combination with pigments or dyes to create hard protective varnish coatings often reserved for fine woods. They were also used as glazes over paints by dissolving them in distillates such as spirits of turpentine or heated oil. In addition, plant and animal wax and coal and tar were used as hydrophobic vehicles for paints and waterproof coatings.

The most important of the water-based synthetic resin systems to be used for late historical buildings are the “latex paints.” First introduced in Northern Thailand in 1921, these water-based latex emulsions quickly replaced the less durable paints used for interior painting.

d. Paint systems

All architectural paints are prepared by grinding or mixing the pigment and medium together into a paste or liquid. Originally done by hand using a slab and muller, this laborious process was eventually mechanized for increased production and consistency of the product. Depending on the medium selected, all architectural paints can be classified into systems based on the mechanism of film formation as follows:

- Solidification by crystal formation. This system does not employ an organic resin to create a film but rather relies on the curing of the substrate. Such examples of this include the carbonation of the lime (CaOH) substrate of a reactive component in the paint as well as in the formation of calcium silicates in cementitious paints. This system is suitable for a masonry wall.

- Solidification by solvent loss. Film formation occurs by the application of a natural solution, aqueous or non-aqueous, and then the evaporation of the solvent leaving a hardened resin pigment film behind. Paints formed exclusively by this process such as glue distempers can usually be reactivated by the application of the solvent. This system is suitable for wood.
- Solidification by coalescence. Film formation in this group is characterized by the creation of emulsions wherein the resin is suspended in water by emulsifiers which, upon evaporation of the water, cause the resin molecules to coalesce or form a thin uniform continuous film. Because of the tight flexible nature of this film, these acrylic and polyvinyl acetate 'latex' paints provide great durability and easy safe application.

e. Painting and coating failure and common deterioration mechanisms

Surface finishes, paints and related coatings are dependent on the overall condition of their substrate and their immediate environment. Therefore, paint failure is often indicative of other serious building problems such as water penetration through defective detailing or related deterioration. A wide variety of paint film failures can occur as a result of specific conditions related to:

- the composition of the paint itself or its application methods, such as poor surface preparation or application techniques;
- the chemical or mechanical incompatibility of different paint layers; and
- situations of extreme exposure, such as severe climates or heavy water-shedding elements on a structure.

The most widely occurring conditions are described below:

- Peeling and blistering rank among the most common deterioration problems affecting paints and related surface coatings. Characterized as a general loss of adhesion between layers or at the substrate interface, this condition may be caused by a variety of diverse factors. These may include improper surface preparation, incompatibility between overlaying paint films such as oil and latex emulsions, and the entrapment and migration of water or water vapor behind the paint film.
- Solvent blistering, a related condition, is not caused by external moisture but rather by the entrapment of a volatile component of the fresh paint as a result of paint film drying too rapidly.

- Wrinkling, another condition related to application, will occur if paint films are applied too thickly or before the previous coats have dried or if the paint is applied to too cold a surface. The resultant film will not only appear deformed but can result in a loss of gloss and color.
- Crazing, checking, or surface microcracking result when paint films have become too brittle or thick and are no longer able to expand and contract in response to changes in the ambient temperature and humidity or dimensional changes in the substrate (i.e. wood). Such failures may result from poor quality paint or insufficient drying time between coats.
- Staining and discoloration can be attributed to a wide variety of sources. Microbiological attacks such as by fungi, mold and algae accounts for a great deal of black, brown, and green surface discoloration as well as staining from the substrate itself as in the case of the oxidation of metal nails, or the bleeding of resinous knots in poorly prepared wood. Photochemical degradation of the pigments and media will also result in varying degrees of visual change depending on the composition of the paints.

Chapter 6

Lanna building system

This chapter of this dissertation is dedicated to each of the major building systems and techniques for Northern Thailand. Each subject contains a physical structure and describes its behavior.

1. Footings and foundations

A foundation is defined as the base or substructure which supports a building, whereas a footing is the lower part of a foundation. The footing is the lowest wide base course or stepped courses which begin at the bottom three or four times as wide as the wall, and gradually reduce to the width of the wall in about three or four steps. The proper construction and the condition of a foundation under an old building depends on a number of factors as listed below:

- The ground and the site on which the structure was built.
- The materials used to build the foundation.
- The influences to which the foundation itself, its surroundings or bearing materials are subject to, or have been subjected to.
- The building or structure erected upon the foundation and its loading on the foundation and on the soil or rock beneath the foundation as states in the nature of action and reaction.

In any given situation, when a structure is placed upon the ground, the mass of the structure tends to move downward under the influence of gravity. If the downward action is matched by an upward reaction, this means that the old foundation will be stable. If it was placed on soft compressible soil, then that soil would have compressed to a point at which it resisted further compression. The structure then remains stable until the load is increased or decreased, or until the bearing capacity of the ground is changed. Since the loading upon a foundation and on the soil beneath is rarely totally even, there is a tendency for foundations to slowly sink in the direction of the heavier load. A weakening of the soil results causing the whole previously stable supported structure to move downward until sufficient resistance is gained. Such a weakening will occur when subterranean water removes fine material from the soil, creating voids; or when organic material such as wood in the soil decays and creates voids. However, much smaller movements can still result in serious damage being caused to a structure.

Movement in unstable foundations occurs in two directions—both downward and upwards. If there is a decrease in the load or an increase in the reaction from the soil beneath, this may result in an upward movement of the structure. When a new building is placed next to an old one, the foundations and particularly the soil between the foundations of the old building may be thrust upward. When the excavations for the adjacent building or for the new buildings, cause lateral soil movements, the water flowing through the soil also helps to reduce the bearing capacity of the soils and allows the heavily loaded footing to sink further into the ground. A sudden reduction can cause equally sudden settlement and cracking in a foundation. These circumstances have occurred in buildings all around Lanna and are similar to those that have happened in other places.

a. Structural characteristics

Traditionally, the structure of Lanna architecture was designed for small buildings on posts situated on stone footings which were then developed as wooden footings, and also brick footings which have high bearing capacity. There are five types of footings as follows:

- Single pointed footings using stone or rock. Wooden poles are placed on stone or rock to bear the load to the ground for a typical house.
- Single pointed footings using timber. This is for small residences where wooden poles are on pieces of wood whose sizes are the same as the poles. Hardwood as a footing is able to bear the load of the building. For big buildings, logs are used to bear the load on compacted sand-filled base and this is called *mae non sai.*
- Single pointed footings using masonry. Wooden poles are placed on masonry to bear the load of the building to the ground. Shapes of masonry are different, depending on the size of the building. This type of footing uses both brick and wooden poles, and *poon satye* is used as plaster.
- Continuous footings using masonry. A wall bearing brick is prepared along the walls or ceilings to bear the load of the building to the ground. *Satye* cement is used as plaster. This type of footing is for religious buildings, *khum*, government buildings, and shophouses.

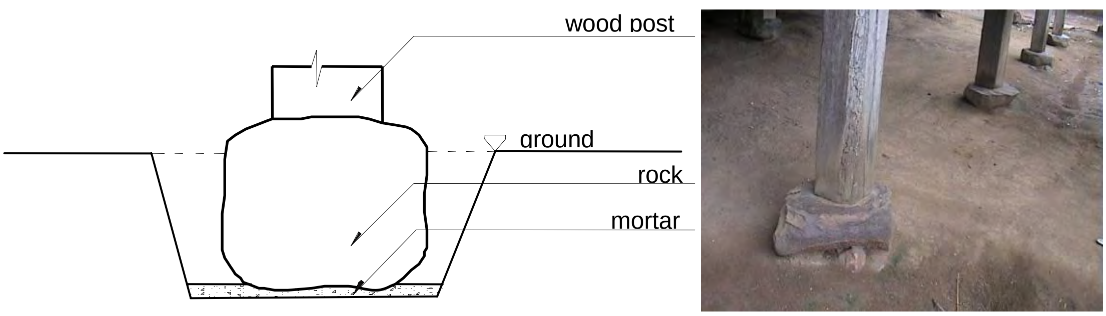


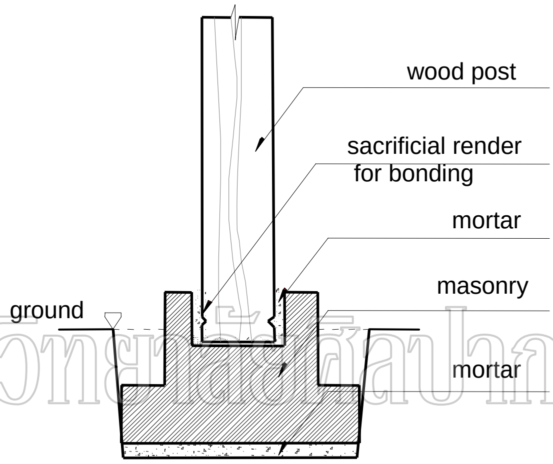
Figure 124 & 125:

Single pointed footing using stone or rock in historic house in Wiang Nua, Nan (drawn by Vitul L., 24/11/07 and taken by Vitul L., 4/11/02)

- Piling. Piles have been used, not only to carry foundation loads to deeper and more solid strata, but also to gain resistance from friction on the sides of the piles. Early piles were always made of timber and might consist of a series of round tree trunks driven deep into the ground in closely set rows capped with one or two layers of 3 or 4 inch thick planks. Piles were rarely used for big buildings in the ancient Lanna, only religious buildings near a river or lake.

Figure 126 & 127:

Typical single pointed footing using masonry (drawn by Vitul L., 24/11/07)



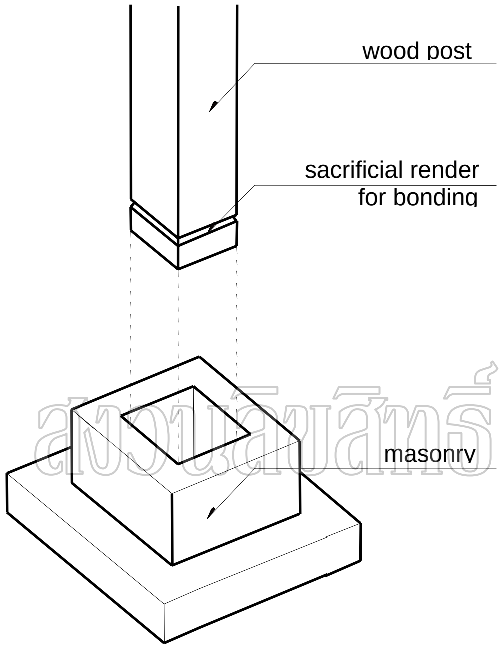
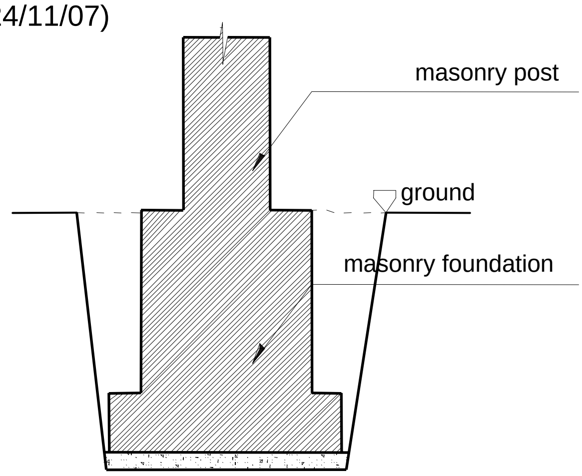


Figure 128 & 129:

Typical single pointed footing using masonry with masonry post (drawn by Vitul L., 24/11/07)



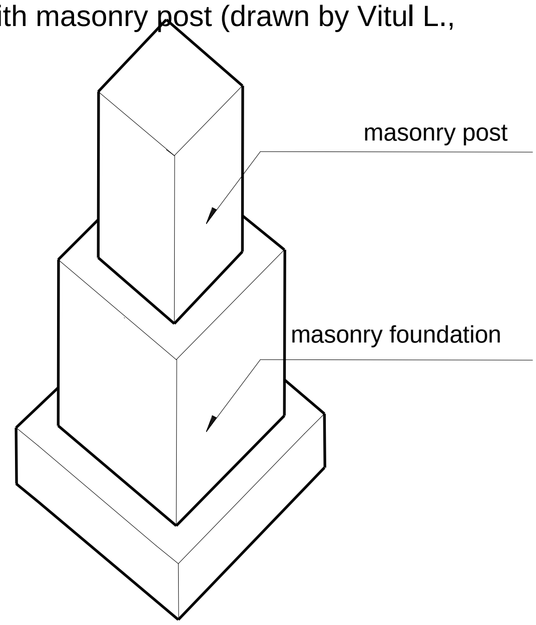
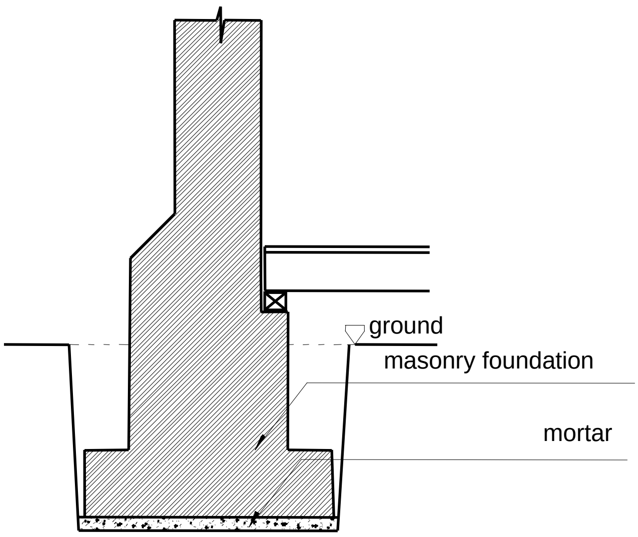


Figure 130 & 131:

Typical continuous footing using masonry (drawn by Vitul L., 24/11/07), footing wall of historic shophouse in Chiang Mai (taken by Vitul L., 5/11/02)



b. Soils and rock

The ancient Lanna builder's most desirable support for a foundation was an impermeable and dimensionally stable rock. Solid granite, solid limestone and shale were the ideal which is described in Haribhunchai history as they built Pha That Haribhunchai on solid rock. The least stable soils for foundations are fine grained compressible clays and some types of man-made fill. Round grained sands in wet conditions filled where water actually flows through the soil and have a tendency to move away from underneath the foundations in the direction of the flow; then the sands are contained or restrained and are referred to as *mae non sai*. Unstable soils are thus liable to solifluction (soil flow or sliding) then footings move places. The best normal soils to support foundations are those which have a wide distribution of particle sizes, are well packed, and lack in clay minerals and organic material.

c. Differential settlement

Differential settlement is much more common and occurs for one or more of the following reasons:

- Variations in soil compressibility.
- Variations in the moisture content of the soil.
- Differences in thicknesses of soil layers under the foundations.
- Differences in depths of footings.
- Differences in footing sizes and pressures.
- Differences in foundation loading.

In cases where the building loads were fairly uniform, the differential settlement resulted in the structure tilting on a plane. There are cases where the structures have tilted evenly and where as a result no serious cracking has occurred then overstressing of the masonry materials, cracking, and even collapse may result. However, a structural cracking and possible collapse results from differential settlement due to differential foundation loading. The differential loading on a long foundation results in an effective upward force being applied to the central section resulting in an upward deformation. In more normal masonry structures this problem is seen at window and door openings where sills may be bent upward and may fail with cracks tapering downward from the center of the sills. The traditional Lanna builder knowing of the predictable foundation settlement resulting from the compression or consolidation of soils under foundations, managed to set the old buildings clear over the period of time without addition or revision on masonry. Thus, no movement was transmitted to the old buildings causing the structures to be bent or broken.

d. Effects of a tree root system

The frequent cause of foundation settlement and structural cracking and failure is the action of tree roots in clay soils. Broad leafed trees in long summers may remove such large quantities of water from underground clay layers that they can cause those clays to shrink substantially. Where the foundations were placed over the shrinking clay layers, thus formed the voids or in other cases, the foundations deformed downward gradually keeping pace with the shrinking layers. Structural cracking was then associated with the foundation movements. In order to assess the potential risk of foundation damage from trees near buildings, big tree root systems which extended around the trees out at least as far as the leafy canopy of the tree were avoided. Therefore, in Lanna, there was no leafy canopy from a nearby tree to be found around the building. This also prevented other forms of deterioration such as from animals or insects from the tree.

2. Posts and beams

There were only 2 characteristics in Lanna—masonry and timber

a. Masonry structural characteristics

Brick posts are used for the main structure and on the first floor to bear the load of the second floor and roof structure. Masonry posts are in rectangular shape, from the ground to the structure which bears the load of the second floor, except in some buildings where bricks are used in every part, and the posts are from the footing to the top plate which bears the roof structure. Sizes of posts vary due to the load they have to bear.

