

LACQUERED DOORS AND WINDOWS AT WAT KAMPANG TEMPLE BANGKOK ANALYZING THE CURRENT PROTECTION SYSTEM AND FINDING ALTERNATIVES TO PREVENT FURTHER DAMAGES



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การก้นกว้าอิสระนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรศิลปศาสตรมหาบัณฑิต การอนุรักษ์และการจัดการมรดกทางวัฒนธรรม (หลักสูตรนานาชาติ) แผน ข มหาวิทยาลัยศิลปากร ปีการศึกษา 2567 ลิขสิทธิ์ของมหาวิทยาลัยศิลปากร

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Title	Lacquered Doors and Windows at Wat Kampang Temple Bangkok
	Analyzing the Current Protection System and Finding Alternatives
	to Prevent Further Damages
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Field of Study	Cultural Heritage Conservation and Management (International
	Program)
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Faculty of International College, Silpakorn University in Partial Fulfillment of the Requirements for the Master of Arts



649020013 : Major Cultural Heritage Conservation and Management (International Program)

Keyword : lacquer work, Lai rod nam, Wat Kampang temple, aluminum framed acrylic protection systems, photodegradation

Miss Tahmida AFROZE : Lacquered Doors and Windows at Wat Kampang Temple Bangkok Analyzing the Current Protection System and Finding Alternatives to Prevent Further Damages Thesis advisor : Dr. Thanya Lunchaprasith

Lacquered Doors and Windows at *Wat Kampang* Temple, Bangkok

Analyzing the Current Protection System and Finding Alternatives to Prevent Further Damages

The doors and windows of many traditional Thai palace and temple buildings, especially those of Ayutthaya period (1351–1767), have rich decorations of an enduring lacquering technique named – *Lai rod nam*, in which gold leaves are applied on black lacquered background. Even though lacquer is one of the most durable natural binders, these art works are facing deterioration and irreversible damages such as loss of lacquer surface and photodegradation due to their exposure to severe weather conditions.

This research aims to study the aluminum framed acrylic protection system on the lacquered door and window shutters of *Wat Kampang* temple in Bangkok. The study focuses on the damage types and failure mechanism of the protection system and tries to find an appropriate solution for the surface protection that can sustain in the long run.



ACKNOWLEDGEMENTS

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In addition, I would like to acknowledge the support and encouragement of my family and colleagues from University of Applied Arts Vienna, Austria, Silpakorn University International College, Bangkok, Thailand and Getty Conservation Institute, U.S.A., who have provided me with emotional and moral support throughout this challenging journey to complete the masters in Cultural Heritage Conservation and Management.

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Introduction

The art of lacquer is one of the most ancient and exquisite expressions of Asian culture. In Thai art and craft, lacquering has long played a significant role ever since this technique was introduced in the 13th century.¹ In Thailand, lacquering on door and window panels in black and gold design is an integral part of traditional religious and royal architecture. Although lacquer is a durable material that retains its colour and bonding with the substrate for a very long time, the lacquered doors and windows at many palaces and temples in Thailand have developed extensive damages in the lacquer coatings. These damages range from small cracks to fading and considerable loss of lacquer surfaces. At most of the significant sites and buildings, to protect the lacquered decoration of the door and window panels, they are covered with acrylic sheets in frames to protect the surface from dust and dirt as well as any accidental touch and vandalism. But unfortunately, this protection system, although can be a good choice in terms of cost, is not able to perform well from the point of preservation and conservation of the lacquered surfaces. Such acrylic protections are not able to prevent damages from many other threats that the lacquered surfaces are vulnerable to, such as sunlight and environmental humidity. In order to prevent further losses of these decorative lacquered wooden panels, a comprehensive protection system needs to be developed which is low cost, easy to install and maintain, and can ensure long term protection of the same.

This research is done in the framework of a master thesis. The primary aim of the study is to evaluate the existing acrylic protection system that is evident in most of the instances of lacquered doors and windows in Thailand, understand the conservation needs of the lacquered surfaces and develop a sustainable solution for their long-term protection. The research is presented in five different chapters that starts with reviewing literatures on history and different types of lacquering techniques that the Thai artisans have been practicing ever since the art of lacquering was introduced in the land. Although there are many techniques that were practiced in Thailand, the study tries to get a deeper understanding of *Lai rod nam* lacquering technique because this sets out the scope of this research, as the door window shutters at *Wat Kampang* temple are decorated with *Lai rod nam*. The history and structure of the building of *Wat Kampang* temple is also studied to understand the context of the lacquer art of the temple. Although proposing conservation interventions for the lacquer art is out of the scope of this

¹ (Simatrang 2002)

research, the condition of the lacquere designs and the wooden door window shutters have been studied to find the association of the protection system to the present conditions. The existing aluminium framed protection system is examined in detail, to understand their installation technique, materials and performance. Based on the findings, several concepts for the improvement is proposed. The findings of this research can eventually contribute to draw a more appropriate protection system that may serve as a solution for Wat Kampang temple as well as other similar examples.

1. Thai lacquer work: Lai rod nam

1.1. History of Thai lacquer work

East Asian lacquer is a type of resin that comes from saps of some specific trees that are native to the region and are known as lacquer trees. There are several trees within the Anacardiacea family, formerly known as *Rhus verniciflua*, that grow throughout a number of geographical locations within Asia (figure 1) from which the saps are collected to produce lacquer. For example, traditional Japanese lacquer *urushi* or Chinese *qi* comes from the sap of *Toxicodendron vernicifluum*, and Vietnamese and Taiwanese lacquer comes from the sap of *Toxicodendron succedaneum*. The Burmese and Thai lacquer is collected from *Gluta usitata*.² Figure 1 shows in different colours where different lacquer-tree species grow in east Asian countries. The area marked in red indicates the region where *Toxicodendron vernicifluum* grows and this includes China, Korea, and Japan. The part highlighted in green is the area where *Toxicodendron succedaneum* grows. The region covers Vietnam and Taiwan. Thailand and Myanmar, are coloured with purple, grow *Gluta usitata*.

All lacquer saps are a complex mixture of catechol and phenol derivatives (60-65%), proteins (glycoproteins 2%) and a laccase enzyme (1%), polysaccharides (7%) and water (30%).³ One of the significant properties of these tree saps is that – once dried, it hardens into a tough transparent layer.⁴ The laccase enzyme is the chemical component that trigger the polymerisation reaction under warm and humid conditions and forms a hard film through enzyme-catalysed reaction in the presence of oxygen and high humidity.⁵ This hard surface is

² (Getty n.d.)

³ (Tamburini et al. 2020)

⁴ (Asian Art Museum 2016)

⁵ (Coman 2016)

resistant to moisture, acid and to some extent to heat.⁶ Because of these properties, lacquer was traditionally applied as a coating or finish to materials such as wood, metal, bamboo weaved objects etc. to give protection to the surfaces from moisture, insects, cracking, corrosion, leaking etc. like varnish.

The catechol-phenol mixture composition varies in the three different types of lacquer trees and results in differences in the final polymer of the three different types of lacquer. The lacquer is usually applied in several coats to the surface of a desired object and once dried the surface is not only hard but also shiny. The gloss makes the surface aesthetically appealing. People in the ancient period explored this aspect of lacquer and developed many techniques to use lacquer for artistic purposes. Thus, the use of lacquer has evolved from a purely practical use as a protective layer on daily utensils to a medium of human's artistic expression. Eventually lacquering, as a form of art has become one of the most treasured aspects of Asian Art.⁷



Figure 1: Zone of different lacquer species grown in East Asia.

⁶ (Chasen, Heginbotham and Schilling 2021)

⁷ (Getty n.d.)

Type of Lacquer tree	Lacquer	Region
Toxicodendron vernicifluum	urishiol	China, Japan and Korea
Toxicodendrum succedaneum	laccol	Vietnam and Taiwan
Gulata usitata	thitsiol	Loas, Myanmar, Cambodia, and Thailand

Table 1: Types of lacquer, lacquer trees and their geographical locations

According to the art historians and archaeologists, the use of lacquer as a protective layer was first introduced in China. A lacquer bow excavated from east China's Zhejiang province indicates that the usage of lacquer dates back to about 7000 – 8000 years.⁸ Lacquer as an art form also developed in China. There were two distinct styles of lacquer art practiced in China in ancient times. Those were - 'surface decoration', in the form of painting or inlay (figure 2) and the other one is 'carving', where relief work is done on a thick layer of lacquer resulting in a three-dimensional design (figure 3).⁹ Chinese artisans also learned the use of carbon black, iron oxide black, and iron oxide red that could make the lacquerware red and black.¹⁰ During the Han Dynasty (202 BC - 220 AD), lacquerware became a very significant part of Chinese people's lives, and they used it extensively for the decoration of the emperor's chair to objects for common people. Chinese artisans kept on exploring the art technique and after 10th century several techniques evolved: engraved gold (qiangjin), filled-in (diaotian or tianqi), carved lacquer (diaoqi), lying lacquer with mother-of-pearl, to name a few. As the book on Traditional Chinese lacquer work, 'Xiushilu' mentions, the craftsmen of China developed 14 kinds of techniques to do decorative art with lacquer. They used coloured drawing lacquer, carved lacquer inlaid with multi-precious stones etc. to decorate vessels and objects. Over time, the craftsmanship of lacquering has become one of the most important aspects of China's intangible culture.11

From China, the art spread to other Asian countries like Japan, Korea, Vietnam, Myanmar, and Thailand by means of the then trade routes. According to historians, Korea and Japan were the first to work with lacquer after China. The Japanese invented the use of metal powders, a technique known as *maki-e*, which are usually powdered gold or silver of specific grades. Such powdered metals are placed into the lacquer surface when it is wet to create background effect

⁸ (CGTN 2020)

⁹ (The Metropolitan Museum of Art n.d.)

^{10 (}CGTN 2020)

^{11 (}CGTN 2020)

or for detailed designs (figure 4).¹² On the other hand, Korean artisans excelled in the technique of mother-of-pearl inlay and thus this technique became the dominant decoration technique for them and continued to be such till present day (figure 5).¹³



Figure 2: Winged cup with geometric design, surface decoration of brown lacquer painted with red lacquer, 3rd century BC, China.



Figure 3: Tray with women and boys on a garden terrace, carved lacquer, 14th century, China.

¹² (Laurin 2013)

¹³ (The Metropolitan Museum of Art n.d.)







Figure 5: Trefoil-shaped covered box with decoration of chrysanthemums, lacquered inlaid with mother-of-pearl and tortoise shell over pigment and brass wire, 12th century, Korea.

However, from the ancient evidence of lacquering and gilding on different materials and objects found in Thailand, it can be claimed that the lacquering, *Ngarn Rak*' in Thai language, had already been in practice in the Siam region from the Sukhothai period (1238–1438).¹⁴ Thai craftsmen, like other countries neighbouring to China, learnt the technique of lacquering from the Chinese.¹⁵ Thai artisans had adopted the art techniques of surface-decoration like gilding and relief lacquer work, that had already been developed in China. The items they did lacquer ranged from everyday utensils such as containers, bowls for fresh flowers, water bowel, betelnut boxes, to furniture like cloth storage boxes, bookcases, tables, and bedsteads. They lacquered not only on objects made of wood but also on bamboo (figure 6 and 7) and metal.

¹⁴ (Simatrang 2002)

¹⁵ (Kopplin 2002)

The degree of sophistication and ornamentation in Thai lacquer work depends on the social status and religious ranks of the person the object is made for.