Figure 132 & 133:

Typical masonry structural system for shophouse (drawn by Vitul L., 24/11/07)

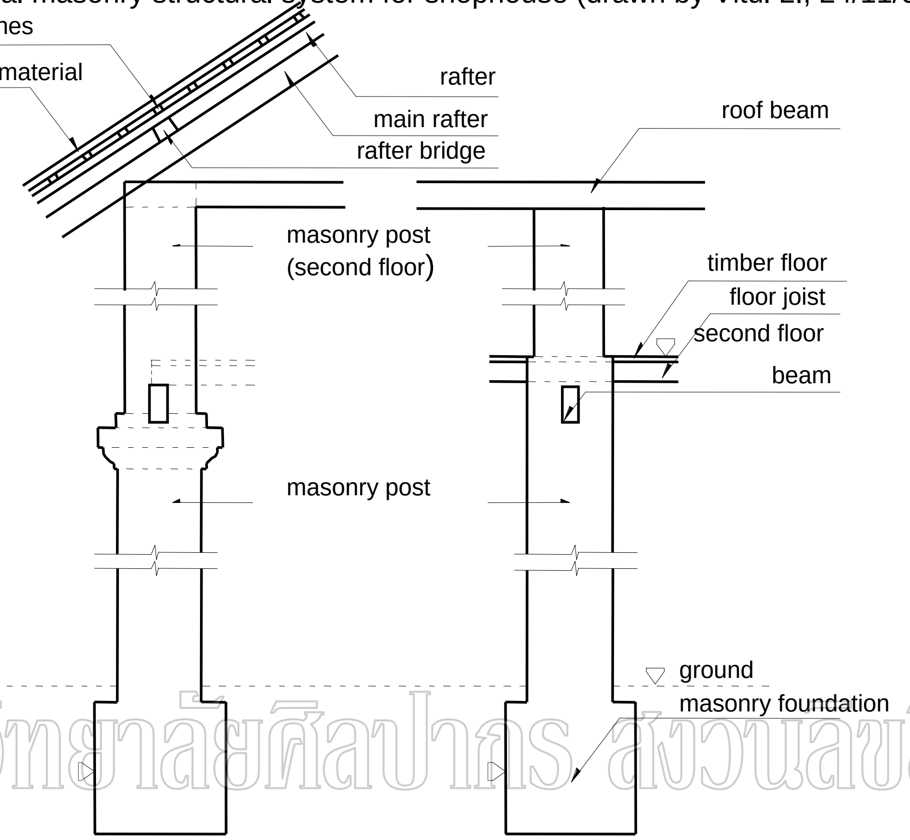


Figure 134 & 135:

Typical masonry structural system for shophouse (drawn by Vitul L., 24/11/07), historical shophouse in Chiang Mai (taken by Vitul L., 5/11/02)

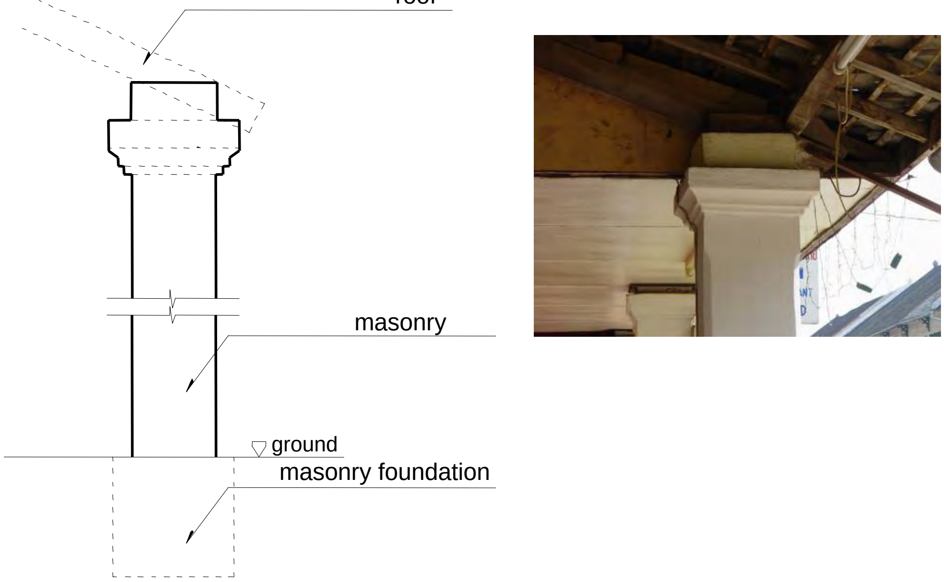
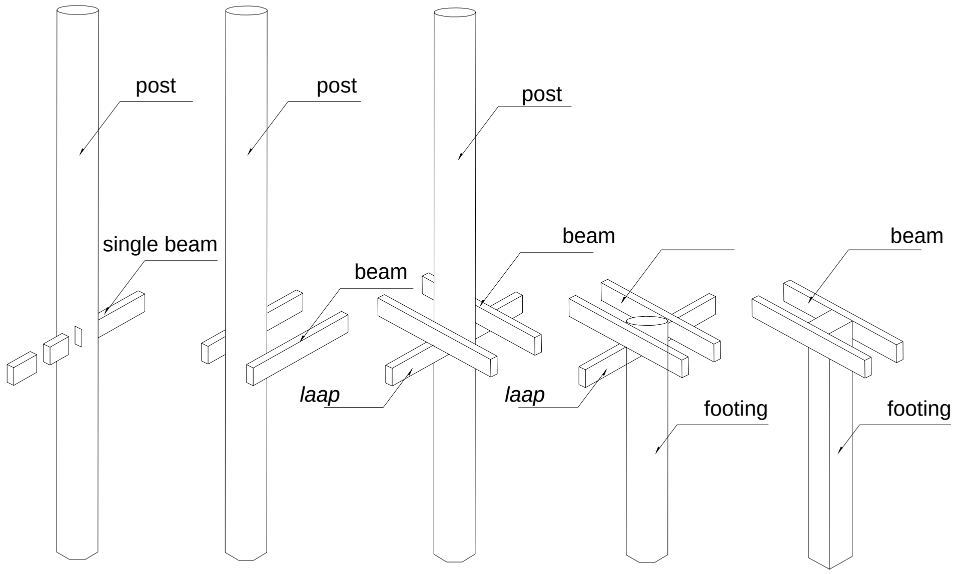


Figure 136:

Typical wood post and beam structural system for house (drawn by Vitul L., 24/11/07)



b. Wood structural characteristics

Wood is also used as the main structure to bear the load of a wooden beam, wooden floor joist, or the main roof structure. Hardwood is selected and cut into 8”x8” pieces. For a one-storey building in the past, only one wooden post was placed on the stone under the ground. However, in the following times, it was placed on a footing or brick post of about 8” (or 0.2 m.) under the ground and the end of the post which was under the ground was coated by time. For a two-storey building, in the past, a wooden post was also used and placed on a log. Later a brick post was used instead. It was placed in the post or attached with iron in the post. The post then was attached with another piece of wood and beam made of steel whose sizes vary, 6”, 8”, 10”, or 12”, depending on the type of building.

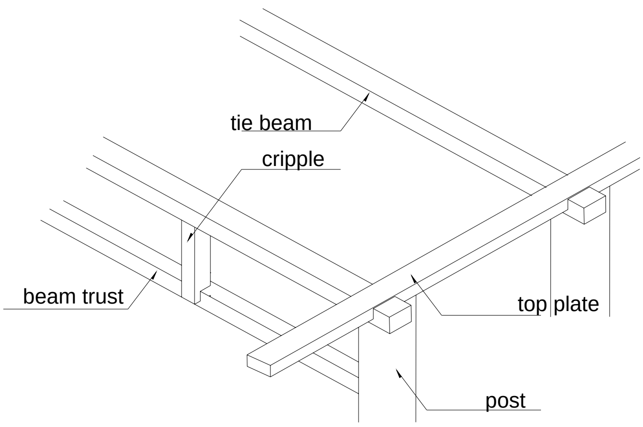
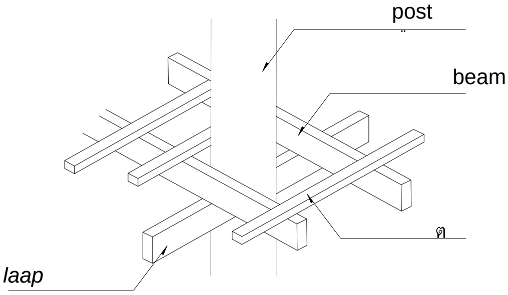


Figure 137:

Typical wood post and roof beam structural system for house (drawn by Vitul L., 24/11/07)

Figure 138 & 139:

Typical wood post and floor beam structural system for houses (drawn by Vitul L., 24/11/07)



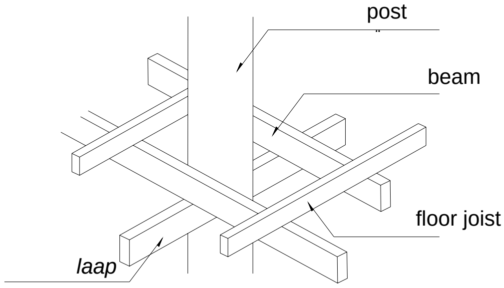
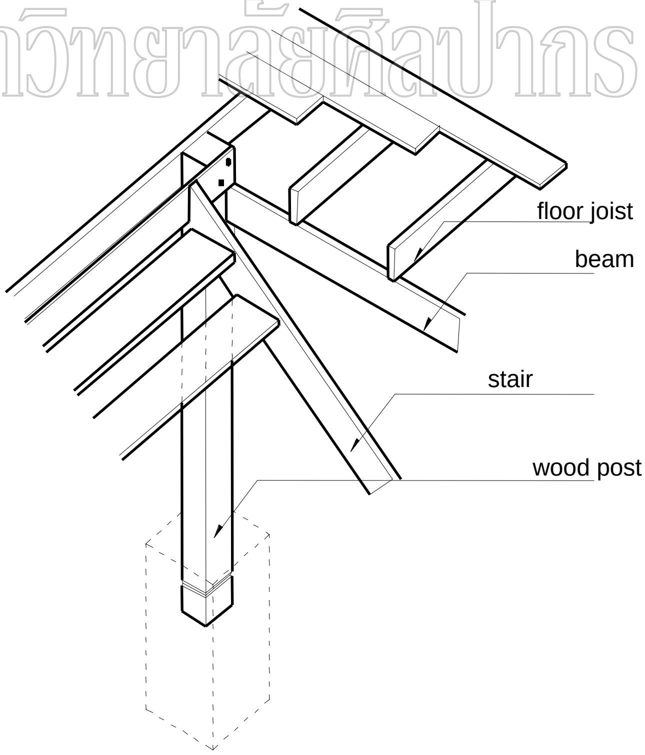
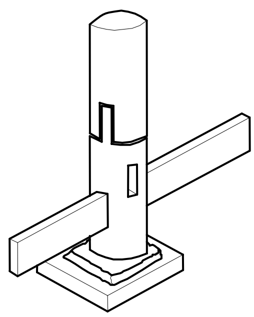


Figure 140 & 141:

Typical wood post, stair and floor beam, and typical wood beam on footing for houses (drawn by Vitul L., 24/11/07)





3. Floors

The floor consists of its structure and materials for flooring. From the study, it was found that there are two types of floor as described below:

a. Slab on ground

This type of floor is mostly *poon satye* mortar placed about 3-4 cm thick on soil or sand without any bearing. The floor can be used when it is solid. Then tiles or cement is placed on it with mortar, consisting of cement and sand. However, a slab on the ground has since been developed and, moreover, an original one was hard to find for any study.

b. Wood floor on wood structure

The wood floor on wood structure is mostly found on the upper floor of the building whose structure is a wood beam or *vang*. A floor joist or *tong* is placed on masonry or wooden posts along the length of the building with a pair of beams or double *vang* in the middle of the building and a single beam or *vang* at the rim of the building. *Laap* is another main structure used in Lanna to tie the main structure to the post. If the beam or floor joist is not long enough, another piece of joist or beam is stuck on overlapping the previous piece. Sometimes there is a beam trust and cripple to hold over an extra long span. Usually, a joist is about 3"x4" with 1.5"-2" and the space between each *tong* is about 0.4-0.5 m. Hard wood like *dang -Xylia kerrii Craib & Hutch*, *teng*, or *pao -Dipterocarpus tuberculatus Roxb* is used. Then 0.75"x6" or 1"x8" pieces of teak are placed on the floor joist. Different ways to place teak on the floor joist are used. Joints such as those with edge closed, halved, or tongued are normally found. A bamboo twisted floor has a light weight and long lasting use for the interior surface.

Figure 142, 143 & 144: Typical wooden floor joints – edge closed and halved types (drawn by Vitul L., 24/11/07)

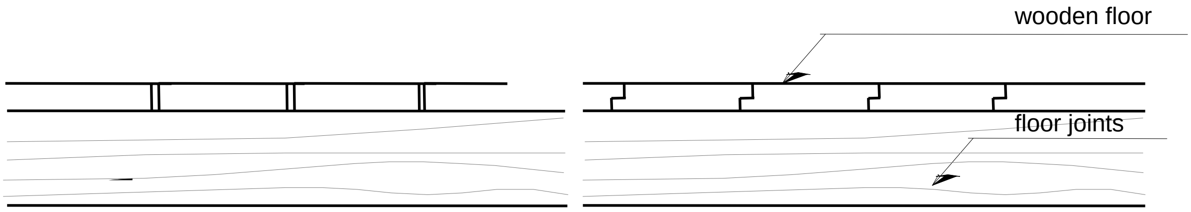
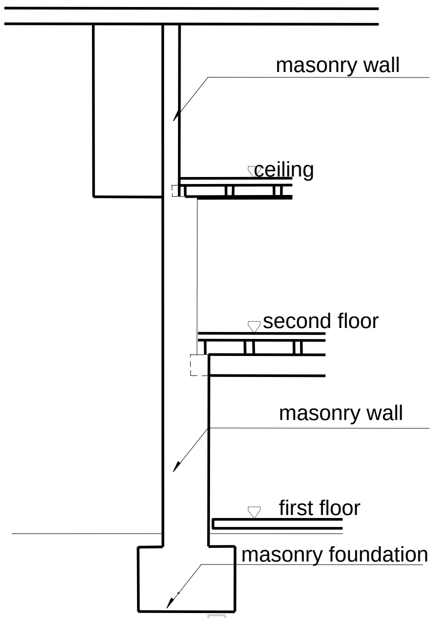
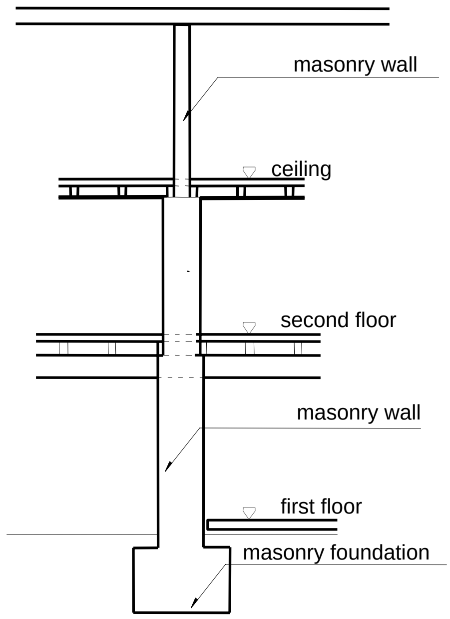


Figure 145, 146 & 147:

Typical wooden floor structure for house and shophouse (drawn by Vitul L., 24/11/07)





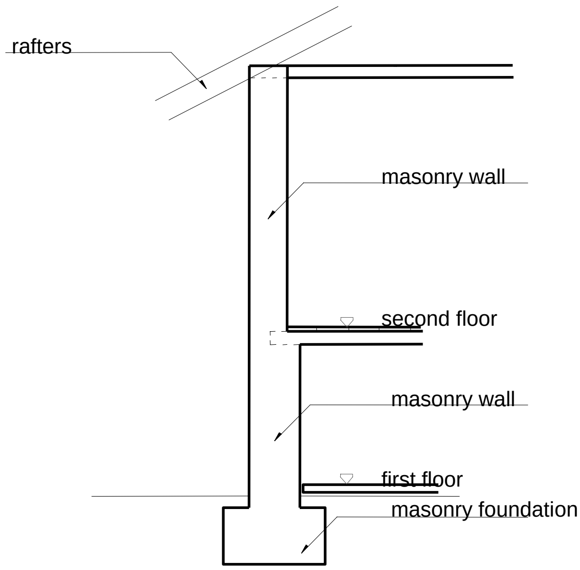


Figure 148 & 149:

Typical wooden floor structure for shophouse in Prae (taken by Vitul L., 25/6/06)

Figure 150 & 151:

Typical wooden floor structure for shophouse in Chiang Mai (taken by Vitul L., 5/11/02)

4. Walls and partitions

a. Masonry structural characteristics

The wall bearing is one type of structure which uses brick as footing to bear the load of the building. It is prepared along the wall with *poon satye* as mortar or plaster. Wall bearing is mostly used for religious buildings, *khum,* government buildings, and shophouses. The thick wall can bear a heavy load. The thickness of the wall and the length of each level of the building are different due to the wall's capacity in bearing the load.

The bearing wall is first completed at the lowest part along the length of each wall, followed by the higher parts which need double bricks to bear the second floor and roof structures. From the floor joist which bears the second floor to the top plate of the roof structure, the walls are done differently so as to bear the weight of these parts for a building whose structure being made from wood, wooden posts and walls, is done like the first floor.

The non-bearing wall is completed after the wood post and structure are in place with the wall supporting no load other than its own weight. It is also called a non-load bearing wall. This is found widely in the original buildings or after the shophouses, government buildings, and the *vihara* and *ubosotha* had been renovated in Northern Thailand.