The art reached its peak in Thailand during Ayutthaya Kingdom (16th–18th century AD) when the artisans used a variety of techniques, in the creation of lacquerware, '*Krueang Rak*' as is called in Thai language. Description of some utensils used in Ayutthaya period such as footed octagonal containers with mother of pearl inlay, gold-gilded Buddha statues, footed tray with lacquer paintings can be found in the ancient document 'The Testimony of *Khun Luang Wat Pradu Songtham*', that was written between 1732–1758 AD.¹⁶ This further establishes the above-mentioned claim of the high time for lacquer work in Thailand around the Ayutthaya period. The use of lacquer was not limited to application on utensils such as bowls and cups but extended to be used on religious icons, exterior and interior decoration of buildings including doors and windows.

With the fall of Ayutthaya Kingdom in 1776, the practice of lacquering started to disappear. The shift of capital of Thailand from Ayudhaya to Dhonburi and then to Bangkok affected the practice of this art. Although the technique of the lacquer work practiced in then Bangkok followed the characteristics of the classic specimens, but the gradual Chinese artistic influence led the art to degrade. The style of the classic Chinese lacquer, was more desired at that time and the very Thai artistic peculiarities started to get lost since that was quite different and could not compete with the trend.¹⁷ Later, King Rama III (1788–1851 AD) attempted to revive the tradition, but it did not remain in practice after his demise. Another reason for the decline of this art after 18th century was the influx of Western arts, notably painting and sculptures, that were replacing Thai traditions. Nowadays in Thailand, the use of synthetic lacquer is found in abundance because natural lacquer is no longer produced due to the scarcity of the lacquer tree (*Gluta usitata*). However, the practice of lacquer art still exists among the present craftsmen or artisans because they are trained to serve royal and religious works. There are also artisans who produce lacquer work commercially.¹⁸

1.2. Types of Thai lacquer work

When the art of lacquering spread from China to other countries of Asia, the local craftsmen experimented and developed their own regional techniques and designs. This resulted in unique

¹⁶ (Thailand Foundation 2023)

¹⁷ (Thailand Foundation 2023)

^{18 (}Abhakorn n.d.)

characteristics of lacquer design that reflects the culture and identity of the land where it is produced.

There was no exception of the above statement in the case of Thailand. As lacquer art technique was introduced to Thailand during the Sukhothai period $(13^{th} - 15^{th} \text{ century})$, the Thai craftsmen kept on exploring the materials and techniques and developed various distinctive features for this art. There is much evidence of applying *rak* or lacquer as a main material and producing minor art, decorative art and fine arts. In Thailand, different lacquering techniques can be found as complete gilding, complete gilding with vermilion, gilding and glass inlay, gilding with black lacquer, gilding with pigments mixed with lacquer and mother-of-pearl mixed with black lacquer or glass inlay. Fused with traditions and wisdom of Thai people, the art of lacquering has been in practice in Thailand for hundreds of years.¹⁹ Lacquering became so popular in Thailand that this was applied in many objects and elements that served both the Buddhist faith and monarchy. Thus, lacquer work can be found in both temples and palaces. In Thai architecture, lacquer art was used to decorate architectural details such as *cho fa* (gable apex), bai raka (sloping edges of the gable), hang hong (lower finial), nak sadung (support structure in the shape of serpent), krueang lamyong (set of roof decorative elements) etc.²⁰ Lacquering can also be found in movable objects like busabok (movable throne) and the base of chukkachee which is the base for placing Buddha statues in ordination halls of temples. The following chapters describe the prominant techniques that the Thai artisans developed.²¹

1.2.1. Long rak pid thong

In this process *Rak* or lacquer is used with gold leaves for gilding the required surface (figure 6). The process starts with smoothening and thorough cleaning of the surface chosen for the art. The surface can be made of wood, cement, or metal. Filtered and sun-dried raw resin from lacquer is then applied on the surface to cover it. Several coats of lacquer are added until it reaches the required smoothness. The designs are engraved on the surface and the rim of pure gold leaves are then placed on the surface with the lightest touch of fingers or with the help of brushes. This process can be applied in furniture, utensils, and religious artifacts.

¹⁹ (Strange and Smith n.d.)

²⁰ (Kopplin 2002)

²¹ (Thailand Foundation 2023)

1.2.2. Pradab krachok

In this technique, lacquer is applied alongside mosaic decorations by small glass pieces. The surface of the chosen material is first coated with *Ton Rak* lacquer. After this layer reaches a required damp state, a special mixture called *Rak Samuk* (a mixture of boiled resin and powder obtained from burnt coconut shell, bricks, dried banana leaf) is applied to facilitate the glass pieces to be placed.

Traditional utensils, architectural elements, and Khon masks are decorated with glass mosaics with this technique (figure 7).

1.2.3. Pradab muk / smook

With this technique, patterns for mother-of pearl inlay are done. The Rak is applied on the wood or rattan surface and then the pattern is done with mother-of -pearl inlays (figure 8). There is evidence of this lacquer technique at the gates of the Temple of the Emerald Buddha, in Bangkok, built in late 18th century, and also at the gates of Phra Si Rattana Mahathat Temple Phitsanulok, built in Ayutthaya period (1782–1932).²²

1.2.4. Lai kammalor

In this technique, a black resin board is prepared that serves as a background. Then a mixture of powdered colour and Rak or its sun-dried raw version is applied for the painting. In this technique the paintings usually have golden decoration done with gold rim made either with gold leaves or gold powder (figure 9). This technique is applied on doors, windows, cabinets, and partitions.

1.2.5. Khrueang khoen

In this technique, *rak* is used for wooden/ rattan items that are decorated with motifs scratched on the surface (figure 10). This technique was introduced by Tai Khun people who migrated to Northern Thailand from Myanmar. Therefore, Khrueang Khoen style of lacquering can be considered as a resultant of Myanmar influence in the Thai lacquerware.²³

²² (Thailand Foundation 2023)

²³ (Thailand Foundation 2023)

1.2.6. Lai rod nam

Thai artisans developed and used the *Lai Rod Nam* technique extensively during Ayutthaya period (1351–1767).²⁴ This technique of lacquering is done by applying black lacquer with gold inlay to surfaces of different materials (figure 11). This technique was applied to adorn not only wooden furniture or cabinet and small boxes that house religious scripts, but also used on architectural elements such as door and window panels in palaces and temples. There are Buddha images, patterns, and also the palaces such as *Wat Sai* Golden Palace, *Bang Khun Thian, Ho Trai* at Wat Ban Kling, presently known as *Ho Khaian Wang Suan Pakkad*, in Bangkok which are fine examples of lacquer art done in *Lai Rod Nam* technique. The Tripitaka cabinet presently stored at the National Museum Bangkok, considered as an important example of lacquer work furniture, was also decorated with *Lai rod nam* technique.

Among other techniques of Thai lacquering, *Lai Rod Nam* is considered as the one that reflects the finest arts and craftsmanship of the Thai artists in the field of lacquer art. Hence it was included in the ten major disciplines in the Thai traditional art known as '*Chang Sim Mhoo*'. The other cardinal disciplines of craftsmanship in Thailand are – painting, sculpture, wood carving, carpentry, masonry, and metal working – which were passed from one generation to the next for many centuries.²⁵

After lacquering was introduced in Thailand, it rapidly started to spread throughout the land and being applied to many materials and elements. However, there was a difference in the art techniques produced or practiced by northern Thailand regions and the Ayutthaya Cultural group. The lacquer art that had either gold or mother of pearl inlay on black background was practiced majorly in the artisan group of Ayutthaya area. On the other hand, Lanna or Northern Thai cultural group used to produce the lacquer art that had a scheme of red painted on black *rak* coated surface.

²⁴ (Bhirasri 1960)

²⁵ (Simatrang 2002)



Figure 6: Golden Buddha image at Wat Traimit, gold gilded with Long rak pid thaon or Pid thong tueb technique.



Figure 7: Figure from Wat Phra Kaew showing Pradap kracok detail.



Figure 8: Door panel with Pradab muk detail.



Figure 9: Scripture cabinet with Lai kammalor technique.





1.3. The technique of Lai rod nam

The saps from the tree *Gulata usitata* that produce lacquer are composed of catechol, an organic compound that is toxic and irritant to skin. In Thailand, out of four species of sap producing plants, only *Rak luang* (scientific name *Melanorrhoea usitata*, family Anacardiaceae) (figure

12) is used for lacquering since it has low toxicity and has the property of drying quickly (4 hours). It can also resist heat and moisture along with acid and alkali.²⁶ The sap is black and sticky (figure 14) and can be applied to surfaces as a raw version if needed.



Figure 14: Raw black lacquer.

²⁶ (Simatrang 2002)

1.3.1. Preparing the lacquer or rak

Raw, liquid lacquer is extracted from lacquer tree by cutting the bark and collecting the sap through notches cut into the tree. The lacquer is scraped off as it oozes (figure 13). The sap is black and sticky (figure 14). Afterwards it is subject to a range of recipes depending on which application technique the craftsman or the artist intends to apply for the art. There are three types of Thai lacquer or *Rak* as follows:²⁷

- i. *Rak nam kliang*: This lacquer is a smooth liquid after the impurities from the raw sap are filtered out. This can be applied on smooth surfaces as a primer coating to prepare them for applying decorative work.
- ii. *Rak smook*: The raw tree sap is mixed thoroughly with different types of powder such as moistened kaolin powder or ashes of banana leaf or animal bone or coconut shells, as fillers. This mixture is thicker than the former one and can be used as a thick coating solution. This is applied on surfaces to prepare them for the design to be drawn on it.
- iii. *Rak shed*: This *rak* is obtained by heating the filtered *rak* (*Rak nam kliang*) over low heat. This makes the water from the *rak* evaporate and thus increases the viscosity. This *rak* is used to wash or scrub a thin coat of lacquer on the surface that is to be designed or painted. This is done by dipping a small piece of cloth into the heated *rak shed* solution and scrubbing the surface. Then the sticky surface is ready for the application of gold leaf.

1.3.2. Preparing surface for lacquering

For a wooden object to be lacquered, the surface needs to be sanded and smoothed. A thin layer of *Rak nam kling* (filtered raw sap) is applied to the whole area of the surface. To make it dry rapidly, the object is placed in a climatic condition that is high in humidity and warm. After this first treatment, a layer of *Rak smook*, that is thicker than the first one, is applied. This goes through the same process for drying as the first layer. Multiple layers of lacquer are applied

²⁷ (Simatrang 2002)

until it reaches the desired thickness. It is important that the first layer is dried completely before a second coat is applied. High quality lacquer may require thirty or more coats.²⁸

The lacquered surface is then rubbed to obtain a smooth and shiny outcome. It is also important that the surface is properly cleaned before the painting is applied on it.

1.3.3. Drawing the pattern

A precise outline is drawn on a tracing paper and the lines are pierced with a needle to make series of tiny holes along the lines of the drawing. The drawing is then placed on the surface and is rubbed by a bag, filled with roasted kaolin powder, over it. Thus, the design is transferred on the surface by the kaolin powder (figure 15).



Figure 15: A bag of powder is applied to transfer the outline of the design on the wood surface.



Figure 16: Painting with orpiment exactly over pre-existing outline.

²⁸ (Simatrang 2002)



Figure 17: Orpiment added to the part to remain black.

1.3.4. Application of horadan

Horadan is a mineral grounded with pumice and mixed with a small amount of water. When it precipitates, the impurities and the water are discarded, and the solution is ready for use. To reduce the alkalinity of *horadan*, a solution of herb called *Pak som poi* is added to it. To achieve the proper consistency of the mineral solution, *horadan*, Krathin glue is added if necessary.²⁹ Once the *horadan* is ready for use, the main outline of the art drawn on the surface is painted with it using a very fine thin brush (figure 16). After drawing the outline of the design, the area which has to remain black, is covered with *horadan* (figure 17), leaving the area blank that is to be covered with gold leaf.