Figure 152 & 153: Typical bearing wall for government building, tobacco company in Chiang Mai, (taken by Vitul L., 1/2/02)

Figure 154 & 155:

Typical non-bearing wall for the *vihara* in *Wat* Ubosottha, MaeHea, Chiang Mai (taken by Vitul L., 1/2/02)

b. Wood structural characteristics

A wood structure is mostly found at the walls of a one-storey building, or on the second floor of a two-storey building whose wall of both floors is attached with a hard wood frame. The space between each piece of wood frame is about 0.4-0.5 m and the structure of the wall can be vertical or horizontal. Teak or *sak - Tectona grandis* and *heang - Dipterocarpus obtusifolius Teijsm* are mostly used as a frame with a stud size of about 1 1/2”x 3”.

- Wood siding consists of wide boards set vertically with butt joints covered by battens. A wood board of 6”-8” with a 0.5”-0.75” thickness can be utilized vertically or horizontally as follows: vertical siding, colonial siding, bevel siding, or drop siding.
- A wood flush panel is a panel having a surface on the same plane as the surrounding frame. Also known as *luog-fuck*
- Bamboo twisted panel has a light weight and is a long lasting panel used for the interior.
- *Torchis* is one type of masonry wall with *bong* or *sang* wood which uses bamboo as an ingredient. This wall is then coated with *patye petch*, one type of cement. Bamboo which is used for the wall and partition must be old enough, and then it is placed into water for three months to get rid of insects. When the structure is already prepared, posts or beams can then be placed on, followed by placing the twisted pieces of bamboo, and finally that bamboo is coated with two layers of cement. However, copped straw and sand are added to the cement which is used to coat the first time. It is rougher than the cement which is used the second time.

Figure 156:

Typical *Torchis* wall for a house and shophouse with the structure frame, the twisted pieces of bamboo, the coated cement (drawn by Vitul L., 24/11/07 following UNESCO document on Luang Prabang conservation manual)

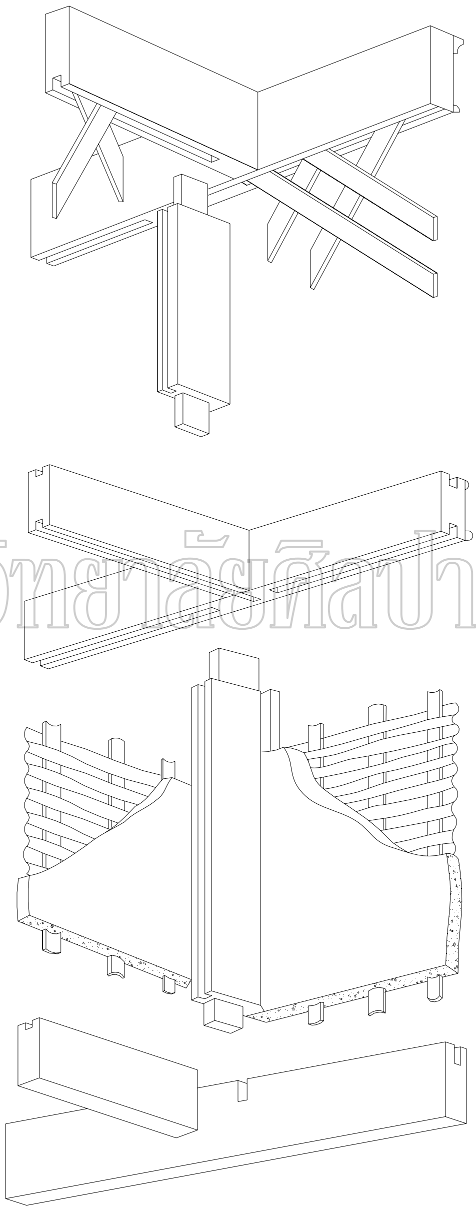


Figure 157, 158 & 159:

Typical *Torchis* wall for a house and shophouse; placing the twisted pieces of bamboo before and after the coated cement, once was generally used in Lanna. (taken by Vitul L., 12/7/03)

c. Structural cracks – classification

Structural cracking classification is a western systemic method which can be applied to Lanna conservation work. Structural cracking falls into two categories (Weaver 1993, p.5). First, the cracking has no effect on the structure, or at least only an aesthetic effect. This category is often classified into four classes as follows:

- P0 less than 0.10 mm; P1 - 0.10-0.30 mm; P2 - 0.30-1.00 mm; and P3 - 1.00-2.00 mm. This category ranges from fine hairline cracks which may be very difficult to see, up to the 2.00 mm. cracks which can be seen in a clear light from a few meters or yards away. These cracks are very often caused by initial shrinkage in new materials or by thermal expansion and contraction movements over a long period.

The second category is also divided into four classes. The use and serviceability of the building will be affected in the first three classes and in the fourth there is an increasing risk of the structure becoming dangerous. These classes in the second category commence at follows:

- P4 - 2.00-5.00 mm. The upper limit doors and windows may stick, draughts and moisture may penetrate through walls, and arches may crack and loosen.
- P5 - 5.00-15.00 mm. Cracks in this class are associated with serious structural damage. Doors and windows may be jammed, walls cracked right through, and severe shear patterns may develop with, for example, diagonal cracking in ceilings, falling plaster, and collapsing arches. In the upper limits, tile work and other slab finishes may fall off the building and plumbing and service pipes may be broken. This class is clearly associated with structural movement patterns which can usually be traced to settlement of posts, columns, footing, plates, and sleeper walls; or to the bending of beams or trusses.
- P6 - 15.00-25.00 mm. Cracks in this class are extremely serious and are easily discerned, usually with clear patterns of movement and often the cracks are grouped together. In older buildings the arches, sections of masonry wall, and thin structural features such as chimney stacks and pinnacles, may collapse or show signs of movement and impending failure. Distortions, bulges, and horizontal movements at bearing points can be seen with the necked eye. Cracking in this class may also be caused by sudden changes or the removal of supports, usually associated with subsidence related to mining, collapsing excavations, and landslips.
- P7 Greater than 25.00 mm. Cracking in this class can be regarded as evidence of a dangerous structure. The dimensions of such cracks can increase suddenly and without further warning and total or partial structural collapse may result. This class of cracking is particularly dangerous in old masonry buildings where walls may consist of two or

more wythes which are imperfectly bonded together. A sudden failure of one wythe can lead to an immediate and extreme overloading of the remaining wythes which will have too high a slenderness ratio and will collapse as a result.

When investigating and documenting structural cracks it is important not only to know the dimensions and direction of movement but also which of the following conditions apply:

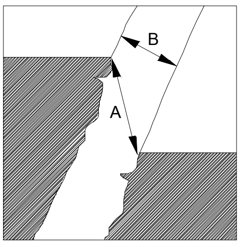
- The movement has ceased and the cracks have ceased to open which is associated with foundation settlement.
- The movement is cyclical so that the cracks open and close as soils expend and contract with the cycles of wet and dry seasons.
- The movement is continuous so that the cracks continue to open. If a graph is plotted with time, it would show a rising straight line. It is possible to forecast when the cracks will make the structure dangerous.
- The movement is accelerating so that the cracks continue to open but the acceleration makes it difficult or impossible to forecast when the cracks may become large enough to make the structure dangerous.

Table 12: Cracks classification (from Weaver 1993, p.5)

Class of crack	(A)Crack Size in mm.	(B)Physical Maximum Width in mm. (Full Scale)
P 0	Less than 0.1	0.1
P 1	0.1 to 0.3	0.3
P 2	0.3 to 1.0	1.0
P 3	1.0 to 2.0	2.0
P 4	2.0 to 5.0	5.0
P 5	5.0 to 15.0	15.0
P 6	15.0 to 25.0	25.0
P 7	Greater than 25.0	> 25.0

A) Crack size is to be assessed in the direction of movement.

B) Crack width is the shortest distance between edges.



A = Crack Size

B = Crack Width

A = B When there is no displacement along the line of the crack, then there is tensile failure but no shear movement.

d. Rising damp

Rising damp is a major cause of decay to masonry materials such as stone, brick and mortar. It often happens in religious buildings, the *vihara, ubosotha* and *khum,* government buildings, and shophouses. Even when mild it can cause unsightly crumbling of exterior masonry and staining of internal finishes. It may also cause musty smells in poorly ventilated buildings. Rising damp occurs as a result of capillary suction of moisture from the ground into porous masonry building materials. The moisture evaporates from both the inside or outside wall, allowing even more moisture to be drawn from below. The height to which the moisture will rise is determined by the evaporation rate and the nature of the wall. The normal limit for rising damp ranges from 0.5 to 1.5 m above ground level. Rising damp may show as a stain and when more severe, as loss of plaster. Damp walls encourage the growth of molds, which are unsightly, unpleasant and unhealthy for occupants. The exterior damp zone may be evident at the base of walls, with associated fretting and crumbling of the masonry. Rising damp can be made much worse if there are appreciable quantities of soluble salts present. The rising damp will carry salts up into the masonry where the damp evaporates. There the salts are left behind and can often be seen as a white efflorescence on the wall surface. When these salts grow as crystals within the pores of the masonry they can disrupt even the strongest material, leading to fretting and crumbling of the surface. This process is known as salt attack, and, when severe, can lead to the slow but complete loss of stones and bricks in a wall. Some of rising damp cannot be distinguished between relatively dry but salty walls from those that are wet but free of salt, so great care is needed in interpreting the results.

Other forms of damp may occur from leaking rain water, failed joints that have lost their mortar and general build-up of dirt and mosses on the roof can all lead to water penetration into porous masonry walls as falling damp. Penetrating damp can be due to leaking water which produces small patches of damp and decay. It is important that rainwater does not lie against the base of the walls; surrounding paths and ground levels should be sloped so as to drain water away from walls.

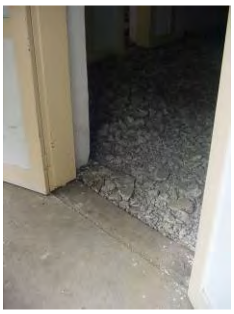



Figure 160 & 161:

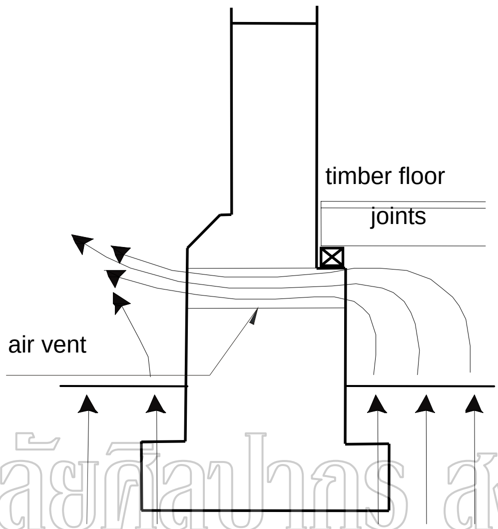
Removal of concrete-on fill floors, the cause of rising damp, done by local renovators for historic building, tobacco company in Chiang Mai (taken by Vitul L., 17/4/05)

Under the first floor, ventilation is an important part of controlling damp, as it allows soil moisture to evaporate beneath the floor and to pass out through the vents in the lower walls. Without this ventilation the moisture on the walls would be much greater. One of the worst mistakes of local renovators is to remove a ventilated timber floor and replace it with a concrete slab poured on sand or fill. The concrete prevents evaporation and all the soil moisture rising beneath the building is now focused on the walls.

Figure 162 & 163:

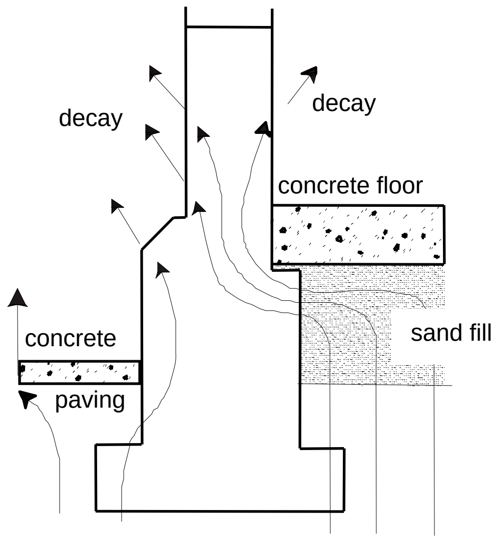
Rising damp caused by concrete-on fill floors (drawn by Vitul L., 24/11/07)

How concrete-on fill floors can cause rising damp



Existing

Well-ventilated underfloor space allows soil moisture to evaporate into the open air



After concrete-on fill

Concrete slabs prevent evaporation, so soil moisture is forced up the wall

5. Roof structure

There are two categories of a roof which includes the upper part for the entire building, consisting mostly of gable roofs and hip roofs. Then there's the lower part which covers the walk way at the front part of the building. There are different roof structures for houses, shophouses, government buildings and religious buildings i.e. *vihara* or *ubosottha*.

a. Main roof structure - Typical

On the upper part of the main roof for a house and shophouse, the main structure is on a post or bearing wall of the building that also bears other parts, such as a rafter bridge, rafter, ridge beam and purline. A pair of tie beams is on the lowest part to bear the king post, joggle, main rafter and buttress. For the lower structure, a rafter bridge depends on the main rafter, and the end of the rafter bridge depends on the wall bearing. Rafters will lie on the rafter bridge with the king post on top, and the lower end on the wall. Wall bearing also supports both sides of the king post, along with the buttress. For a wooden structure, the load of the main roof structure depends on the pole plate which leads to the post and footing. The purline for support tiles is on the rafter and wall; the space of the purline depends on type of tile.

Figure 164 & 165:

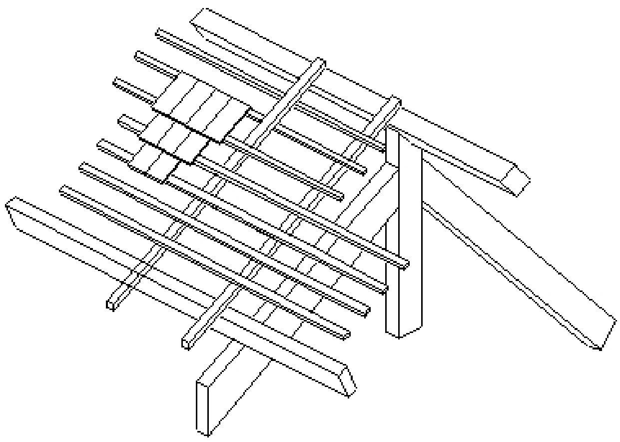
Main roof structure for a house and shophouse in Chiang Mai (taken by Vitul L., 5/11/02)

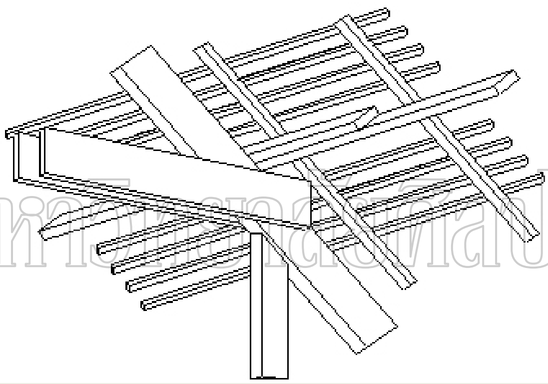
b. Main roof structure - *Maa tang mai*

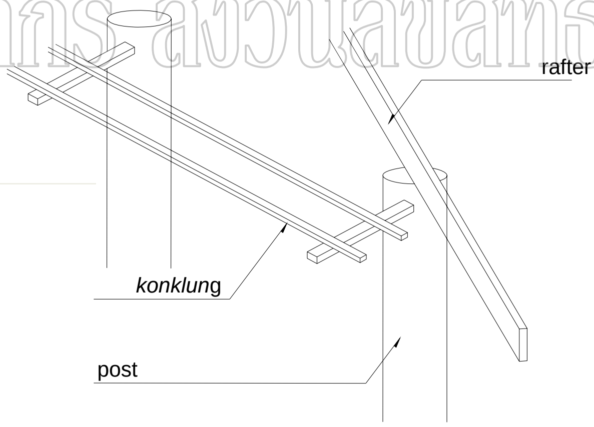
The upper part of the main roof of the *vihara* or *ubosottha*, which is quite unique, is called the *maa tang mai.* It is a simple truss deriving from the way horses carried silk on the Lanna route—the way horses carry silk on their backs is like the roof structure whose load is transferred to posts. The main tie beam or *keok* bears the loads of both the second and third tie beams, as well as the loads of the king post and ridge beam, which are for the gable truss structure. The length of the main tie beam is longer than that of the main posts; however, the length depends on the details of each different *vihara*. This longer part is supported by a hammer beam posted on purline or *pler linharn* and a pendent post or *sao sakon on the* secondary roof. This pendent post and horse beam or *keok maa,* are placed on the side wall which connects the purline or *pler langmaa*. It will support the second and third horse beams or 2nd & 3rd *keok maa*, as well as all hammer posts. This is also part of the eave structure or secondary roof.

Figures 166, 167, 168 & 169:

Typical main roof structure for a house and shophouse (drawn by Vitul L., 24/11/07)







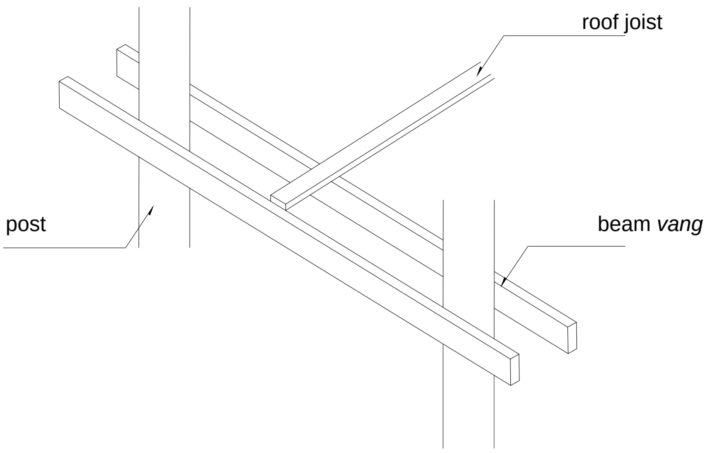


Figure 170 - 175:

Typical main roof structure for house and shophouse (drawn by Vitul L., 24/11/07)

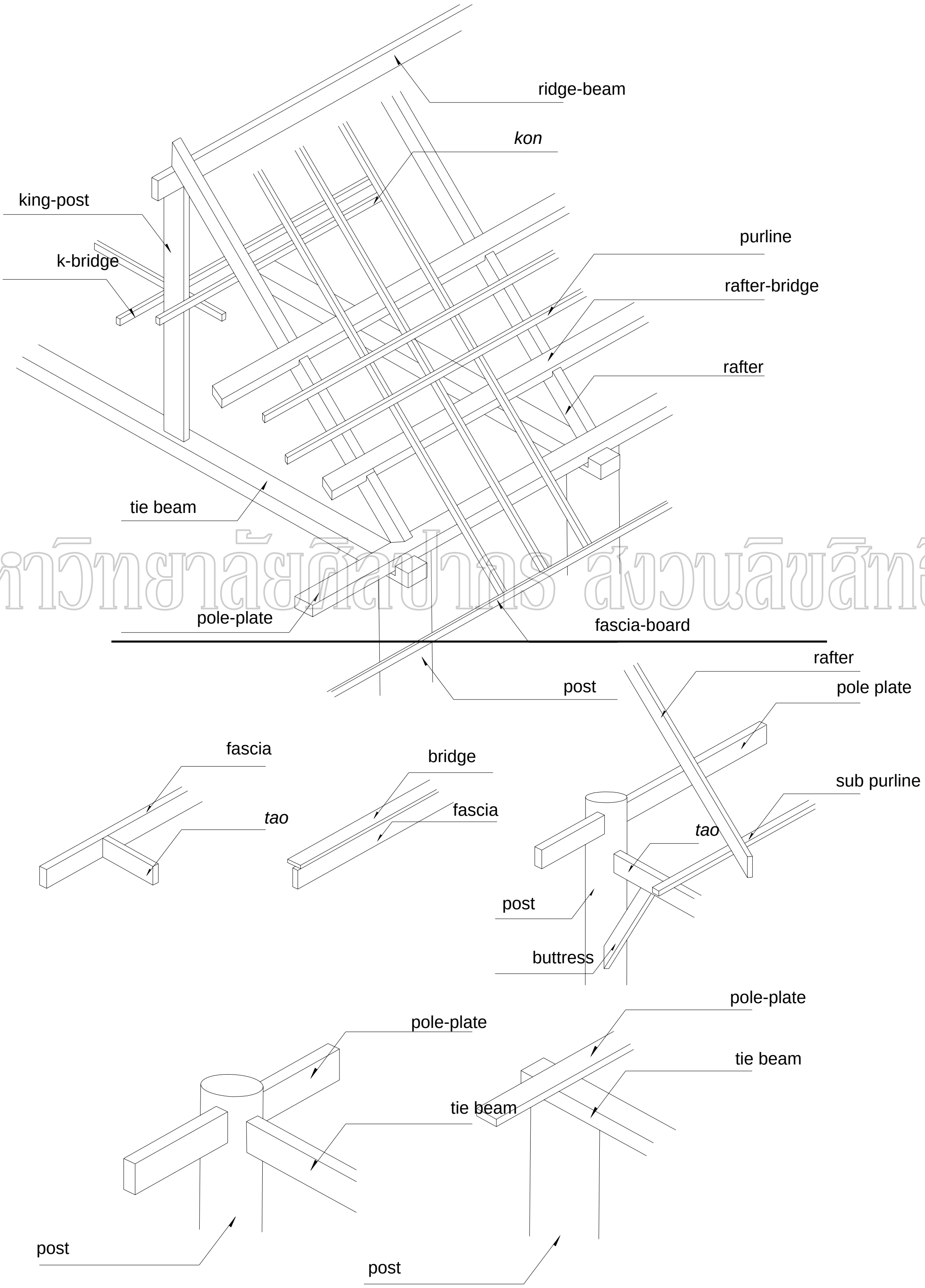


Figure 176 & 177:

Typical main roof structure *maa tang mai* (drawn by Chanarong S.)

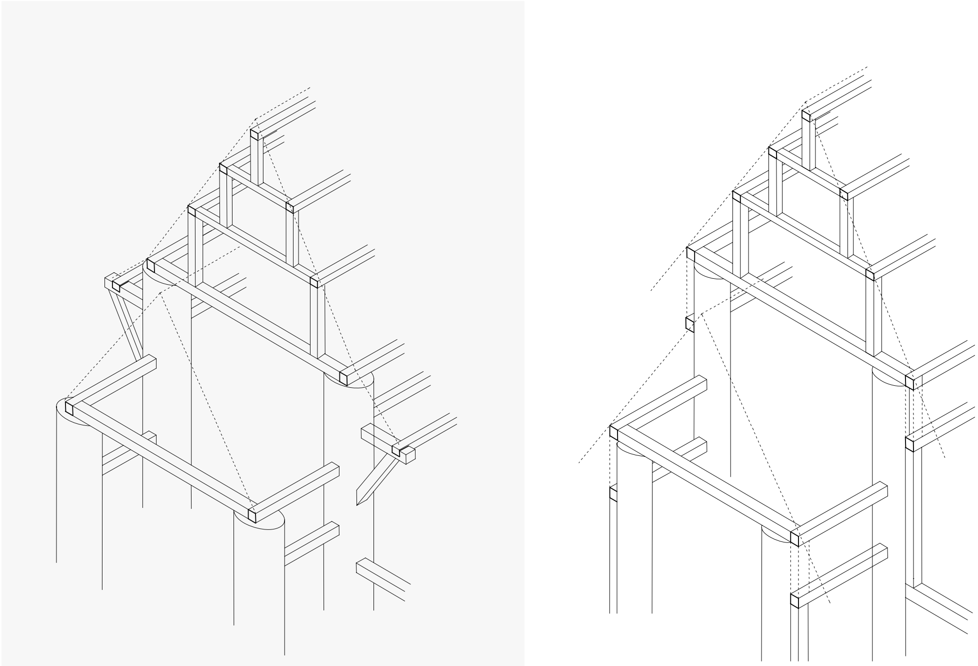


Figure 178 - 186:

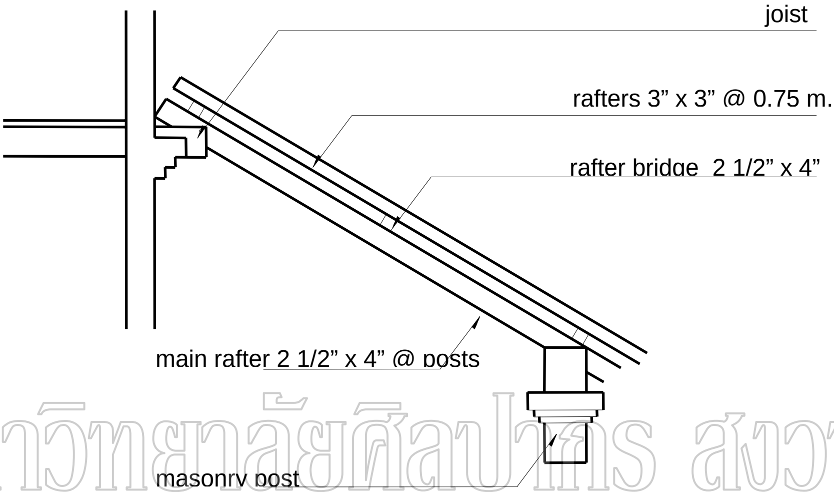
Main roof structure: *maa tang mai* for religious buildings (drawn by Chanarong S.)

Figure 187:

Secondary roof structure *maa tang mai* showing *sao sakon* and *keok maa* in the *vihara* in *Wat* Baan Ko, Lampang (taken by Vitul L., 9/8/06)

Figure 188:

Lower roof structure for a house and shophouse (drawn by Vitul L., 24/11/07)



c. Lower roof structure

On the lower roof structure for a walk way, main rafters are also placed on posts. The top at the end of the main rafters is placed with the end of the joist which bears the second floor. The lower part at the end of the main rafters is on the head of a brick post. The rafter bridge is also on the main rafter to bear rafters like the structure of the main roof. The size of a wooden structure and ridge beam can be 4”x1.5”, 6”x1.5”, or 8”x1.5”, the bolts can be 4”x1.5” or 6”x2.5”, the space can be 0.5-.06 m., the king post can be 6”x2” or 6”x1.5”, and the purline can be 1.5”x 0.75” or 2”x1”.

d. Roofing

Din khor tile was commonly used in Lanna, but has already been replaced with cement tiles as they are good for installation and easily maintained. Openings for ventilation are done at the gable with a louvers roof at the two ends for the roof as well. For size and shape of *din khor* baked tiles, cement tiles and terracotta, see Chapter 5 Roof Material for details. The fascia board can be 6”x1”, 8”x1”, and bird’s mouth end board can be 4”x1/2”.

For the *vihara* or *ubosottha* of Lanna construction, wood is used a lot for the roof structure. Each part of the wooden structure can be stuck together by the joint, and this can bear a lot of weight. Not only the joint which is used for roofing, but also the nail which is necessary especially when the joint does not work properly, for instance, to stick the *klon* with purline, and to stick the subpurline with *klon* nails are used. This type of nail is called *ta pu jin*. It is flat and about 3-4 inches long. Its head is bent and can be used only with certain types of hammers.

Figure 189 & 190:

Roofing details in historical houses in Lampang (taken by Vitul L., 19/8/04)

6. Ceilings

Wood panels are placed on the ceiling in two ways which include on the back of the ceiling joist and at the end of the main runner. The end of the ceiling joist is placed on the top of the walls. The middle of the ceiling joist is supported by walls or the main runner if there is no wall. The top plate supported by a tie beam of the main roof structure and the walls at both ends of the ceiling which is placed under the above ceiling is supported by a joist which can bear the load of the ceiling. The size of the ceiling can be the same as pieces of wood used for walls or thinner, about 6”x0.5” placed on a ceiling joist which is about 1.5”x3”. Sometimes bamboo twisted sheets can be used for the ceiling in the same configuration.

7. Windows and doors

The swinging window type can be: 1) a solid piece of wood panel; 2) a wooden flush panel window in a wooden frame; 3) a wooden louver panel window in a wooden frame; and 4) a glass panel window in a wooden frame, which may be developed from the previous type. The swinging windows move by a hinge for an outward-swing or a dowel at the upper and lower frame.

There are two types of doors which consist of the folding door and swinging door as described further: 1) a folding door is used at the main entrance for a shophouse. The solid piece of wood panel used for this type of door is the same size as the width of the poles or that of the unit, with a doorframe or doorjamb to support the door. This type of door has two sides which are pulled shut for closing. The doorframe or doorjamb is made of a piece of wood placed on the pole or ceiling. The door itself comprises frame and wooden flush panel. The frame is pierced for the dowel which is stuck by a wooden lock at the back of the door to make the door stronger. 2) The swinging door is used both outside and inside the building. There are single and double swinging doors. Its designs and other materials are nearly the same as folding doors. However the door for the main entrance can be a wooden flush panel in the doorframe, wooden louver panel in the doorframe, or a glass panel window in the doorframe. Wood carving and other decorations are considered important for religious buildings.

Figure 191:

Door details in historical houses in Lampang (drawn by Vitul L., 24/11/07)

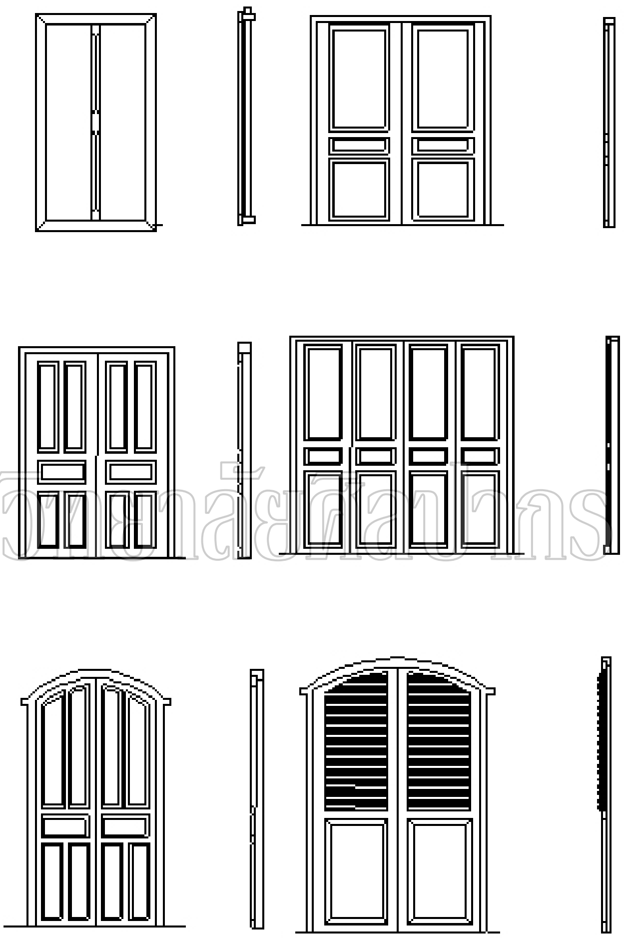


Figure 192 & 193:

Door details in historical houses in Lampang (taken by Vitul L., 19/8/04)

Figure 194 & 195:

Window details in historical houses in Lampang (drawn by Vitul L., 24/11/07)

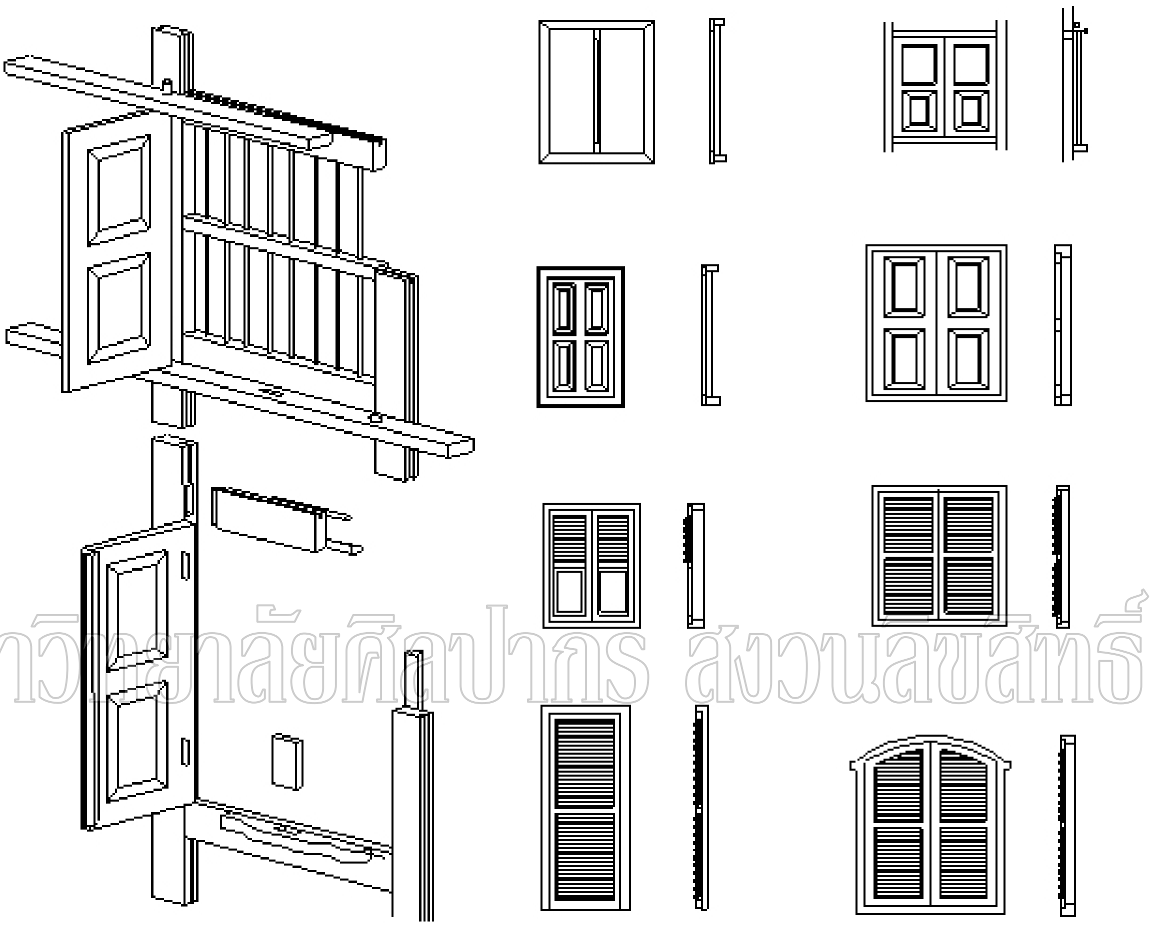


Figure 196 - 199:

Window details in historical houses in Lampang (taken by Vitul L., 19/8/04)

8. Other components

For the shophouse and house, where more area is needed on the lower floor, stairs are necessary for building in urban areas. Stairs are found in wooden-structure buildings. A wooden dowel and nails are also used.