Figure 18: Application of gold leaf over the lacquered surface.



Figure 19: Moistened paper placed on surface covered with gold leaf.

²⁹ (Simatrang 2002)



Figure 20: The lacquer art after completion.

1.3.5. Application of the gold leaf

The gold leaf that is used in *Lai rod nam* technique are slim and thin sheets of gold, that comes from solid gold pounded into fine sheets of approximately 0.1 micrometers thickness.³⁰ The area that is planned to be covered with gold leaf needs to have the correct amount of lacquer and be coated in an even layer of lacquer. If too much lacquer or *rak* is applied, the gold leaf will sink into the lacquer and the surface will not be even and therefore will not be as shiny as wanted. On the other hand, if there is not enough lacquer, the gold leaf will not stick. To make sure the correct amount of lacquer is present on the surface, the lacquer is evenly applied by rubbing the surface with a small bag of cotton wool.

Once the rubbing is done, gold leaves are applied on the surface. The process starts from one end by pressing the thin gold leaf lightly on the surface (figure 18). With overlaps of 2–3 mm for each successive leaf, the process is repeated until the entire area is covered. After finishing covering, a direct and vertical pressure is put with finger to help the gold leaf set. Finally, the cotton wool bag is used to clean the surface and keep it smooth.

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1.3.6. Finishing

Moistened straw paper is placed over the treated area for a short time (figure 19). Then the entire surface is rubbed with a cotton wool bag, to take off excess *horadan*. In this stage the *horadan* comes off easily detaching the gold leaf adhering to this solution. The area is washed with water once again with the cotton wool bag so that all excess *horadan* is removed, and the gold design appears with all details (figure 20). The *Lai rod nam* process is finished once the surface is completely dry.³¹

³⁰ (Royal Thai Art 2018)

³¹ (Saengramroungroj 2002)

2. Wat Kampang temple

2.1. History

'*Wat*' is a Thai word, derived from Pali–Sanskrit, that means 'school' or more precisely 'dwelling' for students and monks. A *Wat* is a Buddhist sacred precinct that comprises of monks' livingareas, a temple hall and edifices housing Buddha image for worship.³² *Wat Kampang* is an ancient Buddhist temple located at Thonburi's *Klong Bang Luang* neighborhood, in Bangkok. The temple was listed on the Historic Sites Registration of The Fine Arts Department (FAD), Thailand, in March 2000. Some of the information about the history of *Wat Kampang* temple in this chapter has been gathered during the weeklong on-site workshop, as part of the master's study program in 'Cultural Heritage Conservation and Management', in February 2023.³³ While some information is referred from the Archaeological Report on *Wat Kampang* temple conducted by the FAD of Thailand, during 2019.



Figure 21: Wat Kampang temple on 1887 map of Thonburi.

Although there is no written information about when *Wat Kampang* temple was built, according to the FAD's 2019 Archaeological Report, the earliest source of the existence of the temple is

³² (Facts and Details n.d.)

³³ Cultural Heritage Conservation and Management (CHCM) workshop at *Wat Kampang* temple, February 14–18, 2023, led by Univ. Prof. Mag. Dr. Gabriela Krist, Institute of Conservation, University of Applied Arts Vienna, Austria

an ancient map of Thonburi in 2430 B.E.³⁴ that was drawn in 1887 (figure 21).³⁵ This map is a survey drawing that was executed during the reign of King Rama V (1868–1910 A.D.). Although the map has no mention of the name of the temple, the outline and surrounding landscapes is illustrated in the drawing.

The area of the temple complex measures 18,624 square meters.³⁶ The ancient map of Thonburi shows that *Wat Kampang* temple shares its boundaries with the *Klong Bang Luang* canal at the north and *Wat Thong* temple at the east, both served as the primary entrances to the temple complex. It had four main buildings and some smaller structures connected with each other through landscapes and passageways. A low height wall encloses the ceremonial area, the most essential part of the temple complex, where the religious rituals take place. At present, the area bounded by the low height wall, known as Buddhavas, has the main ordination hall or *ubosot* in Thai, some small chedis or stupas and the monks' living quarter (figure 22). The ordination hall or the *ubosot* is the main structure of the temple and placed in the middle of the layout. There are smaller, secondary stupas known as *chedi rai, chedi thit* and *chedi kuu*, lined up around the building of the main ordination hall.



Figure 22: Plan drawing of Wat Kampang temple with its surroundings.

³⁴ (Manycoders 2024)

³⁵ (The Fine Arts Department, Thailand 2019)

³⁶ (The Fine Arts Department, Thailand 2019)

It is assumed by historians that *Wat Kampang* temple was built sometimes in the late Ayutthaya period (1351–1767 A.D.) because the temple layout, the architectural features and the wall murals and paintings inside the main prayer hall, are similar to the style of that period.³⁷ As mentioned in the report by the FAD of Thailand, *Wat Kampang* temple went through a major restoration and alteration in 2426 B.E. (1883 A.D.) when Phraya Pisalphonpanich (Jean Shi), a Chinese officer provided funding for the execution of the restoration. After that, there is a long period of time when no events related to *Wat Kampang* temple are formally recorded. In the framework of this research, apart from the FAD's Archaeological Report, some of the recent history has been traced from the conversation with the community people who manage and oversee the temple. Figure 23 combines all collected information about the history of the temple and is explained in the following texts.



As mentioned by the community people during the conversation in February 2023, the aluminum framed glass panels were installed at the exterior of all doors and windows at *Wat Kampang* temple in 2009.

The masonry walls of the temple building were damaged due to ground water penetration upwards. Because of that, the wall paintings on the interior surfaces of the ordination hall were also damaged. The restoration of the wall paintings was conducted by the Painting and

³⁷ (The Fine Arts Department, Thailand 2019)

Sculpture Conservation Group, Archaeological Division, FAD, in 2011–12. In 2017, the lower part of the window openings, inside the *ubosot*, were covered by wooden panels by the community people (figure 26).

In 2018, the Painting and Sculpture Conservation Group, Archaeological Division worked on the restoration of the arch gate at the northern side of the *Buddhavas* wall and on the conservation of the Buddha images enshrined in the small viharas adjacent to the main temple building.

In 2019, the two viharas and the Buddhavas wall were restored.

In 2020, FAD put support for the pagodas at the back of the main ordination hall. In the same year, the Archaeological Registration Academic group did a survey of the temple complex to facilitate the registration of the temple in the Heritage list. The survey and the study identified eight historic structures, out of twenty-two in the master plan of the temple complex, particularly worthy of being listed as heritage structures. This includes several other structures apart from the main temple building.

However, the monks' residence within the boundary of the *Buddhavas* is a later addition, but the information when it was built could not be extracted.

2.2. Environmental context

Wat Kampang temple is located in Bangkok, the climatic zone that can be defined as predominantly tropical wet and dry. The relative humidity (RH) remains between 66%–79% all the year round, and the temperature varies from 34.4° celsius in the hottest months to 21.3° celsius in the coolest months (figures 24 and 25).³⁸ The city gets sunlight between 5.2–9 hours per day, and the day light hours range from 11.3–12.9 hours annually. *Wat Kampang* temple is naturally ventilated and does not have any mechanical means of climate control to maintain a stable temperature and humidity level inside the temple.

³⁸ (Time and Date n.d.)



Figure 24: Asiatic humid tropics showing the area that has daily average RH 65% throughout the year and 80% in the wettest months.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature "C ("F)	26 °C	27.4 °C	28.8 °C	29.9 °C	29.1 °C	28.5 °C	28 °C	27.8 °C	27.3 °C	27 °C	26.7 °C	25.9 °C
	(78.8) °F	(81.4) °F	(83.8) °F	(85.8) °F	(84.4) °F	(83.3) °F	(82.4) °F	(82.1) °F	(81.2) °F	(80.5) °F	(80.1) °F	(78.6) °F
Min. Temperature °C (°F)	21.3 °C	23.2 °C	25.1 °C	26.5 °C	26.3 °C	25.9 °C	25.5 °C	25.3 °C	24.9 °C	24.1 °C	23 °C	21.3 °C
	(70.3) °F	(73.7) °F	(77.1) °F	(79.6) °F	(79.3) °F	(78.6) °F	(77.9) °F	(77.6) °F	(76.8) °F	(75.4) °F	(73.4) °F	(70.4) °F
Max. Temperature "C	30.7 °C	32.1 °C	33.4 °C	34.4 °C	33 °C	32.1 °C	31.5 °C	31.5 °C	30.9 °C	30.6 °C	30.9 °C	30.5 °C
(°F)	(87.3) °F	(89.7) °F	(92.2) °F	(93.9) °F	(91.4) °F	(89.8) °F	(88.7) °F	(88.6) °F	(87.7) °F	(87.1) °F	(87.7) °F	(86.9) °F
Precipitation / Rainfall	18	15	45	72	137	133	141	150	244	196	46	10
mm (in)	(0)	(0)	(1)	(2)	(5)	(5)	(5)	(5)	(9)	(7)	(1)	(0)
Humidity(%)	63%	67%	68%	69%	75%	76%	77%	77%	81%	81%	69%	60%
Rainy days (d)	3	3	5	8	16	16	17	18	18	15	5	1
avg. Sun hours (hours)	9.2	9.4	9.6	9.9	10.0	10.2	10.2	10.0	9.4	8.9	9.0	9.2

Figure 25: Climate data of Bangkok.
2.3. The structure / building of *Wat Kampang* temple

The basic shape of the structures of a religious building in Thailand is rectangular with gable roofs, the style that has been developed in the 11th century and has been maintained until the Ayutthaya period.³⁹ Wat Kampang temple also has a rectangular ordination hall measuring 10 X 35 m (figure 26). It is a brick building having high walls with a two storied roof and porches at the front and back. The *chua* or gable roof in Thailand usually has a steep concave shape with multiple layers, various ornamentation, and adornment. The roof helps the building to gain height. The height of a building above the ground symbolizes the building's significance. All these components represent the royalty, Buddhism, and the richness of the patron of the building.⁴⁰ Functionally, the concave shape of the roof provides protection to the walls during heavy rainfall by sluicing water down and shooting it out past the wall. Additionally, the projection of the roof below the main roofs provides protection from the sun (figure 27). The roof of Wat Kampang temple is made of timber and covered with unglazed terracotta tiles. The main structure of *Wat Kampang* temple is raised from the ground level by a lion base. The entrance to the main ordination hall, or the ubosot, is from the north, which can be approached by three stairs leading up to the porches. There is a smaller porch at the opposite side of the temple which is also approachable by two stairways (figure 26).



^{39 (}Facts and Details n.d.)

⁴⁰ (Sathāpitānon and Mertens 2012)



Figure 27: Photogrammetry perspective of the ubosot of Wat Kampang temple, north-east view.

There are two doorways to enter the main hall. The wall between the doorways has a high painting of a standing Buddha. The painting was done on the entrance wall during the time of King Rama IV or King Mongkut (1851–1868 A.D.) (figure 28).⁴¹ The interior of the *ubosot* is a rectangular hall with high walls painted with scenes from Buddha's life and other religious symbols and motifs. The paintings are done to give the interior of the ordination hall an impression of a sacred and holy space suitable for sheltering the Buddha image or the statue (figure 29).

⁴¹ (The Fine Arts Department, Thailand 2019)



Figure 28: Entrance view of *Wat Kampang* temple at the north.



Figure 29: View of the ordination hall or ubosot, overlooking the main Buddha image.