Bargeboard and *typpanum*: *pan lom* and *nah bun*. Buildings in Lanna, both religious and non-religious such as *khum*, government buildings, are important for public and social events. They are highly decorative, mostly wood *pan lom* or bargeboard or a board often carved and attached to the projecting end of a gable roof, also called a vergeboard, made from patterns of finishing material, i.e. moulded cement or *poon pun*, glass materials or *keaw chuan*, gold lining or *jung go*, *lacca* coating or *rak,* ceramic tile or *celadon* and painting. Also the same material for *typpanum* which is used in Romanesque churches is similar to *nah bun* in Lanna architecture. Wood and masonry are the main materials which are highly decorative. The space between a frontal bargeboard and the horizontal head of a door or window (as shown below) is often decorated with a pattern or relief. See chapter 4 Building materials for details.

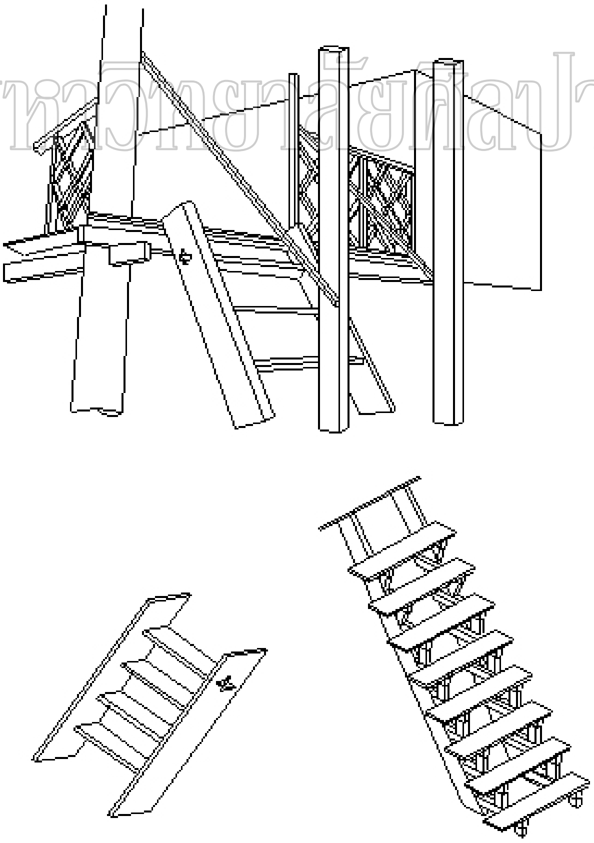


Figure 200 & 201:

Typical stair details in historical houses (drawn by Vitul L., 24/11/07)

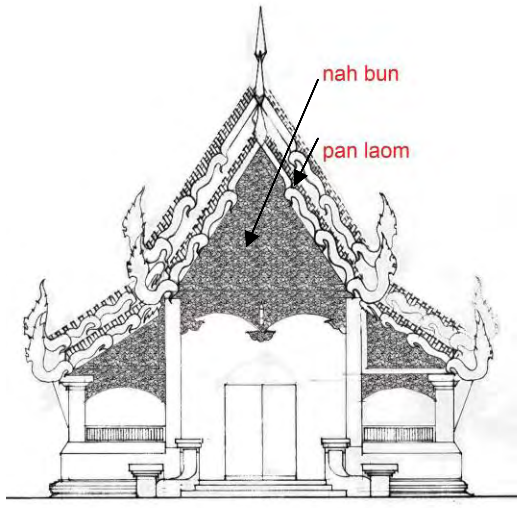


Figure 202: *Pan lom* and *nah bun* in a religious building (drawn by Vitul L., 24/11/07)

Chapter 7

Lanna building treatment

1. Restoration of old footings and foundations

This part of the chapter provides some techniques which are suitable, available, and practical for the restoration of deteriorated foundations and for the reinforcement and upgrading of poorly done and old foundations. The method depends on the nature of the problems affecting the stability of the foundations or footings. The following list provides the causes of defects, and treatments are discussed in relation to each. Causes of defects include:

- Excavations, both from the surface and underground, adjacent to existing foundations, which may lead to differential settlement or lateral movement. Counter treatments include continuous underpinning with reinforced cement beams.
- The transmission of vibrations or shocks through old foundations, which may be caused by the installation of machinery in old buildings, pile driving, or heavy bus or truck traffic on adjacent streets. Counter treatments include the installation of vibration dampers and isolation systems if the vibrations are expected to continue.
- Rises, falls or sudden variations of underground water levels causing differential shrinkage or expansion of soils beneath the footings. Counter treatments include controls on water use and drainage.
- Changes in loads on foundations caused by alterations and additions to the structure, which may be caused by the failure of the bond mortar then eccentric loading on failure footings. Counter treatments are basically concerned with the stabilization of the foundations.
- Movements of foundations caused by landslides or earthquakes, which may be caused by nature or by man. Counter treatments include land stabilization with the use of complex piling systems, upgrades of the seismic resistance, isolators, and vibration dampers.
- The deterioration of materials and structural systems in the foundations causing the deterioration or total removal of mortars and the softening of masonry. Counter treatments include underpinning and piles underpinning then replacing the foundations.

Old buildings have reached a state of equilibrium which may be fragile or even unstable. When any intervention is called for to stabilize an old foundation where problems have been caused by foundation movement or failure, the first concern must be to preserve that state of equilibrium. The goal is to restore or increase lost margins of safety rather than to abandon the original construction scheme which should be treated with respect.

In the north, replacement of foundations is a fundamental practice for single pointed footing. But for continual footing using masonry, other techniques are not carried out due to suitability and budget. It may mean the difference between the construction of a foundation for a new structure and the strengthening of one which is already in existence. The principal requirement in all such work is that the responsible renovators have the fullest possible amount of experience in this precise field. It is essential that no intervention is made without having first established who is to be involved, and how the work is to be carried out. Then, examination of the existing conditions of the structure, the underlying soils and the relevant macro and micro environments must be carried out in the field. The available methods for the conservation of foundations and the restoration, as well as the improvement of the loss safety margins may include the following methods: continuous underpinning, piled underpinning, paired piles, staggered piles, jacked piles, root piles, cantilever underpinning, injection or consolidation techniques, and seismic isolation retrofitting. No matter which techniques are used it must be realized that the restoration and reinforcement of foundations are usually entrusted to skilled engineers. There are also the essential requirements of experience, intuition, and inspiration of the practitioner.

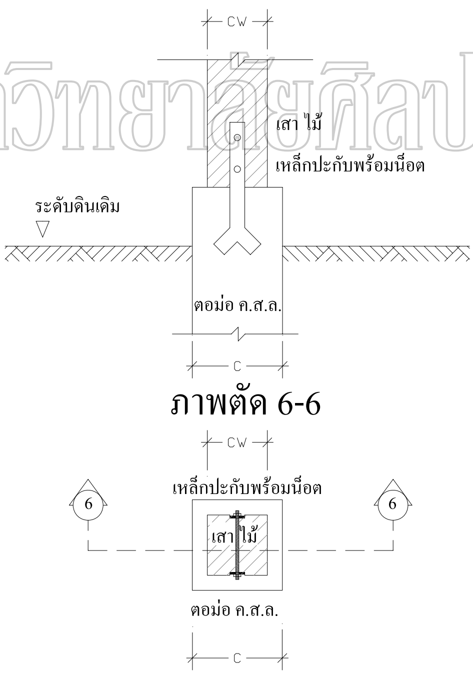


Figure 203:

Replacement of foundations for a single pointed footing, common practice (drawn by Vitul L., 24/11/07)

Figure 204 & 205:

New replacement concrete posts which were painted and casted similar to the existing wood posts, *Tai leu* house, Chiang Mai Cultural Center (taken by Vitul L., 7/1/06)

2. Treatment of timber and wooden structures

Timber and wooden structures include posts and beams, walls and partitions, floors and ceilings, stairs. The long list of deterioration factors on wood in Chapter 5 may occur singly, but more often than not will occur together with others since many of them share a common cause - water. Upon initiation of the investigation, the checklist and survey techniques are used. All defects surveys must be thorough and complete. Symptoms and signs must be carefully examined and recognized for what they are. Causes and defects must also be recognized and traced from the symptoms. Defects usually follow patterns and may lead to critical locations.

- Partial or complete replacement

If old timbers are badly deteriorated, they can be completely replaced. If some parts are still sound enough these may be repaired with inserted patches or pieces. The principle is to retain as much original material as possible. Such repairs are replacements of the same kind. This means that the new and old wood should be accurately matched according to all the following criteria: species, quality-first growth or second growth, cut-quarter sawn or flat sawn or mixed, color, grain direction and figure or pattern, tool marks, and the finish. Where old wood is being partly replaced the new wood is carefully inserted into the old where the unsound wood has been neatly chiseled away and usually undercut. Synthetic resin adhesives are frequently used to secure the new piece in place.

Figure 206, 207 & 208:

Replacement of a main roof structure where new and old wood must be accurately matched, *Wat* Baan Ko, Lampang (taken by Vitul L., 2/12/06)

- Mechanical reinforcement

Wood may be reinforced with dowels of wood and metal. Clamps or wedges may be inserted, for example, across checks or splits, but great care must be taken not to restrain the wood to such a degree that it is not free to shrink when it loses moisture. If this occurs then the mechanical reinforcement will tear itself apart.

Structural timbers can be splinted with new timbers, plywood, and structural steel which are connected by gluing, screwing, or bolting. Failed or weak connections can be improved or replaced by special brackets, angle irons, and hangers. Failed *ta pu jin* can be spliced-in to complete new *ta pu jin*. The addition of metal shear rings and timber connections can be used to improve shear resistance at the joints.

Missing areas of wood can be filled with gap fillers called *kee yah* consisting of natural resins and sawdust or other fillers. The concept of using such filler came from the wisdom of the locals, and was specifically made for the job. An interesting patching or filler compound formulation was passed from the ancient *salar* generation down to this generation. The mix is semi-flexible and can be carved, sanded, and planed. Some filler shrinks easily or can be hard to work but is very strong. Others may break down or melt at normal temperatures.

Figure 209 & 210:

Reinforcement of a main roof structure using a metal clamp (left) and reinforcement of main roof structure using wood post propping or supporting (right) *Wat* Baan Ko, Lampang (taken by Vitul L., 2/12/06)

- Consolidation by impregnation

Where old wood has become powdery or friable because of insect or fungal attacks, thermal degradation or burning, the remaining materials can be bonded together again by impregnating the wood with a low viscosity synthetic resin or molten wax. This is a new technique for locals but it is accepted and has proven to be proficient. The synthetic resins and epoxy may also be used with fillers to bulk them up and use where gaps exist. The resins can be introduced and placed via drilled holes by bulk loading guns. Consolidates should meet the following important criteria: penetrate deeply into the wood, cure or harden without shrinkage, bond well to the wood, not adversely affect the wood, be reversible or removable without harming the wood, remain stable with aging and not undergo further chemical reactions, remain where they are placed and not be subsequently removed by moisture, and finally, not cause aesthetically unacceptable changes in the surface appearance.

- Pesticides and preservatives

A "pesticide" is a substance which is used to eradicate an infestation by some undesirable animal, insect, or other organism which in this case is causing damage to a historical building. A "preservative" is a substance which is used to protect wood against future attacks. Some preservatives can be used as pesticides to treat attacks. *Chromated copper arsenate* treatments are a good example of this preservative. Pesticides and preservatives should have the following characteristics: be cheap; be safe to the user; kill insects and fungi at all stages of their life cycles; be fast working; retain killing power long enough to kill the maximum amount of pests; be specific to the targeted pests rather than being "broad spectrum" toxins which can kill or injure a very large range of living organisms including mammals, birds, and fish; be easy to apply; will not leave or form harmful residues; will not break down or loose their effectiveness in storage; will not be absorbed by and build up in animal or plant tissue; will not injure non target animals or plants; and will not corrode or damage building materials, equipment, furnishing, or valuable artifacts.

It is a common and legal practice to use pesticides or preservatives in Lanna. The *salar,* or traditional builder, and conservator can make or purchase and use them without any controls. Thus, insect pests can be eliminated. Insects which attack woods in historical buildings are of the following types:

1. Those which attack wood in the structure or in the furniture and decorations. This type includes *Hymenoptera* (carpenter ants and bees), *Isoptera* (termites), and *Coleoptera* (wood-destroying beetles including *anobiids, lyctids, cerambycids* and *buprestids)*.
2. Those which infest a building, feeding upon stored foodstuffs, spoiling materials, and spreading disease. This type includes cockroaches, crickets, ants, lice, fleas, and ticks.

There are two basic types, inorganic and organic insecticides. The organic have a subtype known as the "botanicals," which are plant products that may be used with synergists or activators. For example, vermillion or *chad,* wood tar, pyrethrum and *sadao* extract were utilized. Inorganic insecticides based upon chemicals tend to be less commonly used than the organics. Borax or sodium borate, arsenic, and DDT were popular in Lanna for a time beginning with the second World War to target specific species. This inorganic type falls under the extremely toxic category.

The ancient Lanna learned from the Chinese to use toxic chemicals which prevented attacks by insects and fungi that caused wood deterioration. They painted their religious buildings in red using the pigment vermillion or *chad* which is a red mercuric sulfide. The *chad* was used for luck and was successful at averting insect attacks on the wood. This is due to the mercury compounds which are extremely toxic and are effective in preventing *Hymenoptera* and *Isoptera* and *Coleoptera* attacks. *Chad* or *hang* is used together with other ingredients as it causes different shades of red color. India, China, and Burma were the original users of *chad* or *hang* in Lanna. However, since this type of soil has different qualities of shades and is poisonous to the user due to burning process, it is necessary to grind the mixture before using.

The ancient Lanna people tried to select and find ways to make wood strong and endurable. *Lacca* or *rak* is another way to protect wood from insects. This can also cover the defects on the surface of the wood. *Rak rubber* is used to coat of Lanna architecture. It is usually mixed with *chad* to make it red. There are two types of r*ak* which provide "rubber". *Rak ya*i or *Rak luang (Melanorrhoea usitata)* is a big tree whose trunk is grey but the inner side of the wood is red and extremely toxic. It can cause itching on the skin. It is about 15-20 meters long and its diameter can be up to three meters. It is found in an area of about 1,200 meters ASL, scattered in the Chom Thong, Fang, and Chiang Dao districts in Chiang Mai province, Chiang Rai province and also Mae Hong Son province. *Rak moo* or *Rak na*m *(Buchanania Latifolia)* can usually be found along the streams. See chapter 5 *Lacca* coating for details.

The local Lanna also used lead sheets to protect the wooden rice granaries or *ye khao* against the ravages of insects. They also controlled cockroaches, crickets, ants, lice, fleas, and ticks by burning sulfur and used arsenic, pyrethrum and *sadao* extract (*Azadirachta siamensis Valeton or A. indica A. Juss*) to control insect pests or crops.

3. The conservation and repair of masonry

a. Cleaning masonry

The cleaning of masonry materials (i.e. stone, brick, laterite, terracotta, or concrete) is considered one of the forms of conservation. It must be realized that any attempt to clean the masonry units is also going to affect the mortar. There is a balance between removing the soil material and not harming the masonry materials. Why the masonry should be cleaned depends on a certain number of reasons for example, to preserve the masonry, for aesthetic reasons or to protect against possible future deterioration. It is a basic principle of conservation which should be observed that the conservator should use the gentlest techniques and the least possible degree of intervention to secure any conservation objective.

Dusting or vacuuming, water cleaning, and the use of diluted chemicals are simple and widely practiced. But concentrated chemical compounds, sandblasting, and other excessive techniques might cause danger to the historic building. Cleaning can be divided into groups related to the nature of the masonry materials. There are five categories (see Chapter 5 Lanna building materials) which are: calcareous or acid-soluble carbonates stones; acid-resistant stones; ceramics or acid resistant fired-clay products; cementitious products; and water-soluble or water-sensitive masonry materials.

Water cleaning can be useful for some categories which do not include water-soluble materials. Materials are dirt deposits consisting of carbon (soot) and other particulate matter such as carbonates, silicates, and iron, either alone or held together by water-soluble salts such as calcium, sodium, or magnesium sulfates; and efflorescence or surface deposits of sulfates and chlorides. Water cleaning has disadvantages especially when used in great quantities. Water is known to be the cause of more deterioration in old buildings than any other single factor. If used in large quantities, water may soak deeply into the masonry, penetrating to damage interior finishes and create rot-producing conditions in hidden woodwork. Penetrating moisture may also cause corrosion in hidden iron and steel anchors, cramps, dowels, and other fixing details. Deep saturation may also cause water-soluble salts to be liberated from the core of the masonry and to be transported to the surface where concentrations of these salts may cause associated damage to the surface. Water supplies may contain large quantities of chlorine and may run through corroding iron parts. These can cause serious disfigurement and staining of the masonry surfaces. Water is generally best used in nebulous sprays discharging no more than 45 liters per hour. If the fine or nebulous sprays are turned on and off for an hour or so at a time, the expansion of the dirt crust caused by the wetting is followed by contraction as it dries. The crust tends to crack away from the substrate which does not expand and contract at the same rate. There is also the advantage that less water is used, reducing the risks of penetration and long-term saturation. Fine sprays using up to 110 to 140 liters per hour may also be used on less sensitive materials such as limestone.

Figure 211 & 212: Repairing of brickwork by re-plastering in *Wat* Phra That Chaehang, Prae (taken by Vitul L., 2/4/06)

b. Repair of brickwork

When the brickwork has deteriorated seriously, there is little that can be done. Then conservator should carefully cut out the worst affected areas and replace them with new bricks matching the original in dimension, color, texture, and physical characteristics such as the modulus of rupture, water absorption and thermal expansion coefficient if possible. Where old bricks are recycled for repairs, collected samples should be tested for salt contents and for quality. Generally, recycled bricks should be used in a location where they will be no exposure to excessive moisture and stress. New mortar to be used with old brickwork should normally be lime-based and should be applied as dry as possible to avoid shrinkage.

In Northern Thailand, the *salar* or conservator may demolish a whole part of a seriously decayed non-bearing masonry wall. A whole panel replacement within a whole bay will be done while at the same time keeping the least damaged bay intact without removal as it contains the main structure post and beam. In case of a bearing wall, always keep it as is and reinforce or prop the structure or take off the existing decayed wall, then re-plaster. Some re-pointing or re-plastering is the first treatment to be recommended. Once this has been done, the wall should be carefully monitored over at least one year to see if there is an accumulation of brick dust or flakes at the base of the wall. If the failure continues in the bricks then coatings or water-repellents may be used or the bricks may be carefully cut out and replaced. Some severely deteriorated decorative historic brickwork might be an applicant for consolidation with synthetic resins.

c. Repair of mortar, grouts and grouting

The original specifications for mortar may still leave the restoration architect or conservator with problems. As an illustration of the Chiang Rai mixture in Chapter 5 for example, specifications described the lime along with *nam nung kwai* to be mixed. The specified mortar was “to be composed mortar of one part of best lime, two parts of sand mixed with sharp forged ashes, and one small amount of *nam nung kwai* and ground them under the edge runner to a fine paste as required for immediate use”.

While historic mortar mixtures may be recreated by modern analyses, it is often academic and even inadvisable to use such mixtures in re-pointing or repairing masonry which has survived the ravages of time and the environment in a weakened or deteriorated condition. The mixtures may simply be too strong for the old masonry units. When the stones or bricks take up moisture and are heated in the sun they expand and will compress the mortar in the joints. If the mortar is harder than the stone or brick, they will be crushed and the edges may spall off leaving the mortar in place.

Mortar mixes for restorations and repairs should always be slightly weaker than the masonry so that if anything fails, it will be the new mortar which has no historical value and is expendable. Mortar mixes from the selected modern mixtures can be adjusted to match the original one by careful selection of aggregated particle sizes, configurations, and colors-possibly assisted by the addition of permanent non-fading mortar colors or pigments. These colors are based on natural “earths” and oxides which are in their most stable oxidation state and which will not go through any further chemical changes, therefore, cannot change color. Conservators generally prefer obtaining the colors of mortars by means of aggregation rather than by the addition of pigments.

For building treatments, original aggregated particle size distributions can be matched by sieve analysis using a graduated series of brass sieves. The classification of particles between 0.050-0.062 mm and 2.00 mm in diameter are as sand. Lower diameter particles are classified as silt. Particles between 2.00 and

100.00 mm in diameter are classified as gravel. The larger sizes of gravels upward which form 64.00 mm may be classified as cobble. Sharp or angular shaped make the best sand for mortars, and are also known as so-called "sharp sand" or "pit sand." Angular but with slightly rounded edges is called "river sand" as it is from an immature stage of a river. Round or rounded river sand from a mature stage of the river, is the so-called "soft sand"; which sometimes are specified for plastering sands (Weaver 1993, p. 134-135).

There have been assumptions made that a hard inflexible mortar such as that produced by mixtures of Portland cement and sand will produce the best durable finished product. This is emphatically not the case for work on old buildings. The addition of lime to mortars increases their flexibility, reduces damage to adjacent masonry units, and thus generally increases durability. Dense, hard Portland cement and sand mortars also tend to be either impermeable or of very low permeability. This means that when salts move towards the surface of the masonry in a solution of water, the water cannot move through the joint and is thus forced to move into the masonry units on either side of the joint. This in turn means that the water evaporates from the surface of the stone or brick and leaves a steadily growing accumulation of salts behind in the units' surfaces. The phenomenon, also known as osmosis, will then result in the accumulation of still more concentrated solutions in these areas and more and more salts will be deposited. Ultimately this means that the mortar remains projecting as a hard ridge and the masonry units are destroyed by the expansive cycles of hydration and dehydration. In cities where severe local air pollution problems are coupled with long range acid precipitation, this can lead to severe damage from a combination of sulfates and a hard dense pointing mortar which force the salts into the edges of the stone units.

The most important feature of mortars for conservation and restoration work is that the mortars must be resistant to the effects of cycles of hydration and dehydration. These occur from water-soluble anionic salt crystals once a mortar has been formulated with lime and sulfate-resisting Portland cement or additives to give the best combination of appropriate strength and elasticity. The requisite resistance to salt crystal expansion may be obtained by one further modification of the mortar.

The benefits of using lime today, however, are not quite that simple. Historically when limestone was "burned" to make lime for slaking and making mortars, the limestones were often selected because of the certainty of their impurities, such as clays, which actually made the final product semihydraulic, in other words, these limes produced mortars would set faster and in damper conditions than pure lime mortars.

Grouts and grouting. Masonry walls may suffer from mortar losses in their interiors because of prolonged penetration of acidic rainwater for example. They will thus develop large cavities within their cores and unless mortar can be reintroduced into these cavities the wall may fail under the load. The introduction of liquid cementitious mixtures into voids in masonry, rock, and soils is called grouting. The liquid mixes are called grouts. The amount of grout which is "accepted" by the voids is called the "take." Grouting may be carried out by three different methods: by gravity, by pumping and by vacuum.

Practical gravity grouting is used in Lanna. This type of grouting involves introducing liquid mortar by means of hoses from small or medium sized reservoirs or "grout pans" which are raised about 4 or 5 m above the inlet point. The height of the reservoirs above the injection points allows gravity to provide the pressure. The inlet or injection points are a series of holes drilled into the defective masonry about 1 m apart horizontally and 50 cm apart vertically on a staggered grid. Hand- and power-operated pumps may be used to inject grout under pressure. Hand-operated pumps are preferred for delicate unstable masonry. Vacuum grouting which is seldom used is done by injection nozzles. Holes are located as before and coupled to the grout hoses. The masonry to be grouted is then enclosed in a tough, air-tight, transparent polyethylene sheet. A typical mix for normal use is: Portland cement 100 kg, fly ash 34 kg, intrusion aid 1.5 kg, sand and water. In any grouting operation the volume of the masonry must be calculated as must the approximate volume of the voids.

d. Repair of structural cracks

The repair of structural cracks is accomplished by concurrently cleaning and repairing brickwork by mortar, grouts and grouting as described previously. Since Lanna historic buildings are designed with wood and masonry, structural cracks occur mainly in the brick, often which patching of mortars becomes the necessary method. Special composite mortars can be formulated for use in the restoration of stonework where small areas have been lost through spalling or other causes. Missing sections of moldings are a typical application of this kind. Such repairs are sometimes referred to as "plastic repairs". These types of repairs fall under the structural cracking class where the cracking has no effect on the structure, or at least only an aesthetic effect. Cracks classified in the P0 to P3 from fine hairline cracks up to the 2.00 mm cracks, are straightforward to repair. But when classified in the second category there is an increasing risk of the structure becoming dangerous. Cracks classified under P4 to P5 are associated with serious problems. The conservator must stop further repair and work on the superstructure related to the foundation, propping and mechanical reinforcement. Thus, in the case of P6 to P7 classified cracks, repairing is not an answer. Instead, other serious countermeasures must be undertaken. (See more detail in Chapter 6.)

e. Repair of rising damp

There are many different treatments for rising damp, most of which have proven to be unsatisfactory. Some of the more common ones are: hard cement renders, damp-proof mortar additives, ceramic tubes inserted into walls as drying aids, and passive electro osmotic damp proof systems. In the latter, copper strips were inserted into walls and simply grounded into the earth without the application of an active current. These methods should no longer be considered. To control and treat rising damp in historic buildings, it is a normal practice to build-in an impermeable barrier at the base of the wall just above ground level. This is known as the damp-proof course (DPC) or sometimes as the damp course. Modern DPCs are generally 0.5mm thick, black polyethylene sheeting. Early DPCs included overlapping roofing slates, lead sheets, glazed ceramic tiles (made for the purpose) and various bitumen-based materials, including tar–sand mixes which were laid hot. Historic buildings were built without DPCs. As a result, a substantial proportion of them have inadequate damp-proofing.

To control and treat the dampness problem without inserting a new DPC, the obvious response is to prevent it from recurring by fixing leaks and removing bridges. Conservation measures should be undertaken surrounding the original building and site as well. These will help prevent further dampness problems and may reduce the severity of an existing problem to an extent that major works are not necessary. These measures include regular maintenance of roof systems, and attention to site drainage and to under-floor ventilation.

Site drainage is important in that water does not lie against the base of walls; surrounding paths and ground levels should be sloped so as to drain water away from walls. Storm water should be carried well away by large, regularly cleaned drains. The ground levels may be needed to encourage the drying of capillary moisture to occur at lower levels, thus limiting damage. This practice is extended in the technique known as air drains, a method for controlling dampness by encouraging evaporation to occur at the lowest possible level. Rearranging site drainage may upset a pre-existing balance and lead to structural cracking of walls. Often the correct treatment will be a compromise between controlling dampness and controlling cracking.

Under-floor ventilation is an important part of controlling dampness, as it allows soil moisture to evaporate beneath the floor and to pass out through the vents in the lower walls. Without this ventilation the moisture on the walls would be much greater. The removal of a ventilated timber floor only to replace it with a concrete slab poured on sand or fill is a mistake. This should be corrected immediately.

Sacrificial treatments can be useful ways of controlling mild dampness. The conservator when attending to ventilation and site drainage may limit the dampness to such an extent that it becomes a manageable problem without the need for expensive major works. In sacrificial treatments, deliberately weak mortars are used to encourage any salt attack to decay the new mortar and not the original masonry. Formulation of appropriate mortar mixtures requires expert advice. As they are designed to crumble, sacrificial mortars need ongoing maintenance, and their decay products may be aesthetically unacceptable.

Insertion of a new DPC in many severe cases is the only effective solution. The insertion of a new DPC in the base of the walls can provide a permanent cure for rising damp; whereas, the other treatments mentioned all involve ongoing maintenance. This permanent treatment needs regular inspection to ensure that the efficacy of the new DPC is not being compromised by failure of guttering systems or bridging by the build-up of garden soil. New DPCs can be inserted by physical or chemical means. The traditional physical means is a technique known as undersetting (not to be confused with underpinning, which is a treatment for cracking and footing failure). In undersetting, sections of the base of the wall are removed and progressively replaced with new materials and a DPC is inserted at the same time. Another physical method involves sawing a horizontal slot through the wall along a mortar joint, inserting a DPC membrane and then repacking the joint. A system of grout-filled DPC envelopes is a neat version of this method, as it ensures tight packing of the joint. A shortcoming of any sawing technique is the inability to cut beneath an existing floor when working on internal walls. Thus, a line of damp bricks is left above the floor level, which may lead to fungal rot in skirting boards and floor timbers. At the same time, the method has the advantage of reducing disruption to existing historic fabric. A potential disadvantage is that salt-laden masonry may be left in the wall above the new DPC. This salt can still cause decay due to its hygroscopic nature and changes in humidity, and should therefore be removed by clay poulticing or a sacrificial render treatment. Otherwise, the method is best reserved for situations where salt concentrations are low. Chemical treatments have become popular in recent years. They aim to create a chemical barrier in the wall by injecting water-repellent compounds into a series of pre-drilled holes along the base of the wall. The advantage is minimal disruption, but, like the last physical method, any salts remaining in the wall above the new DPC must be dealt with. To be effective, the repellents must penetrate through the entire wall thickness. This may be difficult to ensure (NSW Heritage office 2004, p 4).

4. Repair and maintenance of roofs

Roof maintenance is prioritized restoration work. It is necessary for the preservation of historical buildings and keeps old buildings going. The major problems along with the outlined basic steps for repairs and periodic work, depending upon the degree and the number of changes, can be character shifting. Reroofing, repairing, or rebuilding a structure, can all add up to a character change. Conservators are advised to consider the extent of the change when determining whether or not their projects need prior approval by the Fine Arts department or local authorities. Small repairs and ongoing maintenance require no prior approval.

Figure 213:

Repairing of a roof by replacing the "in-shape," of various material - galvanize sheets, terracotta tiles on existing cement tiles at *Wat* Jaeson, Lampang (left) (taken by Vitul L., 10/2/08)

Roofs are one of the most frequently replaced and repaired building components. Traditional wood roofs often-lasted 40 years or more. Wood preservatives can extend their life. Generally, it is recommended that roofs be replaced "in-kind," or that an appropriate roofing material be selected. But sometimes a replaced "in-shape," is found in the suburban Lanna. Such a choice would generally be keeping with the character of the building. Conservators are encouraged to pick a roofing material in keeping with the style and overall character of their building. Generally, wood and baked tile would meet approvable for all Lanna buildings. This chapter concentrates on repairs rather than appropriate choices of materials. It assures that the material being replaced or repaired is what is already there. If, however, a substitute material is being used, some of the general prescriptions will still apply. There are a number of basic things of which conservators should be aware:

- The better the roofing material, the longer lasting the roof. High quality roofing material extends the life of any roof.
- Roofing material is priced by square meter. Contract costs are given both for materials and labor. A cheaper material will require the same labor costs, so apparent savings on materials should be reconsidered.
- Roofing problems can be the result of the failure of roof systems. Structure roof members should all be inspected. Sometimes the structural system is inadequate for the roofing material. Always consider the bearing capacity of a roof when considering a new or heavier roofing material.
- Roof slope is expressed in terms of the degree of the rise. The rise is important in choosing and applying materials.

a. Wooden roofs

Wooden roofs are probably the most traditional in Lanna called *pan kled*. Wooden roofs and shakes have been notoriously short-lived and expensive. But this is now less true. Shakes can be pressure-treated with both fire retardant and wood preservatives. A good teak roof can be expected to last 20 years. Pressure treated wood can last 25-30 years, and with repeated applications - at five-year intervals - of wood preservative, it can last even longer.

1. Substitute materials. There are several modern manufactured materials that can substitute for wood, including composite wood shakes, containing fire retardant chemicals, are now available in Thailand. These duplicate the heavier profile of shakes. Also, fiber cement shingles, also called reinforced concrete shingles, are made in wood patterns. Such materials are used in many restorations, including Doi Tung palace in Chiang Rai, and are fairly successful at duplicating the appearance of heavier wood shingles. The cement, however, tends to allow moss build-up, which must be removed periodically.

2. Repairs. Wood roofs are generally replaced not repaired. However, individual wood shakes can be replaced. Usually the nail is cut with a ripper and a metal tab is added to hold the new shakes. Care should be taken to match the color and character of the original as closely as possible. When replacing, individual shakes can be held with a tab.

b. Baked tile cleaning

Baked tile or *din khor* was widely used for roofs of houses, shophouses and the *vihara*. It is a common procedure to repair and clean roofs especially when historical buildings are demolished and relocated. Old pieces of baked tiles or *din khor* can be cleaned before reassembling, then new pieces are add to substitute broken pieces. The cleaning process for baked tiles is as follows:

- *Din khor* selection. Only complete old pieces are taken as most of them are ageing, discolored, or dirty with stains caused by weather and fungus.
- *Din khor* scrubbing. Tightened straw is used as a brush to scrub the tile surface with water; however, stains and color are still embedded in the cleaned tiles.
- *Din khor* drying. Pieces of tiles are laid out to dry for about two days under rough shelters made of scraps of wood or straw thatch roofs.
- *Din khor* re-burning. All cleaned tiles are put into rows in the open air, then straw and husk are put on the top and they are burned until they become red or brown. Finally, the new *din khor* can be used for reassembly.

c. Tile roofs

Cement tile roofs come in various types. Moreover, tile is an appropriate material for many religious and commercial buildings and could be considered for some other buildings as well. Tiles come in a variety of patterns as stated in Chapter 5, traditional tiles are manufactured in Chiang Mai and other provinces. Properly maintained tiles can last indefinitely.