The main ordination hall or *ubosot* has high walls and a high ceiling. There is a flat wooden false ceiling in the interior of the hall. The walls have extensive paintings on lime plaster. The upper part of the walls, beyond the doorways on both the northern and southern walls, have paintings depicting different events from the life of Buddha. The front wall has the scene of Buddha's confrontation with *mara* (demon), and the back wall has the scene from *Traiphummikatha*, the story of the Lord Buddha's life when he descended from heaven to the human world. The wall surfaces along the windows and doors depict scenes from the *Mahanipata Jataka* (the Thai rendition of the 'Ten great birth stories of the Buddha'). This part of the wall painting also has the daily life of ordinary people harmoniously inserted in the design. The wall surface above the window openings is divided into three tires and have images of God and Goddesses, sitting cross legged and facing the main Buddha image. The ceiling has a similar paint work like the upper part of the walls, but there are no figures drawn on the ceiling. An image of gold gilded Buddha is placed at the end of the *ubosot* and the devotes sit on the floor of the hall and practice devotional activities.

2.4. Lacquered shutters of doors and windows

Wat Kampang temple has ten window openings in the building, five on the east wall and five on the west wall (figures 26 and 27). On the building plan in figure 26, the windows are named W-1 to W-10. Windows and their frames are placed in window openings. Each window opening has two wooden shutters that swing and open inside of the temple hall.

Figure 32 shows a plan drawing of a window opening. Each window has a wooden frame surrounding the window opening. The wooden shutters are placed adjacent to the wooden frames, on the windowsill, the bottom horizontal member of a window opening at the inner side of the temple hall or *ubosot*. The shutters are fixed with metal hinges that help the shutters to swing and open at the interior side of the temple hall (figure 30). The hinges run through the wood plank of the window shutter, crossing across vertically and are not visible from outside. Window frames are commonly attached to the window opening and the shutter panels are mounted and hinged onto the frames. The frames support the weight of the shutter panels and keep them aligned. But, at *Wat Kampang* temple, the wooden shutters, and thus the shutters do not move beyond the wooden frames when they are closed. They also prevent any rainwater from coming in through the window openings. All the window frames are covered with red lacquer on all sides. On the exterior of the building, all windows are framed by floral stucco ornaments (figure 31).

The wooden shutters are painted on all sides. The exterior faces of the shutters are lacquered in black and gold, done in *Lai rod nam* technique (figure 30). The interior faces of the shutters has paintings that are similar in colour scheme to the interior walls (figure 31). However, the edges of the wooden shutters are lacquered in red. The frames of the windows are also painted with red lacquer with no decorations (figure 33).





Figure 30: Window shutter in Lai rod nam lacquer design on the exterior surface, and red lacquered wooden frames.



Figure 31: Interior view of the window shutter.





The intricate black and gold *Lai rod nam* lacquer design has not been executed on the entire surface of a window shutter. Each shutter has a solid black lacquer border running around the black and gold lacquer design (figure 34). The black borders get hidden behind the red lacquered wooden window frames when the window shutters are closed and thus cannot be seen from outside (figure 35). This is a trick of the artisans to avoid waste of energy and time and save cost on designing an area which eventually would not be visible.

However, the designs of the doors at *Wat Kampang* temple have followed the same concept as the windows, although their sizes are different (figures 36 and 37). There are four doorways, two on the north wall and two on the south. Like the windows, doors are also double shutter with wooden frames. The frames of the doors are fixed on the floor and the wall of the door openings. Unlike the window frames, the door frames have *Lai rod nam* decorations on the exterior faces (figure 38) but the surface facing the interior show only red lacquer with no decoration (figure 39). On the building plan in figure 26 doors are marked as D-1, D-2, D-3 and D-4.



Figure 35: Exterior view of a window.



Figure 36: Exterior view of a door at Wat Kampang temple.



Figure 37: Interior view of a door at *Wat Kampang* temple.



2.4.1. Design and symbolism of the lacquer work

The lacquer designs of the doors and windows at *Wat Kampang* temple have different figurative scenes of religious, mythical, or realistic characters, different motifs and groups of mythological beings, flamboyant foliage etc. It is traditionally believed that the doors and windows of a temple are passages between different realms, and therefore the decoration on the doors and windows have special motifs to ward off the entry of evil spirits. The images of guardian demons and other auspicious figures, warriors or beasts drawn on the doors and windows, are places for protection.⁴² On each door panel at *Wat Kampang* temple, a single figure of *Dvarapala*, a protective figure, is presented who is carried by a lion (figures 40 and

^{42 (}Facts and Details n.d.)

41). According to Thai belief, *Dvarapala* is the gatekeeper god that guards the doorways and keeps out evil spirits and enemies.⁴³ There are also animal figures such as snakes, deers, furious animals resembling lions, elephants semi human beings etc. drawn on the doors. These characters come from Thailand's national epics – the *Ramkien*, which is the Thai version of the Indian epic *Ramayana*.

Most of the *Lai rod nam* designed areas on the window shutters are occupied by flamboyant foliage. Within the vegetation, there are animals and insects such as monkeys, squirrels, rabbits, birds, lizards, butterflies etc. flying or perching among the leaves in a natural way (figures 42, 43, 44 and 45). The upper parts of the lacquer designs depict some semi-realistic trees with flowers, and skies with clouds.

In Thailand, like other east Asian countries, the use of gold leaf with lacquer got popularity not only because the illuminated dazzling effect of the golden colour enhance the luxurious touch of the art but also because Thai people believed that gold is a symbol of prosperity.⁴⁴ It was also an indication of the owner's ranking in the society when it comes to the members of royal and noble courts.⁴⁵



Figure 40: Dvarapala, the gatekeeper god.

- ⁴³ (Buntem 2023)
- ⁴⁴ (Royal Thai Art 2018)
 ⁴⁵ (Buntem 2023)



Figure 41: Lion holding the mythological figure.



Figure 42: Birds, sky, and clouds.



Figure 43: *Dvarapala*, the gatekeeper god.



Figure 44: Monkeys and Tigers in a natural setting.



Figure 45: Plants, flowers, and butterflies.

2.4.2. History of the lacquer work on the doors and windows

There is no written evidence about when the lacquer work on the doors and windows at *Wat Kampang* temple was executed but this chapter tries to find its history by looking at the evolution of the style of the artwork and the information of historical events describes in chapter 2.1.

The classic style of Thai *Lai rod nam* lacquer art has a very specific characteristic. It was typical that the artisans used to form the background with flamboyant foliage termed *'Lao kanok'* representing the luxurious growth of tropical vegetation – drawn with mastery skill. Traditionally, the decorated surface was filled up with well distribution of figures and ornaments that brings in harmony of the dark and light masses and details (figure 46).⁴⁶ The technique of *Lai rod nam* and the style of *Lao kanok* was at its peak in the Ayutthaya period from the 17th to the first half of the 18th century and was being applied extensively to ornament many objects but principally to enrich door-window shutters and bookcases that kept the holy scripts written on palm-leaves. But in later productions, during the Bangkok period (19th century), Chinese influence was noticeable which is assumed to be driven by the desire of the artists and patrons of that time to bring change in style, that would differ from the traditional ones (figures 47 and 48). In the Chinese compositions, large areas of sky, earth or water is evident and trees, human beings and animals appear as smaller figures.⁴⁷

^{46 (}Bhirasri 1960)

^{47 (}Bhirasri 1960)

If the lacquer art on the doors and windows at *Wat Kampang* temple is compared to the specimens from the Ayutthaya and the Bangkok period, it seems that they have more similarities with the style of the latter. The traditional *Lai kanok* motifs are not at all evident in any of the lacquered surfaces at *Wat Kampang* temple. It is mentioned in the earlier chapter of this research that *Wat Kampang* temple had gone through a major restoration in 1883 A.D., as reported by the FAD of Thailand.⁴⁸ It might be possible that, although a late Ayutthaya temple built in 18th century (assumed), the original *Lai rod nam* lacquer work has been altered during the 1883 restoration and the artisans of that time did the designs with influence from China. However, more research needs to be done to find the actual dating of execution of the lacquer works at *Wat Kampang* temple.



Figure 46: A Lai rod nam specimen from Ayutthaya period.

⁴⁸ (The Fine Arts Department, Thailand 2019)



Figure 47: Example of Thai lacquer from Bangkok period.



Figure 48: Design of a side panel of a bookcase showing Chinese influence.

3. Technological survey of the lacquered shutters of doors and windows

During the study, a small piece of black and gold *Lai rod nam* lacquer sample, that detached from one of the wooden window panels, was collected and investigated under microscope. The cross sections and microscopic views were generated by Elias Campidell⁴⁹ at the laboratory of

⁴⁹ Elias Campidell, Univ.-Ass.Mag., Institute of Conservation, University of Applied Arts Vienna, Austria, (former), Conservator and teacher, Silpakorn University International College, Silpakorn University, Bangkok, Thailand, (former)

Silpakorn University, Bangkok, in 2023. Figures 49, 50 and 51 show the microscopic views of the sample's top, bottom, and cross sections respectively. As mentioned in chapter 1.3.3., the Thai *Lai rod nam* technique involves the application of several layers to the core material or substrate. The sample cross section also shows different layers attached to each other from ground to the top lacquer and gold leaf surface. However, the morphology and elemental composition of the sample was not examined during the study which might be useful to obtain more detailed information about the composition, structure, and the relationship between different layers.⁵⁰

In this chapter, the *Wat Kampang* lacquer sample is referred to a recent scientific analysis on another *Lai rod nam* lacquer sample that was collected from *Tam nak thong* (wooden court) of King Sanphet VIII (r. 1703–1709). The reason for the comparison between the sample of *Wat Kampang* and *Tam nak thong* is that – both buildings were built during the same time (late Ayutthaya). It is assumed that the *Lai rod nam* designs on the door and window shutters were also done during the same period. The scientific analysis of the *Lai rod nam* lacquer sample from *Tam nak thong* was executed by Radchada Buntem.⁵¹ She investigated the morphology and elemental composition of the sample by scanning electron microscopy-energy dispersive X-ray (SEM-EDX).



Figure 49: Microsopic view of lacquer sample showing gold leaf.

⁵⁰ (Buntem 2023)

⁵¹ A scientist at the Faculty of Science, Silpakorn University Thailand



Figure 50: Bottom surface of lacquer sample showing ground layer.



Figure 51: Microscopic view of cross section of lacquer showing different layers.

3.1. Substrate

Lacquer is a binding material that is applied on a substrate that serves as a backing for the art. At *Wat Kampang* temple, the substrate for the black and gold lacquer work is wood. The type of wood has not been investigated but considering the fact that teak is the most common type of wood used in Thai architectural elements,⁵² it is assumed that the wooden door window shutters at *Wat Kampang* temple are made of teak wood. the property of teak wood makes it

⁵² (Sathāpitānon and Mertens 2012)

appropriate for withstanding the hot and humid climate and termite infestation. A specific sap within teak makes it resistant to insects and fungus, helping the wood used for building elements to last up to 200 years.⁵³ Teak trees are tall and straight and can be milled into quality timbers. Teak is the most used wood for timber structure in Thailand. Other common timbers used in Thailand for building structures and furniture come from Narra, Siamese rosewood, Monkeypod tree and Malabar ironwood etc.⁵⁴

Each shutter of the doors at *Wat Kampang* temple measures 350 x 175 cm and each window shutter measures 250 x 60 cm.⁵⁵ All the shutters are 5 cm thick. However, the crafting of the wood panels, if made from one single slab of wood or multiple segments of wood planks laid side by side vertically and attached to each other, is not known. If it is done by segmented pieces, further investigation needs to be done to identify if they have been attached by adhesives or by any traditional wood joining technique.