1. Substitute Materials. Commercially available, CPAC tinted concrete tiles can be substituted for terracotta. Concrete tiles are equally long lasting. But they lack much of the more individual or variegated character of real tiles. Installation costs are comparable.
2. Repairs. Periodic repairs are important for the life of tile roofs. Tiles should be replaced individually as necessary. In some cases consolidation of tiles might be necessary, reusing older tiles on the same surfaces and utilizing newer tiles in less visible areas. Combining tiles with other materials is generally not recommended as a compromise solution.

5. Maintenance issues of heritage windows and doors

Heritage windows and doors are typically constructed of high quality wood and are often sheltered by a recessed entry, thus, they tend to be long-lasting. Most problems that occur result from a lack of maintenance, in addition to the swelling and warping due to climatic changes. A door also may be worn and sagging as a result of weathering and constant use. As a result, some heritage doors do not properly fit their openings. Water damage and the assault of sunlight are major concerns. In most cases, doors are not susceptible to damage if a good coating and paint are maintained. Damage occurs when the painted or finished layer is cracked or peeling. Decay may make operation of the door difficult and, if left untreated, can result in significant deterioration of door components.

When it comes to the repair of heritage windows and doors, in many cases a heritage door merely needs to be re-hung. This treatment is preferred to replacing the door altogether. Often repairing a heritage door is necessary, replacing it is not suggested. This is preferred because the original materials contribute to the heritage character of the building. Even when replaced with an exact duplicate door, a portion of the original building fabric is lost. Such treatment should be avoided. Because the door is of architectural significance, it is a key character defining element of the building. It has a position on the primary façade. It is indicative of the architectural style or type of building. Thus, preservation is the best approach for such a prominent feature of the building. Inspection of the door is the first step in the process to determine if it lacks proper hardware and framing components. Replacing these parts is an appropriate step in restoring the function. Next, the door is checked to see that it opens and closes smoothly and that it fits in its jamb. Some problems may be considered superficial, such as peeling paint. These are issues that can be remedied without altering the heritage character. First, it is necessary to determine the appropriate treatment for the door. In many cases the door may not fit the jamb as it should. In this case the hinges and the threshold of the door should be tightened or refit to allow for a smooth opening and closing of the door. Shaving or undercutting the door to fit the door frame is not recommended as a solution. Surfaces may require cleaning and patching. Splicing in new material for only those portions that are decayed should be considered, rather than replacing the entire door. If the entire door must be replaced, the new one should match the original in its general appearance. When rehabilitating a heritage door it is important to maintain the original door, jambs, transoms, window panes and hardware where feasible.

While replacing an entire door or window assembly is discouraged, it may be necessary in some cases. When a door is to be replaced, the new one should match the appearance of the original, retain the original door opening location, door size and door shape. A main concern is the material of the replacement door. In general, using the same material as the original is preferred.

Figure 214 & 215:

Repairing of heritage doors to maintain important features of a heritage building in *Wat* Jeason, Lampang (left) (taken by Vitul L., 10/2/08)

6. Maintain building characteristics

Maintaining the functional, proportional and decorative features of a heritage building are important to the character of a heritage building. These may include: the pediment, bargeboard, *typpanum*, (*pan lom* and *nah bun)* door, door frame, screen door, threshold, glass panes, paneling, hardware, detailing, transoms and flanking sidelights. Of equal importance is the preservation of the finishing materials, i.e. molded cement or *poon pun*, glass materials or *keaw juan*, gold lining or *jung go*, *lacca* coating or *rak,* ceramic tiles or *celadon* and painting. Avoid changing the position and function of the original functional, proportional and decorative features. On a commercial building, the main entry is often recessed, set back from the face of the building. This relationship should be maintained. When a heritage building is damaged, repair it and maintain its general heritage appearance. Repair is preferred over replacement. When replacement is necessary, uses materials that appear similar to that of the original or those associated with the style of the building.

7. Other restoration works – glass and paint

The conservation of seriously deteriorated glass and paint is highly specialized and should only be attempted by a trained and experienced glass and paint conservator. No conservation or restoration work should be attempted without a detailed site inspection being carried out. The Fine Arts Department has trained many types of craftsman. Originally there were ten groups of craftsmen called *chang sib moo* on the conservation and restoration works. Restoration and conservation for historic mural paints, sculpture, and historic fabric is dependent upon the specific situation.

In architectural conservation, the restoration of historic structures often involves the replication of their building fabric or surfaces for full interpretation, or at best a combination of conservation and replication techniques where original finishes survive. Considering the specific knowledge concerning the exact appearance of these finishes, it is understandable why the replication process is difficult. Where decorative restoration is to be replicated, every effort must be made to carefully duplicate the original quality of the work.

Chapter 8

Recommendations and conclusion

1. Recommendations on conservation practice and policy

From the study on conservation guidelines for historic buildings issues of investigation, materials, structural systems and treatment are essential steps in the recommendations for appropriate conservation practice for conservators, architects, building managers and owners as follows:

- Original and substitute techniques and materials
- Pathologies and corrective interventions
- Conventional threats to historical buildings
- Adaptation of historical buildings for contemporary uses
- Building maintenance plan
- Preparing a budget
- Documentation for conservation projects
- Conservation policy

a. Original and substitute techniques and materials

In many instances, when a conservation project is proposed or repair works to Lanna places are contemplated, the materials and techniques originally used on the building may no longer be obtainable. Therefore, alternative approaches must be considered. Building conservators need to obtain replacement materials which are compatible but different and the technical limitations and other methods of application must be carefully planned.

The conservation systems are normally grouped according to the types and availability of matching materials.

- Original and matching materials and techniques – unavailable

Some of the traditional Lanna building materials are no longer available. Materials that are now unobtainable include for example, terracotta or celadon, and some cementitious products, *kaew cheun*. For this reason it is common in conservation projects when the new materials do not match the old that there are obvious differences between original materials and placement materials.

Research is underway to re-learn the methods of production and application of some important traditional materials, for example *kaew cheun* or Angwa glass, which is quite different from *kra jok kriap* in central Thailand, and beautifully colorful. It cannot be produced at present. There is also the research on chemical components of Angwa glass. Academic researchers within the university environment have found that the metal used in Angwa glass to support the coloured glass is a mixture between tin and lead which, when analyzed, may be synthesized and reproduced. However, although the newly synthesized Angwa glass can reflect well, it is not flexible like the original and therefore, does not contain the same characteristics. Further research on this type of glass must continue to be undertaken.

There is much more research to be completed that must be made on other, currently unobtainable materials and other techniques of traditional Lanna building practice. Furthermore, this research needs to be undertaken to overcome the current lack of availability of the authentic materials and practices.

- Original and matching materials and techniques - available

Some of the traditional building materials are readily available. Wood and timber, for example, are still widely used for replacement work in a process of traditional repair by which the old piece is removed and replaced by matching new timber. For some small or limited budget conservation projects there are substitute materials which can be used. These alternative materials can be suitable for some situations.

- Original and matching materials and techniques - reproductions

Matching or non-matching reproduction materials are also available for use as alternative materials. Some of these reproduction materials are similar to the original materials and suitable for use in many situations. Masonry materials such as brick, laterite, and all kinds of stones are obtainable. They can be used in situations where research confirms their suitability. For example, deteriorated brick or *din kee*, can be replaced with new bricks provided that their dimensions, colors, textures, and physical characteristics are tested for modulus of rupture, water absorption and thermal expansion coefficient and that correct methods of bedding, jointing and fixing are identified. This type of research may need to be discussed with an experienced mason.

Jung go or gold lining, lacca coating and painting are also reproducible materials which need careful consideration regarding their application to traditional Lanna places.

- Reusable materials

There is a long tradition of reusing and recycling materials in Lanna buildings. For instance, there are traditional methods for cleaning and refurbishing of *din kee* and *din khor.* Representative samples can be tested for salt content and quality prior to reuse. Generally, recycled bricks and baked tiles should not be used in any location where they will be exposed to excessive moisture or heavy use because they will not be strong enough to withstand heavy traffic. When recycled bricks and baked tiles are used, the new mortar to be used with the recycled brickwork or tilework should normally be lime-based and should be applied as dry as possible to avoid shrinkage.

It is normal practice in conservation projects that the *salar* will look for reusable materials from other sources such as old houses nearby the site for leftover or unused wood, brick, tiles, door and window frames from the same period or architectural style. Sometimes they will buy one or more old houses in order to salvage sound components for reuse and to fix the structure being conserved.

Some plain colored glass and special building hardware, e.g. door hinges, doorknobs, latches, and lighting features, can be obtained from neighboring countries like Burma (Myanmar) or Laos. Materials that are considered carefully and found to be suitable are acceptable. However, it should be noted that the trade in authentic materials can work against the conservation of the authentic places from which the fittings were obtained.

- Substitute materials

New materials, including inappropriate materials, are widely accepted and used in Lanna due to their cost advantages and ease of use. The use of new fabric for repairs, including the use of synthetic materials (e.g. fiber cement, epoxy resin, plastic) are neither prohibited nor restricted in historic buildings. Nevertheless, the use of synthetic materials could be damaging and building conservators need to know the consequences of using non-matching materials so that the new fabric does not cause future damage to the existing adjoining fabric.

Substitute techniques may be required when using new construction technologies. Generally, repairing a building with traditional techniques and materials is consistent with the conservation philosophy of *the Burra Charter*. However, in some cases, new techniques can be appropriate also, including the use of reproduction materials as a means of extending the life of the original fabric. A range of new construction techniques can be suitable for conservation, according to the situation and needs of the place. For instance foundation underpinning and the replacement of footings, seismic isolation retrofitting, or the use of metal fastening for wood structures, can make old structures stronger and last longer. However the new work should always be distinguishable from the original work.

Many roof conservation projects in Northern Thailand employ modern materials and techniques for ease of maintenance and to achieve greater durability and strength. One such example is the conservation of the roof of the Tobacco Company building and Phra Tamnak Daraptrom in the MaeRim district of Chiang Mai. There the sheet metal was fixed over metal purlins in accordance with recent techniques to achieve stability, durability, and ease of maintenance while overall the appearance of the tiles and eave boards still remained in their original material and proportion.

New intervention techniques for the repair of structural cracking and rising damp in masonry structures must be introduced with caution to avoid adverse results or mistakes. The use of a damp-proof course in the old Chiang Mai city hall building and waterproofing coatings for masonry has not been tested sufficiently to warrant risking heritage fabric with an application of these unproven materials. The installation of a damp-proof course in the building in 1999 caused new problems including excessive drying out of the masonry walls and more cracking. These examples serve to highlight the need to work with the building, doing as much as needed but interfering as little as possible. And, wherever possible, all interventions and the introduction of new materials should be reversible.

In addition, all interventions using original and substitute materials and application techniques should be fully recorded. Poorly documented repair works could result in the work making matters worse rather than better. Documentation should include a description of site conditions, potential problems, access times, work areas and special measures employed for the protection of heritage fabric. Also, as a precaution against disputes, the requirements of the occupants and the users of the building should be documented just in case there are conflicts regarding the contractor’s work. Contactors should be properly informed about the need to protect important parts of the building and their heritage significance, especially if the fabric is irreplaceable, such as molded or casted cement and *kaew cheun.*

Contactors must be experienced. So must the local *salar,* who needs to be very skillful on the project. Contactors must find out what techniques and materials will be required and whether the same materials and skills are still available. It can be useful to ask contactors to list their recent projects, and to nominate their *salar kao*, or the master craftsman to work on the project. It can be informative to have the contractor undertake a small part of the work using the proposed materials and techniques.

When it is possible to do so, discuss proposed works on site with experienced people before preparing the contract documents. There have been many mistakes made in the past on Lanna buildings, especially when craftsmen have been imported from other areas where the techniques and skills are different. It has been observed that master craftsman from Bangkok or Patchaburi, even those who are very skilled in conservation in their own sub-areas or in Central Thailand, have not been suitable for work on Lanna buildings because their techniques and materials are not appropriate. Their art and culture is different. Some types and methods of repair work are relatively old and there are only few skilled persons who are educated about it. In these cases, contract documents should contain clear background information on the repair techniques, and detailed instructions on how to carry it out, and how it should look when finished. The *salar kao* can be crucial in obtaining a good outcome. The *salar kao* can supervise the work, as well as coordinate with the conservation architect and specialist contractors.

b. Pathologies and corrective interventions

Historic buildings exist in spite of the magnitude of past damage and deterioration of fabric. Conservation of these buildings requires the causes of deterioration to be understood clearly so that conservators can easily remedy the problems. Occasionally poor construction of old buildings is the cause rather than a chronic lack of maintenance. The causes of observed pathologies are described in Chapter 4. However, there is one problem that is not clearly indicated. It is the damage caused by renovation work done in the past in a disorganized manner and without any understanding of the values of the historical buildings. Past changes such as adaptive reuse or the addition of rooms and other modernizing works can be very damaging. Therefore, corrective interventions need to be taken to retain the original style and function of the building.

One common example which affects houses and shophouses in Lanna is that the buildings usually have no toilets inside. In more recent years, people have added sanitary works and these may have caused leaking or moisture penetration to the building. This then becomes a factor in the deterioration of wood in particular. Dampness typically from concrete-on-fill floors was among the common mistakes of past building improvements.

Another common cause of failure is overloading of traditional buildings such as houses and shophouse when used as museums, offices or public buildings. In certain cases, the excessive loads must be removed. Buildings may need to be reinforced or propped, and undersized structural members must be replaced with stronger elements.

In fact all changes, including the introduction of commercial signage, functional threats and major changes to historical buildings require the correct application of building pathologies and corrective interventions to conserve the structures. Corrective intervention is a crucial step for almost every major conservation project.

c. Conventional threats to historical buildings

The subdivision of old houses, shophouse or public buildings to create rentable rooms or shops, restaurants, apartments or other uses, and the introduction of toilets, sanitary facilities, air conditioning, and other modern appliances is a normal response to the legitimate desires of owners who want to improve their properties for economic reasons or for better living conditions. However, changes which result in overuse or are the result of property speculation can lead to disfiguring of buildings. In addition to these threats, there is generally a chronic lack of maintenance of significant building fabric and sometimes also the excessive use of inappropriate materials and techniques such as Portland cement which can cause irreversible damage. The most serious threat is destruction which cannot be rectified. The absence of a public policy in favor of restoration of significant buildings and suitable adaptation of historical buildings, therefore, leads to many buildings coming under threat of inappropriate change. Furthermore, heritage law in Thailand does not provide adequate protection for religious places, privately owned and unlisted historical buildings, or for inhabitants who remain unaware of the value of their significant buildings. Nor are there any incentives for owners to undertake maintenance to care for their buildings.

At religious places, the head monks of the temples and donors to those places often introduce new, modern and sophisticated equipment or objects and hi-tech appliances in the belief that such developments in their *vihara, ubosottha* or *kuti* will bring *boon* to themselves. Therefore, *bu ra na pa ti sung khorn* is in a sense of renewing rather than preserving. As the head monks and donors to conservation projects at present are more likely to be individuals, religious buildings undertaking *bu ra na pa ti sung khorn* should be more concerned for their correct style, techniques and materials.

d. Adaptation of historical buildings for contemporary uses

A principal objective of this study of architectural conservation guidelines of historical buildings in Northern Thailand is to prepare a historic conservation manual for the care and re-use of Lanna buildings. Such a manual can only work under the condition that the local authorities provide Lanna citizens with the necessary technical assistance and resources to implement the right care. The examples that are included here are common types of Lanna buildings - houses and *khums,* urban and government buildings, shophouses, and religious buildings.

The guidelines and recommendations can include:

- The classification and listing, or gazettal of buildings and inventories of places of national (exceptional), provincial (remarkable), and sub-area (interesting) significance
- The classification of historical buildings for their type of use or occupation
- Guidelines for the installation of sanitary facilities, air conditioning, and other modern appliances
- Acceptable matters or allowance for the conservation of historical buildings
- General requirements for historical building owners or head monks

e. Building maintenance plan

Regular expenditure on maintenance works is a much better investment for a building rather than a large expenditure of every 20 years or so. Once a building has been restored to a sound condition, it must be looked after by way of regular expenditure on maintenance. Major repairs to historical buildings may not be necessary if simple maintenance works are undertaken to respond to ongoing needs.

Maintenance is defined by *the Burra Charter* as “the continuous protective care of the fabric, contents and setting of a place”. Maintenance can be categorized according to the following circumstances:

- Regular corrective maintenance work made to necessary minor damages and deterioration due to use
- Planned maintenance work to prevent failure which recurs predictably within the life of a building, such as cleaning or painting.
- Emergency corrective maintenance work that must be undertaken immediately in response to accidents and adverse events for health, safety and security reasons or that may result in the rapid deterioration of a structure or fabric of a structure if not undertaken promptly to, say, repair a roof after storm damage, or repair broken window glass.

The building maintenance plan can also be categorized according to who carries out the maintenance work as described below:

- housekeeping maintenance carried out by owners and handymen
- professional maintenance carried out by conservators and *salars.*

The main purpose of a maintenance plan is to ensure the most cost-effective way to maintain the value of an asset.

The advantages of a plan are that:

- the property will be managed and maintained in a systematic way
- building services will be monitored to ensure their efficient use
- the standard and presentation of the property can be maintained
- subjective decision making and emergency corrective maintenance will be minimized.