On the other hand, the frames for the wooden shutters of the doors and windows are also made of wood. The frames are made of 20×15 cm wood planks.⁵⁶

3.2. Ground

The primary results gained from the microscopic views of the lacquer sample from *Wat Kampang* temple show that there are three layers beneath the top lacquer-and-gold surface – two of them are white and the other is red (figure 55). But if the lacquer works at *Wat Kampang* temple were done during the late Ayutthaya period, it can be assumed that the white ground layer seen in the sample of *Wat Kampang* is calcium carbonate (CaCO₃) because this was commonly used by the Thai artisans at that time as ground layer to smoothen the underlying wood surface.⁵⁷

Ground layer in lacquer object provides a smooth surface for the top lacquer layer. For lacquering, when a substrate does not have a finished surface where the final coat of lacquer and the decorations can be applied, imperfections such as dents and ridge in the substrate are

⁵³ (Francis 2012)

⁵⁴ (Sathāpitānon and Mertens 2012)

⁵⁵ Measured in situ by the author, February 2023

⁵⁶ Measured in situ by the author, February 2023.

^{57 (}Buntem 2023)

smoothed out by application of a ground layer. Although ground layers are not seen, they impact largely on the quality of the final lacquer layer decorations.

Recent scientific research on a *Lai rod nam* lacquer sample from *Tam nak thong* (the wood court of King Sanphet VIII), *Wat Sai*, (figure 52) which was built at the similar time, as *Wat Kampang* temple (late Ayutthaya), found two ground layers underneath the top gold and lacquer layer (figure 54). One of the layers is primarily calcium carbonate (CaCO₃) mixed with barium sulphate (BaSO₄). The research claims that barium sulphate (BaSO₄) was mixed with the calcium carbonate as a white pigment. The other layer is *Rak sa muk* or *Rak smook* which is a composition of *thitsi* (pure lacquer from *Gulata usitata*) and ashes (animal bone/ coconut shell/ banana leaf) as ground layer.⁵⁸ In the past, substitutes were used with pure lacquer to reduce the cost of ground. *Rak sa muk* was widely used by Thai artisans during Ayutthaya period. *Thitsi* or the lacquer serve as the binder in the mixture.



Figure 52: The Lai rod nam of Tam nak thong of King Sanphet VIII (1703–1709), Wat Sai.

^{58 (}Buntem 2023)



Figure 53: The Lai rod nam of Wat Kampang temple



Figure 54: SEM image of the cross section of lacquer sample from *Tam nak thong* (wood court) of King Snaphet VIII, *Wat Sai*.



Figure 55: Microscopic view of lacquer sample from Wat Kampang temple

In the sample of *Wat Kampang* temple, the red and additional white layer is unknown. For the red layer seen on the ground, there is a possibility oft he presence of cinnabar pigment because using cinnabar to get red colour, was the trend at that time.⁵⁹ Cinnabar is a natural mercury mineral, chemically known as mercury sulphide (HgS), used to produce bright vermillion pigment.⁶⁰

3.3. Lacquer layers

The cross-section of the sample collected from *Wat Kampang* temple shows a black layer of lacquer on the top. And the top view of the lacquer sample shows bright gold surface, which is the gold leaf applied on the black lacquer surface with *Lai rod nam* technique as described in chapter 1.4.5. From the observation, it is assumed that there is a final coating of transparent lacquer layer over the gold leaf, to give a gloss to the finished surface and to protect the gold leaf design which otherwise would torn away easily with minute abrasion.

The lacquer sap that is used by the Thai artisans comes from *Gulata usitata* trees. the sap produced from Gulata usitata tree is called *thitsiol*. The main component of *thitsiol* is catechol $(C_6H_6O_2)$ and phenol (C_6H_6O) derivatives (60-65%) and water (30%). Hardened *thitsiol* is not sensitive to water or any common solvents and inert to acids and alkalis. Lacquer surface is also resistant to heat up to 300° C.⁶¹

While most organic coatings are prone to auto oxidative degradation, lacquer is not, due to its structure.⁶² Lacquer forms a resistant barrier against aerobic oxidation when polymerises and hardens into a tough film. But the long-term stability of lacquer surface can be affected by environmental factors such as sunlight (and UV) and fluctuations in temperature and RH. In an indoor context, they have strong durability, but lacquer is extremely sensitive to light and UV because UV induces significant changes to the polymer network of the film of lacquer.

⁵⁹ (The Metropolitan Museum of Art n.d.)

^{60 (}Hirst 2018)

⁶¹ (Tamburini et al. 2020)

4. Condition survey of the lacquered shutters of doors and windows

This chapter presents the conditions of different layers of the lacquered shutters of *Wat Kampang* temple. The type of deterioration that can occur in a lacquered surface depend on the properties of the different layers which were applied on the substrate. Different materials have different properties and have their own mechanism of deterioration. For this reason, damage formation in lacquer work and evaluating the causes of the damages can be complex. In the following chapter, observations will be described in terms of changes in colour, development of cracks, loss of materials etc. Then, the influence of site conditions, such as the location of the lacquered shutters relative to the sun, temperature and RH of Bangkok will be considered to describe the mechanisms that have potential to explain the damages.

4.1. Substrate

The substrate for the lacquered door window shutters and their frames at Wat Kampang temple is wood. The physical condition of most of the wood shutters of the doors and window is good, in terms of their size and shapes. Each shutter was examined for operational soundness and found to be in a good condition, although they are kept open and are not frequently moved for closing and opening. However, some wood shutters of windows show signs of cracks (figures 56 a, b and c). Although wood is the most common material used in Asian lacquer work, it is not very durable in terms of the interaction of wood with the fluctuations of environmental moisture or changes in relative humidity.⁶³ Wood as a hygroscopic material exchange water molecules with the air according to the level of RH of the surrounding environment. Whether the wood surface will gain or lose moisture depends on the difference between the relative humidity of the environment and the moisture content of the wood itself.⁶⁴ However, wood shrinks as it looses moisture and swells as it gains and therefore the dimension of wood changes. Stress sets up in wood as it swells and shrinks and an unbalanced stress between the surface and the inner part of wood may result in warping and cracking.⁶⁵ The cracks seen on the wooden shutters at Wat Kampang temple are due to the stress by frequent changes in the temperature and RH that the wooden shuuters have experienced over the years.

^{63 (}Webb 2000)

^{64 (}Loffer 2020)

⁶⁵ (Forest Products Laboratory and Forest Service U.S. Department of Agriculture 1957)



Figure 56: (a), (b) and (c): Signs of cracks on different window shutters.

Unlike the wood shutters of the doors and windows, the condition of the frames shows varying degrees of mechanical damage such as surface decay, cracks and loss of wood mass. Surface decay in the wood frames is the most observed pattern of deterioration of the wood components at *Wat Kampang* temple. At the wooden frames of D-3 and D-4 (figures 57 and 58), the frames attached to the ground show substantial roughness in their surfaces and loss of wood mass. The term 'rough' is referred here to describe features such as corrugating annual rings of the wood and protruding, loose fibers. Developments of voids due to loss of wood mass have also been found at several window frames. From figure 59, it is apparent that material has had been removed in an uneven manner from the surfaces of the wooden frames. The frames also show deep relief due to peeling off of wood mass and erosion. Such damage is the effect of natural weather conditions combined with external physical forces.



Figure 57: Wooden frame of D-4, showing loss of wood mass.



Figure 58: Closer view of frame of D-4, showing loss of wood mass.

Weathering is a general term used to define slow degradation of any material that is exposed to the climate. The degradation is a result of a complex set of reactions induced by a several factors found in nature: oxygen, moisture, sunlight, heat/cold, chemicals, pollutants, abrasion by wind flow, and biological agents.⁶⁶ Unprotected wood surfaces, when exposed to cycles of solar radiation, rain and moisture - start to discolour, become rough, loosened, or checked with passage of time as part of weathering. Among all the agents of deterioration present in nature, the solar radiation (UV, visible and IR light) is the most damaging component for wood degradation because it initiates the chemical changes in the organic components of wood. Cellulose, hemicellulose and lignin are the organic components of wood. Lignin is a very stable component which generally absorbs UV light to a certain degree and has strong resistance to hydrolysis due to its chemical bonds. But with age, lignin becomes sensitive to oxygen and oxidation reactions occur on lignin when solar energy hits the surface of wood. The first outcome of the interaction of UV light with lignin of wood is discolouration. Moreover, by absorbing the energy from light, lignin also produces some soluble molecules that react to environmental moisture and water of any sort, leading to a decrease in lignin content.⁶⁷ Thus, loss of the intercellular substance takes place and wood can reduce size during the weathering process.

Continuous decay not only affects the appearance of the wood by changing colour but also its physical properties, strengths and the load bearing capacity. One of the non-visible changes that

^{66 (}Mi et al. 2023)

^{67 (}Ouadou et al. 2017)

happens to wood due to weathering is a decrease in overall strength properties of wood, where the strength of the outermost layers faces the greater relative decreases in strength. Wood becomes friable and fragments can come off easily. The wood frames at *Wat Kampang* temple are not bearing the loads of the wooden doors and window shutters but as they lost their strength significantly due to weathering, they have experienced mechanical damage from human movement through the doorways and by mishandling. The decay of aged wood causes physical and mechanical damage because the microstructure of cell walls and the chemical component of the wood changes irreversibly as the wood ages.

As a matter of fact, weathering does not happen to unprotected wood surfaces only but wood that has been protected by lacquer, varnish, paint, or other coatings can also face all these weathering effects if exposed to outdoor for long time. The wooden lacquered doors and windows at *Wat Kampang* temple have been exposed to natural weather conditions for many years. Therefore, the damage to the wooden frames and shutters at *Wat Kampang* temple, despite having the red lacquer coatings, can be attributed to the weathering conditions.



Figure 59: Window frames showing loss of wood mass.

3.2. Ground

Ground layers at some of the doors and windows at *Wat Kampang* temple were found to have faced adhesion failure, where the wood substrate got de-bond and separated. The sample piece of the lacquer that was studied for this research was one of such segments that detached from the wood substrate and came out of the wooden support with all its lacquered layer composite.

However, different layers within the ground in the sample are intact and do not show any delamination (figure 55). To understand the bonding fail of the ground with the wood substrate, it is necessary to define the ways the failure can occur.

Traditionally, artisans used pure lacquer as ground.⁶⁸ But as lacquer is an expensive item, substitutes were used for ground, but lacquer was still mixed with the ground solution as a binder. If the ground layers are formulated with lacquer, they are invariably stronger than those where lacquer has not been used as binder.⁶⁹ According to a study done by Yin Chengzhong,⁷⁰ natural lacquer can penetrate deeper into the structure or material (wood) that it is applied on and can provide durable seal that acts as a protecting surface coating.⁷¹ In the case of the lacquer work at *Wat Kampang* temple, it is assumed that a primary layer of pure lacquer or any of the *rak*, as described in chapter 1.4.2, was not applied on the substrate at the start of the lacquer work. If it had been applied, there should have been good bondage of the ground (and the lacquer composite) with the wood.



Figure 60: Red layer of ground is exposed.

^{68 (}Webb 2000)

^{69 (}Strahan 2001)

⁷⁰ Yin Chengzhong is a Chinese modern lacquer painter.

⁷¹ (Qin 2021)



Figure 61: Red and white layer of ground is exposed.



Figure 62: Red and white layer of ground is exposed.

Apart from the detachment of the ground layer from the wooden substrate, there is evidence where the red layer of the ground is exposed after losing the top lacquer layer (figures 60, 61 and 62). While some indicated abrasion due to the friction that the shutters might have faced during closing operation (figure 62), a potential explanation of such flaking off ground layers can be the reaction of the different materials of the different layers in the lacquer work with environmental moisture. Since different layers of lacquer work, from a wooden substrate to the top lacquer surface, have different material property, they will react to the moisture of the environment differently and change dimension at different rates. For this reason, stress increases in the interface of different layers and the stress is relieved by cracking. This might have caused the detachment (cracks and lose adhesion) of the lacquer coating from the wooden substrate at various locations.⁷²

3.3. Lacquer layers

Two key problems have been observed on the lacquer layers of several door and window shutters at *Wat Kampang* temple during the study. First, the black lacquer background shows various degrees of photodegradation, with associated loss of colour, matt appearance and network of microcracks. The microcracks do not always endanger the gold decorations on the lacquered surfaces and are not easily visible with bare eyes. Second, evidence of moderate to complete loss of gold decorations from the *Lai rod nam* surface designs. Damages are also evident in the surviving gold layers such as lifting and wrinkled gold layer with considerable associated loss of designs (figures 64 and 65). However, the lacquered surfaces of the door shutters that had been protected from the exposure to light by their location and from physical contact of external objects or human touch by aluminum framed acrylic protections are, by contrast, glossy and smooth (figure 63). The detailed analysis and description of the aluminum framed protection system is presented in chapter 5.

As mentioned earlier, lacquer is one of the most durable materials as it polymerises and hardens into a tough film, but the long-term stability of lacquer surface can be affected by environmental factors such as light and UV and fluctuations in temperature and RH. Among all the damaging factors, light and UV radiation are considered to be the most important for promoting degradation to lacquer surfaces.⁷³ Loss of gloss or fading in lacquer surface is a result of exposure to light and UV radiation combined with fluctuations in RH. When a lacquered surface is exposed to light, the energy contained in light breaks the polymer of lacquer into smaller molecules. Research has found that some of the resulting smaller molecules are volatile and get lost from the surface easily by contact of environmental moisture.⁷⁴ This loss of molecules makes a network of very fine cracks on the surface that can only be seen under magnification. The network of cracks causes the lacquer surface to appear dull and faded.⁷⁵

⁷² (Laurin 2013)

^{73 (}Liu, Liu, and Lv 2023)

^{74 (}Strahan 2001)

^{75 (}Strahan 2001)

Some of the lacquered surfaces at *Wat Kampang* temple lost gold decoration from the lacquered surfaces (figure 48). This loss of surface decoration by abrasion, handling, and cleaning is linked to photodegradation. If the photodegradation is severe on a lacquer surface, it can cause additional damage. When photodegradation proceeds, it increases the formation of cracking in lacquer layers, and eventually leads the gold layer on the lacquer surface to lose its adhesion to the lacquer coating and starts to peel off. In this circumstance, gold surfaces can get swiped off very easily by simple cleaning with soft brushes. Since the degraded lacquer layer has loose particles, each cleaning activity can remove a layer of original material (gold surface) and expose a new layer, making it extremely difficult to remove only the dirt and dust from the lacquer surface. An informal discussion with the community people and monks at *Wat Kampang* temple reveals that the regular maintenance and cleaning of the temple is done by the monks who do not have the skill and knowledge of handling lacquer art. The evidence of cleaning marks on some of the lacquered surface with loss of gold layer indicates that mishandling, while cleaning, has caused such degradations.

An experiment on light degradation of lacquer states that lacquer falls into Blue Wool Standard⁷⁶ number 4 and the lifetime of Asian black lacquer is three and a half year when displayed at 900 lux, before damage can be physically evident. The lifetime may increase if exposed to dimmer light. This display or exposure is meant to be for 8 hours a day and excludes UV radiation.⁷⁷ Sunlight has more energy and can make the degradation proceed in an increased rate. At *Wat Kampang* temple, the windows at the east and the west walls are exposed to sunlight and get direct solar illumination many times higher than what it should be for the conservation of the lacquered surfaces. This exposure for a significant amount of time of the day, for many years, has caused photodegradation on the lacquered surfaces and resulted in fading and discolouration of several lacquered surfaces. Fading or colour change in lacquer work due to light is one of the damages that are permanent and irreversible.⁷⁸

⁷⁶ Internationally accepted scale of measuring light damage

^{77 (}Webb 2000)

^{78 (}Nakagoshi and Yoshizumi 2011)



Figure 63: Lacquer surface that has retained its gloss and design.



Figure 65: Faded lacquered surface, partial loss of gold layer.

Exposure of lacquer surface to light and fluctuating RH weakens the resistance property of the lacquer surface to moisture, heat water and organic solvents. Although an undamaged continuous lacquer coating is resistant to water and supposed to protect the substrate from some of the environmental changes, light degradation can make a lacquered surface lose its durable

character and make it vulnerable to damage by water and moisture content of its surrounding. When the polymer structure of a lacquer coating is broken by the energy of light, and breaks into smaller molecules, some of the degraded products become soluble in polar solvents such as water and alcohol. The possibility of the surface to react to the change in RH gets higher when it faces photodegradation. Thus, a lacquered surface becomes extremely vulnerable to the moisture content of its surrounding.⁷⁹

For ensuring safety of lacquered surfaces in museums, it is recommended that lacquered objects are kept in a condition of 50–60% of RH and in a temperature with minimum fluctuations.⁸⁰ Due to geographical location, the lacquered doors windows at *Wat Kampang* temple are exposed for many years to the temperature and humidity levels, that is much higher than the recommended value.

5. Protection system for the lacquer work on doors and windows

5.1. Existing protection system: material and installation

At present, there are two types of protection systems that have been applied for the lacquered door and window shutters at *Wat Kampang* temple. The first one is – aluminium framed acrylic sheets installed over each wooden panel (figures 66 and 67). And the second one is – aluminium framed glass window shutters installed at the exterior side of each door and window opening (figures 68 and 69). The plan drawing in figure 70 illustrates the protection systems with relation to the lacquered window shutter. Although the doors are different in sizes, the concept of protection system is similar to that of a window shutter. This chapter discusses the installation system of these protection systems.

^{79 (}Webb 2000)

^{80 (}Webb 2000)



Figure 66: Acrylic sheet protection on the lacquered doors.





Figure 68: Aluminum framed glass shutter outside of the wooden lacquered door.


Figure 69: Aluminum framed glass shuuters outside of the wooden lacquered window.



Figure 70: Plan drawing of a window at Wat Kampang temple showing the protection systems.

Acrylic sheet is a solid, transparent, and waterproof organic material based on polymethyl methacrylate (PMMA).⁸¹ Aluminum is a lightweight, strong and corrosion-resistant material widely used for framing.⁸² As measured during the study, the acrylic sheets used at *Wat Kampang* temple are 2 mm thick and are mounted on the wooden door and window shutters with half inch thick aluminum U channels. As described in the earlier chapter, the *Lai rod nam* lacquer designs on each of the door window shutter at *Wat Kampang* temple have a solid black lacquer border around the *Lai rod nam* decorations. For protecting the lacquer design, acrylic sheets are applied to cover only the area that has the black and gold lacquer designs, leaving the solid black borders outside of the acrylic protection in each lacquered shutter (figure 71). To do that, acrylic sheets are cut into the preferred sizes, as per the outline of the black and gold

^{81 (}Conte et al. 2010)

^{82 (}de Naoum 2023)

lacquer designs on the doors and windows. As shown in the cross-sectional drawing of a window opening in figure 71, the area marked in yellow indicates the area that is decorated with black and gold Lai rod nam design and the same outline is followed for the acrylic sheet (figure 72). On each panel, a single piece of acrylic sheet has been taken to cover the lacquered design. Aluminium U channels were cut to fit the lengths and widths of the acrylic sheets, and the acrylic sheet is fitted in the aluminium channels and placed on the lacquer designs before anchoring them to the wood panels. The aluminum channels are used as a frame to secure or mount the acrylic sheets and are fixed to the wood substrate with metal nails directly inserted into the wood panels (figures 73 and 74). Metal nails are put at regular interval along the lengths of the aluminium channels to ensure secured attachment of the acrylic and aluminium channel system to the lacquered wood shutters. The heads of the metal nails are resting on top of the aluminium channels and are visible, although they are very small in size. Some installers use adhesives to position the protective sheet so that they do not move during installation, but there was no evidence of use of adhesives to fix the acrylic sheets to the aluminium U channels at Wat Kampang temple. This allows the acrylic sheets to have some movements and minor adjustments. The aluminum channels also work as protective edges for the acrylic sheets. The gaps between the lacquer surface and the protective acrylic sheet are less than 2 mm (figure 74). On the wood shutters that have the vertical handle wood log, the acrylic sheet is bent to move around the handle log in each case (figure 72). The plan drawing of figure 70 shows in green lines how the acrylic sheets have wrapped around the handle part of the wooden shutters and mounted a straight piece on the other. This technique is followed in all the lacquered door and window shutters. ารกยาลัยศิลปา

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Figure 71: Cross sectional drawing of the wooden shutters and the acrylic protection (shown in yellow), and the aluminum double-pane window shutters outside.



Figure 72: Drawing of a window at *Wat Kampang* temple showing the acrylic protection systems.



Figure 73: Aluminum channel nailed directly into the wooden shutters to hold the acrylic sheets.



Figure 74: Sketch (not in scale) of the cross section of the aluminum framed acrylic protection system.

Apart from the shutters of the doors and windows, none of the wooden frames at *Wat Kampnag* temple has acrylic protection except the entrance doors at the north. The part of the door frames at the north that have the black and gold lacquer design are covered with acrylic sheets (figures

75 a and b). But the lacquer designs on the frames are not fully covered with acrylic protection, it rather stops at a certain height (figures 75 a and b). This is probably because the intention was to protect the lacquer design from direct touch of human, and that is why the acrylic sheets do not continue beyond the reach of a human. However, the door frames at the southern wall do not have acrylic protection despite having black and gold lacquer designs. It is also to be noted that none of the wooden window frames have any acrylic protection, maybe because they are coated with only red lacquer and do not have any black and gold decorations.

According to the discussion with the community, who oversee and maintain the functions of *Wat Kampang* temple, all the acrylic sheets were installed during the renovation work done in 2009. As tested during the study, the acrylic sheets have UV protection property.





Figure 75: (a) and (b): Lacquered door frames at the entrance covered with acrylic protection.

The other method of protection for the lacquered door and window shutters that has been applied at *Wat Kampang* temple is aluminium framed glass shutters installed at the outer side of each door and window openings (figures 68 and 69). These additional glass shutters are operable like doors and windows. The additinal aluminium framed shutters are double-pane aluminium casement windows, and ordinary aluminium framed glass doors respectively for windows and doors. Unlike the lacquered wooden shutters, the glass panels swing and open outward towards the exterior of the temple building. According to the discussion with the community people, these aluminium framed glass panels were also installed in 2009 and the primary reason for installing the additional glass panels was to strengthen the security of the temple during night time and to protect the interior from natural phenomenon such as rain. These aluminium framed glass shutters are generally kept open during the day to ensure air flow and ventilation of the temple hall or *ubosut*. However, the glasses of all these additional shutters are tinted and covered by UV- filtering films.