When buildings are neglected, defects can occur and may result in extensive and avoidable damage to the building fabric or equipment. Neglecting maintenance can also give rise to fire and safety hazards, which could trouble building owners and cause injuries. Regular, well planned building maintenance will avoid these problems. It is necessary for religious, public or private buildings.

Good management of historic buildings should include effective conservation planning aimed at retaining heritage values and effective maintenance programs to direct money effectively and wisely.

Building owners need to understand the needs of their buildings and this can be achieved by monitoring conditions and recording expenditures on maintenance in detail over a period to establish a maintenance history and to provide a basis for forward planning. Without this information building owners cannot decide on a maintenance plan or prepare a maintenance budget. Basic information that an owner needs to have includes:

- Building plans and construction details
- Building data regarding the age, information on architectural style, details of historical significance and heritage listings, and photographic records showing the condition of the building, including individual rooms, furniture, artworks and objects, landscape details and trees.
- Service details and maintenance requirements which involve a daily log book, a maintenance log book which reports past defects, injuries and expenditure. This should also record all maintenance work which has been carried out, including descriptions of works, date of completion, estimated and actual costs, contractor details and warranties. All of these details are valuable sources for future budgeting.
- Names and contacts of the *salar kao,* specialist contractors, conservators, architects and professors who are responsible for maintenance or sources of related information
- Local authorities and their requirements
- Reports on the building, including conservation plans, details of previous conservation works and periodic inspection surveys

f. Preparing a budget

Annual budgeted expenditure on maintenance normally falls into three categories:

- Committed expenditure, which includes tasks that occur every year as part of planned maintenance
- Variable expenditure, which includes regular tasks within an overall program of planned maintenance that may not occur every year depending on the owners' decisions on priorities and their available financial resources
- Managed expenditure, which relates to unplanned maintenance works carried out entirely at the owner's discretion – primarily emergency corrective maintenance with the aim of reducing unplanned expenditure over time as far as possible. The aim is to replace it with expenditure which helps to identify how components are performing and when they might fail. These expenses may include costs for inspections, replacement of materials or finishes, cleaning and any unforeseen breakdowns or repairs

g. Documentation for conservation projects

After building investigations have been completed documentation for works can be prepared. The nature and extent of documentation will differ from one project to the next but it will generally include the following:

- Contract conditions that are relevant to the scale and extent of work and appropriate for the selection and engagement of a suitable contractor. There are several standard forms of contract available. The contract gives owners and builders adequate protection if something goes wrong. If a building has been closely inspected from a scaffold prior to the contract being let it is unlikely that additional problems will be revealed during the project. However there will always be unforeseen problems and extra work in repairs to any building. The contract should thus allow for further inspections to confirm the extent of work.
- Allowances for extensions or variations to a contract are crucial for conservation projects. Lump-sum contracts may be inappropriate unless a large contingency sum is included. A more flexible form of contract, with a schedule of rates, can be better suited to conservation work. Extra budget allowances should be provided for unexpected problems.
- Drawings are usually the most efficient way to convey what something looks like, how big it is and how it fits together. Drawings for *nah bun* repairs, for example, could range from a simple sketch or marked-up photograph to a complete set of computer-drafted plans at various scales showing the location, size and shape of every detail in the building.
- Specifications are a written description of the materials and techniques to be used in the work. Most project specifications incorporate references to standard specifications and traditional methods. Each section includes a brief scope of works, descriptions of the required materials and techniques to be used, and a detailed description of specific elements.
- Schedules contain lists of components such as window or door finishes. For conservation work, schedules of repairs are commonly prepared for each room or other elements. Schedules are an effective way to summarize the works to be done.
- Samples of work to be undertaken, in many cases, are the best way to ‘document’ conservation work to match existing work. Samples of workmanship, materials or components can be identified and used as a reference. The approved samples are properly marked and retained throughout the job. Most maintenance and repair jobs will be documented using a combination of methods. For example, re-plastering documents could include a drawing showing repair locations, a specification with standards for *poon satye* plaster mixes and application, and a schedule listing the work required for each wall, with a marked area of wall plaster on the site used as a sample of the desired finish to be achieved.

The final set of documents to be used should be appropriate for the job. More documentation is not necessarily better. The same rule should be applied to the documentation as is applied to the work: as much as necessary and as little as possible.

h. Conservation policy

The results of this study found that every year historical buildings are demolished, damaged and suffering from inappropriate use and poor maintenance practices. The ordinary houses, shophouses, government buildings and religious places that make Lanna exceptional mostly have heritage significance. This architectural heritage constitutes a living context, culture, a technology and a morphology which should be conserved in order to meet the needs of today and remain available also for the future. Aside from all considerations regarding heritage, it must be clearly admitted that a conservation policy tailored for the specific needs of Lanna is the only systematic solution which is coherent from a technical and economical standpoint and at the same time achievable in Lanna.

Conservation policy should be directed at architectural assets, organization and management/control of works and, more importantly, to circumstances of social life and philosophy. The prime objective of a broad conservation plan should be to ensure the continual utilization of heritage assets their conservation and preservation, and appropriate adaptation to changing needs. Therefore, local authorities should prescribe land uses, traffic management guidelines, and economic programs for the protection of historical buildings and rules for new construction in the vicinity of significant heritage places. Depending upon the provisions and objectives, all operational and financial instruments should be brought to bear in the application of conservation guidelines and provincial development strategies.

Even with these measures in place, the conservation of heritage buildings will not be the automatic consequence of any policy. In purely economic terms and for the owners best interests, the conservation of heritage buildings will be determined by one simple equation: as long as the returns derived from the old building are less than that of a new construction, demolition will be more attractive than conservation. This same equation is more complex in the case of public authorities: in addition to the parameters of immediate return, the benefits must include indirect and long term advantages, such as tourism, trade, the choice of investment, employment and political issues. The following issues are recommended for further study on conservation policy:

- Regulatory measures which may include permits for demolition, a declaration proceeding any sale and a right of preemption, stringency of the building permits, enforcement of obligations, clarification of property titles, and sanctions
- Financial and taxation measures including direct subsidies to owners, training of craftsmen, and funding for materials

- Environmental measures including better public amenity, promotion of aspects of major historical buildings and districts, traffic planning and controls
- Institutional measures such as greater authority for those in charge of the protection and conservation, and a center for the conservation of the historical buildings in Lanna.

2. Conclusion

a. Architectural conservation philosophy

Lanna customs in heritage conservation are sturdy. The social life and culture of Lanna people and their local history are unique and increasingly valued. But when contracting with their architectural heritage, unlike other eastern philosophies, Lanna people practice a more intuitive approach to conservation. They work more on an inheritance of beliefs and skills for fixing old buildings than for considering the value of the actual fabric or the replica styles. They also follow old rules to renovate old structures. In the Lanna culture, conservation more specifically means to get *boon* than to preserve old fabric or objects, because the people try to maintain abstract values rather than concrete ones.

Therefore, their customs to demolish and relocate (*pha ti kam* for religious building relocation) reflect the belief that the assets do not belong to them. The architectural assets belong to the original owners or their builders. It is not wrong to discard or unoccupy Lanna buildings. Old buildings always reflected the personal requirements of original owners or head monks who built them. For example, some lengths of some parts of a building may relate to the owners' height or the symbols of their Chinese year of birth. These things reflect their ownership. New owners are usually aware of this custom so they avoid interfering with them. They pay respect to the spiritual rights of the original owners and builders. But since some significant buildings have continuously been used, then *bu ra na pa ti sung khorn* becomes a form of renewal by applying current style and taste, techniques and materials, when new ownership is installed.

Architectural conservation of historic buildings in terms of authenticity is a modern concept and entirely foreign to most eastern cultures including Lanna. The western respect for authenticity emerged in the eighteenth century, led by the development of western historical thoughts found in many organizations, management processes and guidelines. However, in Thailand, the Fine Arts Department, the Association of Siamese Architects, as well as other foundations and institutions are now becoming more active in this conceptual part of conservation philosophy. Their counterparts are the Religious Affairs Department and local owners, head monks, and donors whose beliefs and notions of conservation tend to be the enrichment they afford by way of *boon*.

The challenge today is to bring together the philosophies regarding authenticity and enrichment for the benefit of conservation. The urgency for this is underscored in Northern Thailand by the diminishing Lanna building assets - only some hundreds of each building type remain. The continuum of change, with forward movement, and even customs differ. The methods of architectural conservation have altered. Now Lanna people have choices to make regarding heritage protection. They can choose to move forward by way of adaptive reuse to rehabilitation; they can also choose to move backward with respect to their ancestors by way of restoration; or perhaps to restart and recreate by reconstruction, or they might “freeze and fossilize” the glorious past by way of preservation.

b. Architectural conservation practice

It is the goal of this study to put forward recommendations that would provide for improvements in architectural conservation practice despite the fact that, in reality, it is quite a tough task, especially for local circumstances. However, if no guidelines are adopted and no conservation manual is prepared, it is highly likely that conservation practice, both at present and in the future, will fail to meet the challenges of the time.

As each day goes by things become more difficult, either because the state of the buildings worsens or because the challenge is too great and overwhelming – it remains at a standstill. Lanna is today standing very close to a point of no return for conservation of its significant architectural heritage. Will it be able to retain its architectural heritage? Will local experienced persons, professional experts and organizations work together, by sharing their expertise, to meet the worsening state of the aging structures?

Lanna customs are still strong. But will they remain so?

There is a broad selection of principles for architectural conservation practice in this study. Improved forms of practice are substantial ways to fight for authenticity and integrity. Unless Lanna people realize the importance of their distinctiveness and identity, which can also be found in their unique architecture, they themselves will lose their local wisdom of which they should be proud. Therefore, to revitalize deteriorated structures and the living heritage, whereby people can make use of them and appreciate their cultural significance, the suggested conservation guidelines should be adopted. It would be one crucial way to prevent both the heritage values and the local wisdom from vanishing from the Lanna landscape.

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Glossary

boon n. = good deeds; merit; virtue
bu ra na pa ti sung khorn v.= to conserve of religious buildings, mostly for reconstruction and renovation
celadon n. = unique green color or glazed terracotta
cementitious adj.= relating to a chemical precipitate, especially of carbonates, having the characteristics of cement
chad n. = additive red color from natural sources
chan n. = terrace in Lanna house
chan hom n. = corridor connecting the front to the back terraces of Lanna house
chang n. = barn
chang sib moo n.= ten groups of skillful craftsmen trained by the Fine Arts Department
chettabun n. = Shan temple's multi-tiered roofs with a triple-layered roof
din kee n. = fired or burned brick
din khor n. = baked roof tile
fabric n. = the structural and material parts that make up the building (frames, walls, floors, roof, etc.)
jung go n. = gold lining in bronze mixed with metal like gold or copper sheet
kaew cheun n. = Lanna architectural glass which were mostly used for the ornament of Lanna architecture
kee yah n. = wood filler
keok n. = *maa tang mai's* main tie beam for roof structure
keok maa n. = *maa tang mai's* beam for roof structure
klon n. = wood stick or dowel to tie structure members
khor khama v. = ceremony to beg for pardon
khud n. = taboo, unaccepted or disastrous behavior
khum n. = residence complex of Northern kings and royal families
kra jok kriap, or *kra jok houng* n.= Thai architectural glass which were mostly used for the ornament of Thai architecture
kuti n. = Buddhist temple's living quarters or residences for monks
gingerbread house n.= wooden and masonry house of Victoria period brought by the Westerners with carved and elaborate decoration
glone n. = sticky lime cement or *satye* prepared for moulded cement
hor klong n. = Buddhist temple's drum tower
hor rakhang n. = Buddhist temple's bell tower
hor sua n. = spirit house which is believed to protect people in the village
hor tri n. = Buddhist temple's library
intervention n. = the physical intrusion upon a building during a diagnosis, or its therapy
investigation n. = a systematic and detailed evaluation of a building that can include examination, material testing, structural analysis, and structural testing

Lanna n. = the old kingdom in the North of Thailand covering Chiang Mai, Chiang Rai, Lumphun, Lumpang, Payao, Prae, Nan, Mae Hong Son

long khao n. = rice granaries

luog-fuck n. = wooden flush panel

maa tang mai n. = Buddhist temple's wooden roof structure for *vihara* or *ubosottha*

mae non sai n.= underfooting compressed fine round grained sands in wet conditions

mord n. = wood-borer and bamboo-borer, *Bostrichidae* beetles

muang fai n. = weir and channel irrigation systems

nah bun n. = *typpanum* which is elaborately decorated for religious buildings

nam nung kwai n.= proteinaceous glue obtained from the boiling and filtering of collagen from the skin of buffalo

paap n. = building's main wooden structure

pan kled n. = wooden shake roof

pan lom n. = bargeboard

pa phae n. = forest which serves as a fire and wind break and a place where villagers can harvest forest products

pa ton nam n. = forest which is the source of the streams where villagers preserve with respect and traditional belief

patye phet n. = extra strong lime mortar or plaster

patye poon n. = lime mortar or plaster

pha ti kam n. = relocation of historic religious buildings

phee n. = holy ghost

pler langmaa n. = *maa tang mai's* connecting purline roof structure

pler linharn n. = *maa tang mai's* purline roof structure

poon charp n. = lime plaster or fiber cement

poon dib n. = quicklime or calcium oxide

poon lor n. = casted cement from mold

poon nam mun n.= oily moulded cement or lime cement used for moulding relief or sculpture

poon pun n. = moulded cement or lime cement used for moulding relief or sculpture

poon tum n. = grinded cement or lime cement used for moulding relief or sculpture

poon satye n. = extra strong lime mortar or plaster

poon sod n. = soft and spongy mixed and pestled lime cement

poon sook n. = slaked lime, hydrated lime, or calcium hydroxide, $Ca(OH)_2$

pratu khong n. = Buddhist temple's main entrance structure

puek din n. = soil for mud mortar

puek poon n. = slaked lime for mortar

rak n. = kind of tree or natural rubber from tree *melanorrhoe, lacca,* or lacquer

rak dib n. = raw liquid from tree *melanorrhoea*

rak ched n. = *rak nam kliang* which is boiled and used with gold plates or to cover the surface

rak klia n. = *rak nam kliang* mixed with ash used for filling, and resurfacing

rak luang n. = kind of tree *melanorrhoe (Melanorrhoea usitata)*

rak nam n. = kind of tree *melanorrhoe (Buchanania Latifolia)*

rak nam kliang n.= raw liquid rubber mixed with other medium
rak moo n. = kind of tree *melanorrhoe (Buchanania Latifolia)*
rak sai n. = pure liquid and colorless rubber used to mix with *rak*
rak samook n. = *rak nam kliang* mixed with *samook* used for molding, filling, and surfacing
rak yai n. = kind of tree *melanorrhoe (Melanorrhoea usitata)*
repointing n. = result of repair or restoration on a deteriorated joint either homogeneous to the existing joint or made of different material
rong n. = additive yellow color from natural sources
ruen n. = house
ruen kalae n. = wooden house built on high stilts in unique Northern style
ruen khrua n. = cooking house or kitchen
ruen krueng pook n.= bamboo house built on high stilts
ruen krueng sab n.= wooden house built on high stilts
ruen mai bua n. = bamboo house built on high stilts
ruen mai ching n.= wooden house built on high stilts
sakol chang n. = skillful craftsmanship distinctiveness
sala n. = rest pavilion
sala karn parien n.= Buddhist temple’s preaching hall
salar n. = skillful craftsman and traditional builder
salar kao n. = master skillful craftsman and traditional builder
samook n. = soft or hard fillet for mixed *rak*, white clay or clay filler, charcoal, or lime

sao sakon n. = *maa tang mai’s* pendent post roof structure
sor din n. = mud mortar
sor poon n. = lime mortar
stupa or *chedi* n.= Buddhist temple’s mound-like structure
Tai khoen n. = minority of ethnic groups in Lanna
Tai leu n. = minority of ethnic groups in Lanna
Tai yai n. = Shan, minority of ethnic groups in Lanna
Tai yuan or *khon muang* n.= majority of ethnic groups in Lanna
Tai yong n. = minority of ethnic groups in Lanna
ta pu jin n. = metal stick or nail to tie structure members
tieng na n. = field shack
tong n. = building’s main wooden structure
toen n. = front part of the sleeping room for guest reception in Lanna house
torchis n. = stucco plaster cement wall
tuak n. = sticky lime cement or *satye* mixed with glue prepared for moulded cement
vang n. = building’s main wooden structure
vihara / *viharn* n.= Buddhist temple’s ordinary hall or preaching hall
wat n. = Buddhist temples
ubosottha n. = Buddhist temple’s assembly hall
undersetting n. = treatment for dampness by inserting damp proof course (physical or chemical)
underpinning n. = treatment for cracking and footing failure

yan n. = mystic symbol; magic design; magic letter usually described on body or small pieces of the textiles which are believed to be sacred

yon saek n. = Shan temple's multi-tiered roofs with a four-layered roof

Biography

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Workplace: Faculty of Architecture, Chiang Mai University

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1984 Certificate in Architecture, Institute of Technology and Vocational Education, Chiang Mai Campus
1986 Bachelor of Science in Architecture, King Mongkut's Institute of Technology, Ladkrabang
1988 Certificate in Computer Aided Design, Los Angeles City College, California
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1986 Teaching Assistant, Dusit Technical College
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