5.2. Damages / faults of the existing protection systems

Although the aluminium framed glass shutters for the windows are in good condition, the acrylic protection system on the wooden doors and window shutters is not. The doors and windows marked red in the plan drawing in figure 76 shows different types of damage in their acrylic protection system, both on the acrylic sheets and the associated aluminum frames. Apart from door D-1, windows W-4 and W-9, the acrylic protection systems on the rest of the wooden shutters have damages of various kinds. Table 3 describes different defects that were observed at the doors and windows at Wat Kampang temple during the study. The types of damages evident on the acrylic protection system range from cracking and partial to full breaking of acrylic sheets and ther associated aluminium frames (figures 77, 78 and 79). There are also scratch marks and dust accumulation on the acrylic surfaces, and trapped insect deposits inside the gap between the acrylic sheet and lacquered surface. Detachments and buckling of the aluminum frames were also found in many acrylic protection systems. Damages in the acrylic sheets as well as the associated aluminium frames, are not only affecting the visual appearance of the lacquered doors and windows by making them less attractive, but also posing risk of getting more damage to the lacquer art by the broken elements of the protection system. This chapter will evaluate the damages (types and their causes) of the existing acrylic sheets and the aluminium channels in the protection system, and the effects these damages have left on the lacquered surfaces.



Figure 76: Plan of *Wat Kampang* temple showing the doors and windows with damage in their acrylic sheet and aluminium channel protection system.

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Location	Condition of the acrylic sheet	Condition of the aluminium frame	
D-1, Shutter 1	In good condition	Slight deformation at several points but	
, ,		not detached from the wood	
D-1, Shutter 2	In good condition	In good condition	
D-2, Shutter 1	A portion of acrylic sheet	The majority is in good shape and	
	cracked, broke and lost at	holding acrylic sheet on the lacquer	
	the top of the wooden	design, apart from the broken acrylic	
	shutter	part	
D-2, Shutter 2	Approximately 50% of the	Approximately 40% of the aluminium	
	acrylic sheet was broken and	frame is broken and lost.	
	lost	Some part of the aluminium frame	
	1997500	detached from the wood and buckled	
W-1, Shutter 1	In good condition, no crack	In good shape and holding the acrylic	
	or damage	sheet on the lacquer design	
W-1, Shutter 2	A portion of acrylic sheet	A portion of aluminium frame broke and	
	cracked, broke and lost at	lost	
	the bottom corner of the		
	wooden shutter		
W-2, Shutter 1	Crack on acrylic sheet at the	Deformation of aluminium frame on the	
	top.	handle.	
W-2, Shutter 2	In good condition	In good condition	
W-3, Shutter 1	In good condition	In good condition	
W-3, Shutter 2	Crack on acrylic sheet at the	In good condition	
	top		
W-4, Shutter 1	In good condition	In good condition	
W-4, Shutter 2	In good condition	In good condition	
W-5, Shutter 1	Crack on acrylic sheet at the	In good condition	
	handle		

Table 2: Condition of the acrylic protection system

W-5, Shutter 2	In good condition	In good condition
D-3, Shutter 1	In good condition	In good condition
D-3, Shutter 2	A portion of acrylic sheet	The aluminium frame associated to the
	cracked, broke and lost at	broken acrylic sheet is also broken and
	the bottom of the wooden	lost.
	shutter	Some part of the aluminium frame
		detached from the wood and buckled
D-4, Shutter 1	Approximately 40% of the	The aluminum channel associated to the
	acrylic sheet is broken and	broken acrylic sheet is also broken and
	lost	lost.
		Some part of the aluminium frame
		detached from the wood and buckled
D-4, Shutter 2	A part of acrylic sheet at the	In good condition, apart from the part of
	bottom of the shutter is	acrylic sheet that is broken
	cracked and lost	
W-6, Shutter 1	In good condition	In good condition
W-6, Shutter 2	Total loss of the acrylic	Majority is lost, the remaining
	sheet from the wooden panel	aluminium channel is loosely attached
	3173526	to the wood panel and are deformed
W-7, Shutter 1	In good condition	In good condition
W-7, Shutter 2	In good condition	Aluminium channel at the bottom of the
		acrylic sheet and along the height of the
	A BUL	handle are detached from the wood and
		buckled
W-8, Shutter 1	In good condition	In good condition
W-8, Shutter 2	In good condition	Aluminium channel along the height of
		the handle is detached from the wood
		and buckled
W-9, Shutter 1	In good condition	In good condition
W-9, Shutter 2	In good condition	In good condition
W-10, Shutter 1	A part of acrylic sheet at the	Aluminium channel associated with the
1	bottom of the shutter is	broken acrylic sheet is also broken and
	cracked and lost	lost
W-10, Shutter 2	A part of acrylic sheet at the	Detachment from the wood and
	top of the handle of the	deformation
	shutter is cracked and lost	



Figure 77: Cracked and lost acrylic sheet, broken and lost aluminum frame.



Figure 78: Acrylic sheet broken and lost.



Figure 79: Aluminum frame detached from the acrylic sheet and the wood shutter.



Figure 80: Aluminum frame detached from the acrylic sheet and the wood shutter and buckled. Acrylic sheet cracked and broken.



Figure 81: D-3, acrylic sheet and aluminum frame broken and lost.

Figure 82: Effect of broken acrylic sheet on the lacquer design – discolouration, dust accumulation and loss of gold layer.





Figure 83: W-6, acrylic Figure 84: Loss of gold layer, dust accumulation, signs sheet and aluminum frame of abrasion after the loss of acrylic sheet. broken and lost.



Figure 85: Figure 86: Figure 87: Evidence of insect related deposits trapped inside the acrylic protection system.

From table 3 and the figures -77, 78, 79, 80, 21, 82, 83 and 84, it is evident that many of the acrylic sheets of the protection system are cracked, broken (partially and fully) and have other signs of damages. Although as a material, acrylic is hard, impact-resistant and solid, it has some

vulnerabilities as well. Acrylic sheet is susceptible to sunlight and heat. UV radiation (300–400 nanometers on the electro magnetic spectrum) from sun exposure can cause photochemical reaction within the polymer structure of acrylic and can lead to breakage of the polymer bonds and eventually degradation of the material.⁸³ Apart from the prolonged exposure to UV radiation, unstable environmental conditions such as temperature and humidity fluctuations also impact the physical properties of acrylic.⁸⁴ Acrylic sheets expand and contract with changes in temperature and relative humidity. If exposed to uncontrolled climatic conditions to experience fluctuations for long, acrylic can bow and break with relatively smaller physical forces. However, for how long acrylic will last also depends on its quality. A high-quality acrylic is able to withstand extreme weather conditions, without significant degradation for around ten years.⁸⁵

The acrylic sheets at *Wat Kampang* temple are more than ten years old and have been in natural climatic conditions for many years. The exposure of the acrylic sheets at *Wat Kampang* temple to uncontrolled weather conditions has weakened the properties of the acrylic sheets and made them brittle. Moreover, the acrylic sheets also faced physical forces and got damaged. It was noted from the discussion with the community and local colleagues that, apart from the regular tourists and devotees coming for prayers, *Wat Kampang* temple gets a large number of visitors during special religious events and festivals. It is assumed that many of the acrylic sheets were broken as a result of both inherent structural weakness of the acrylic sheets and also accidental forces by movement of heavy items.

On the other hand, the lacquered shutters that lost the acrylic sheets partially, got their lacquer designs exposed to different kinds of new risks. The exposed parts have heavily accumulated dust and dirt and because of that the coherence in the appearance of the black and gold lacquer on the wooden shutters have been disrupted (figures 81 and 82). However, the acrylic sheets that are intact are providing protection to the lacquer designs on the shutters from direct contact of any external objects or human touches as well as from getting damaged by the sunlight (photodegradation), because the acrylic sheets used at *Wat Kampang* temple has UV protection

⁸³ (Impact Solutions 2017)

^{84 (}PLEXIGLAS® n.d.)

⁸⁵ (Impact Solutions 2017)

properties.⁸⁶ But where the acrylic sheets are broken and the lacquer surfaces got exposed, the photodegradation is taking place without fail. Whether visible or not, photodegradation starts off fading and the detaching oft he gold leaves from the lacquer. This makes the gold leaves get loosened and become vulnerable to getting swiped away with inappropriate cleaning. There are signs of loss of gold decorations at several wood shutters (figures 83 and 84). Moreover, as the acrylic sheets are not covering the black border outside of the *Lai rod nam* decorations, all the borders got faded in all the wooden door window shutters.

At several door and window shutters, the aluminium frames associated with the broken acrylic sheets are also detached from the wood shutters and some of them are buckled and deformed (figures 79 and 80). The detachments happened due to removal of the nails that were used to fix them to the wood shutters. This might have been caused by pressure imposed on the nails from the stress on the wood panels and the acrylic sheets during dimensional changes for relative humidity and temperature fluctuations. Some of the aluminium frames got severe deformation and some are torn away after getting detached from the wood shutters. Such deformed aluminum frames are causing further damage to the lacquer surfaces by scratching (figures 79 and 80). They are also increasing the risk of getting injury to the people coming close to them or operating the shutters.

Apart from breaking and cracking, some acrylic sheets have scratch marks on the surfaces as acrylic sheets are prone to scratching. The scratching marks on the acrylic surfaces are indicating improper handling and use of inappropriate method of cleaning of dust that accumulated on the surfaces. Dust particles, if not cleaned with proper method, can leave scratches on acrylic surfaces. Because of the scratch marks, many of the acrylic sheets have a ragged appearance.

At some of the lacquered door and window shutters, insect related deposits were found that are trapped in between the gaps of the acrylic sheets and the lacquered surfaces (figure 85, 86 and 87). Although apparently intact, the aluminium frames and the acrylic sheets do not have complete isolation from the surrounding environment and may have created a microclimate environment within the protection system that is suitable for insect growth. It was not investigated how much the damage increased by those insect related deposits, because the way the acrylic sheets are installed do not allow them to be opened or removed easily to untertake

⁸⁶ On site investigation done in May 2024

any investigation. Moreover, due to scarcity of funding, the damaged acrylic sheets and the aluminium frames were not repaired or replaced, leaving room for more dust accumulation and insect infestation.

5.3. Repair of existing protection system

5.3.1. Removal and replacement of the existing acrylic sheets and aluminum frames

For the protection of the Lai rod nam designs, the acrylic sheets mounted on the lacquered door and window shutters at *Wat Kampang* temple have aged and got affected by their exposure to the environmental factors such as direct sunlight, temperature fluctuations etc. Because of the vulnerability of acrylic sheets to sun exposure and uncontrolled weather conditions, a lot of them are broken and the remaining ones are also getting damages with time and eventually will break in the future. On the other hand, the aluminium frames that are used to fix the acrylic sheets to the wooden shutters are not strong enough to withstand much stress and impact. They are bendable by hands and with small pressure. The strength of aluminium depends on their grades, and from the damages occurred in the aluminium frames at Wat Kampang temple, it is assumed that they are not of high grade. Due to the tensile strength, reliability and sturdiness of aluminium, it is a widely used metal for a variety of construction purposes. But pure aluminium has limited use and to enhance durability, strength and performance, all aluminium is alloyed with other metals such as copper, magnacium, silicon, zinc and nikel. Based on the strength, aluminium alloy is given a number, and these numbers are also considered as their grades. The various grades of aluminium are numbered from 1 to 8 where grade 1 is unalloyed and the other seven grades are alloyed with other metals. The lower the grades, the less is the strength.87

The small nails that have been used to fix the aluminum frames to the wood shutters do not assure a strong attachment of the frames to the shutters and hence can be removed easily by relatively small tension or pulling pressure.

Since the intactness of the overall protection system consisting of aluminium framed acrylic sheets is not assured, it is recommended that all the existing acrylic sheets and their aluminium frames, be removed from the wooden lacquered shutters. However, removal of the frames and

^{87 (}IQS Directory n.d.)

acrylic sheets requires a lot of handling and technical skills, it is recommended that the task is done with proper planning and executed by experienced carpenters. The technical person/s to be involved in the removal task needs to be accompanied and be monitored by experienced conservator/s while executing the job.

5.3.2. Cleaning the lacquered surfaces

After the removal of the acrylic sheets and the aluminium frames from the lacquered door and window shutters at *Wat Kampang* temple, the lacquered surfaces need cleaning to revive their appearance. The dust and dirt, insect deposits, fingerprints etc which are present on the lacquered surfaces, are not only responsible for the lacquered surfaces to appear dull but also posing threats of further damages by themselves.

Dust is a heterogeneous mixture of organic and inorganic matter and can have both large and tiny particles. Dust can cause a range of issues on a surface that it accumulates on. Dust particles not only make a surface look dull but also damages the material it has collected on because dust is abrasive and acidic.⁸⁸ Moreover, dust, being hygroscopic, attracts water and thus can corrode or stain the object.⁸⁹ The level of dust accumulation is different in different lacquered shutters at *Wat Kampang* temple, depending on the level of damages in the protective acrylic sheets. The shutters that have lost part or full portion of the acrylic sheets have accumulated a lot of dust. The lacquered panels that have the acrylic sheets and the frame more or less intact show less amount of dust. The exposed surfaces also have varying degrees of damage in the black and gold layer surface such as fading, complete or partial loss of gold lacquer etc., after losing the acrylic protections.

High dust accumulation is contributing to certain types of damages of the lacquered surfaces, yet its removal can also cause damages. Cleaning is a high-risk activity which has serious consequences if executed in an improper way, therefore, it is advisable to do a thorough examination to determine the condition and state of every damage type and identify the type of surface dirt before planning and executing any cleaning activity. Different types of dirt should be treated differently. The cleaning activity can start with simple dry removal of loose surface dirt and the insect deposits. The lacquered surface at *Wat Kampang* that are photodegraded,

⁸⁸ (Trinity College Dublin 2013)

^{89 (}SpaceVac Intenational n.d.)

will be difficult to clean without removing degraded particles from the lacquered surface. To avoid accidental abrasion, soft brushes and soft microfiber cloth must be used.⁹⁰ However, it is to be noted that photodegraded lacquer becomes soluble to polar solvents such as water, therefore, no wet cleaning should be executed, without consultation from an experienced conservator.⁹¹ However, it is recommended that any cleaning task is done by experienced conservators. An experienced conservator can also identify consolidation needs to improve cohesion of loose or friable parts of different layers of the lacquer work and reattach them to the substrate.

Eradicatind dust completely in the context of *Wat Kampang* temple is not possible, therefore it would be beneficial to undertand how quickly it is accumulating on the surfaces. Scientific research on the constituents of the dust might be helpful to plan preventive actions to reduce impact.

5.3.3. Enhancing UV-filtering properties of the existing aluminium framed glass shutters

The existing aluminum framed glass shutters outside of the lacquered door and window shutters have UV-filtering films. UV-filtering films are flexible films that are adhered to the glasses and can block ultraviolet and visible light to a varying degree. UV-filtering films are laminated polyester film layers that can absorb, scatter or reflect UV light and thereby reduce the transmission of UV and visible light through the glass that they are adhered to.⁹² The UV-filtering films on the aluminium glass shutters at *Wat Kampang* temple are quite backdated as they were installed back in 2009. There has been a great increase in the number of manufacturers producing these films and they typically state elimination of ultraviolet light as 95–99% (in the range of 200 to 380 nm). But it is to be noted that the sun emits two types of UV radiation– UVA and UVB. The major difference between these two are their wave lengths where UVB has much smaller wave lengths than UVA and thus are more damaging. According to the Professional Picture Frames Association (PPFA), to qualify as 'providing UV protection' the UV filter must be able to block both UVA and UVB at least 97%.⁹³ At *Wat Kampnag* temple, the lacquere designs on the wooden door and window shutters have not been saved

^{90 (}Webb 2000)

^{91 (}Webb 2000)

^{92 (}Springer 2008)

^{93 (}Rogers n.d.)

from photodegrdation despite having the UV-filtering films on the aluminium framed glass shutters. It might be because of two reasons- the films on the glass shutters do not have high filtering property and they are kept open during the daytime and do not work as an obstacle for the sunlight to impose directly on the lacquered surfaces. Moreover, at few locations, the UVfiltering films are damaged and created air bubble because of the failure of adhesion with the glass. There are also different types of films, clear ones are installed at the eastern glass windows and darker ones on the southern doors and western windows. This is impacting the coherence in the appearance of the glass panels as well as the visibility. To minimise the impact of the direct sunlight on the lacquered shutters, it is recommended that the UV-filtration of the existing aluminium framed glass shutters are improved by replacing the existing films by better and modern UV absorbent films. With the rise of interest in green building, the use of solarcontrolling window films has increased in the past decades and more efficient versions are available. These films are seen as a cost-effective solution for reducing energy costs for various building types. Such window films are transparent (figure 88), flexible, self-adhesive, and when applied on window panels, can act as a solar shield because they can block up to 99% of UV light and 80% of the sun's heat, without interrupting visibility.⁹⁴ These films need to be applied by skilled person so that they are undetectable, and no air bubbles and ripples are evident.

Improved performance of the existing aluminium glass shutters for UV protection can also be achieved by replacing the existing glasses with laminated UV filtering glasses. Commonly used for car windshields, laminated glasses are a type of safety glasses that uses sheets of glass with an interlayer of polyvinyl butyral (PVB), like a glass sandwitch, which makes sure the glasses do not shatter if cracked. The UV filter is added to the interlayer so that it remains safe from scratching or being removed. Due to considerable weight and cost, laminated glasses are less common in use in cultural heritage fields, but this type of laminated glasses can completely block both UVA and UVB. Manufacturer such as Tru-Vue produces this type of glasses for art works.⁹⁵ However, the cost of UV- filtering films and the labour involved in the application of the films need to be evaluated and compared with the cost of replacement of all glasses with 'laminated UV filtering glasses, before making decisions.

^{94 (3}M n.d.)

^{95 (}Rogers n.d.)

To get the benefit of the UV filtered glass shutters, they need to be kept closed during the time when the sunlight falls on the lacquered door window shutters. If the windows having UV protection films are kept closed during the daytime, it can significantly reduce the effect of sunlight falling directly on the lacquered surfaces. Moreover, because of the heat gain controlling property, these films can also help control the cooling and heating imbalances that result from the weather condition of Bangkok. Temperature and humidity fluctuation inside the building may get reduced in this way. Keeping the windows close will also benefit the temple interior to accumulation less dusts.





Figure 89: Aluminium framed glass window, view from outside of the temple.

But keeping all the Aluminium framed glass shutters closed might not be a feasible solution considering that the temple does not have any mechanical ventilation and air conditioning inside the hall. The doors and window shutters, when kept open, help to ensure the air flow and maintain cross ventilation of the interior oft he temple, keeping it in a reasonable climatic condition for human comfort. To address this, a sun path diagram can be a valuable tool to understand the movement of the sun throughout the day and year and its impact on the building surfaces. By analysing the sun path of *Wat Kampang* temple site, the natural light and shading condition, the hours of the day when each wall is getting direct sunlight can be determined. A simple and manageable schedule can be generated to close off and open the window shutters. It would not need to keep all the glass doors and windows closed all the time and thus cross ventilation can be ensured.

5.4. Redesigning the protection system for the lacquered shutters

In chapter 5.3.1 (p. 66) it is recommended that the existing acrylic sheets that are mounted on the lacquered surfaces be removed because many of them are damaged and the others are assumed to be damaged in future. But it is also not recommended that the lacquered surfaces are kept unprotected. This chapter proposes a new design concept for installing aluminium framed acrylic sheet protection with an attempt to address the deficiencies of the existing system.

One of the problems with the existing acrylic sheet and aluminium frame protection system is that the acrylic sheets are fixed on the wooden shutters by the nails which on one hand does not make it fully sealed from the environment and on the other hand does not leave provision to be opened if necessary. As a hard, waterproof, transparent material, acrylic sheet is providing protection from accidental damages, some air tightness, which reduces the effects of dirt, dust and air pollution, and environmental fluctuations, yet ensuring visibility. But because of the loose fitting of the acrylic sheets and the aluminum frames to the wood shutters, dust could penetrate inside the protection system and be trapped in the gaps between the acrylic sheets and the wood shutters. Moreover, insects can also find ways to get inside and make their homes and breed. This is why, glazing can sometimes be warranted for surface damages that are fragile and sensitive to RH fluctuations. Since there is no provision for opening the acrylic protection and ensure cleaning of the lacquer surfaces, the dust and dirt, insect deposits remain there for years. This is not only making the surface look unattractive but also posing threats of further damage. Another problem observed with the existing mounting system of the aluminium framed acrylic sheet protection is that they are attached too close to the lacquer design surface. A glazing or acrylic sheet should never touch the painted surface, and the framing method should include a spacer to hold the glazing away from the painted surface.⁹⁶



⁹⁶ (Canadian Conservation Institute 2018)



Figure 91: Plan of the proposed design for operable acrylic sheet protection system.

Figure 92: Micro hinges and locks.

To address the problems mentioned above, a new design is proposed as illustrated in figure 90. First, the existing acrylic sheets need to be replaced with UV filtering non-reflective acrylic sheets that are abrasion-resistant and have non-reflective coating on both sides of the sheets. This material has good clarity and light transmission capacity in addition to being light and durable. The gap between the lacquered surface and the acrylic sheet should be $\frac{1}{2}$ inch to 2 $\frac{1}{2}$ inch, as suggested by the Canadian Conservation Institute.⁹⁷ To secure the acrylic sheets on the lacquered surfaces, the frames must be strong and rigid, therefore a better grade aluminium frame should be chosen. At *Wat Kampang* temple, it is not necessary to have a very high-grade aluminium for framing the acrylic sheets, because the purpose for tis aluminium frames is to hold the acrylic sheets only which are very light in weight. But it is also understood from the damages of the aluminium frames, that they are not strong enough and will continue to get damaged. Therefore, it is suggested that a better grade aluminium channel is chosen to replace the existing ones so that they ensure the durability of the same. To ensure the provision for cleaning the lacquered surfaces periodically, it is proposed that the new aluminium framed acrylic sheets are installed in a manner that they are not fixed on the lacquered surfaces but will allow to open whenever necessary (figures 90 and 91). This can be done by using contemporary micro hinges and hooks which are very small in sizes and will have very small visual impact (figure 92).

5.5. Installing UV protection screens outside of the lacquered shutters

Another recommendation for the protection of the lacquered window shutters at *Wat Kampang* temple is to install UV protection screens outside of the building to serve as curtains to the lacquered surfaces (figure 93). Installed in front of the windows, such solar screens can decrease heat gain and glare by filtering 65–90% UV rays.⁹⁸ These are readily available, economical, low maintenance and easy to operate. The installation system is simple and the material and devices necessary to install them are light in weight. There are different design and installation options such as, fix the screens to a wall, to roofing edge or to have as free-standing supports. It is proposed that the solar screens are hung from the eves of the existing wooden roof overhanging the east and west walls of *Wat Kampang* temple building (figures 94 and 95).

⁹⁷ (Canadian Conservation Institute 2018)

^{98 (}Efficient Window Coverings n.d.)

Because of their light weight, the risk of posing structural stress on the roof is quite low. There are varieties of screen fabrics available in the market, the one that ensures the least visible impact can be chosen. However, the lacquered door at the entrance (D-1 and D-2) may not need the screens because they are located on the northern side and do not get direct sun much fort he deep roof cover or porches. But the doors on the southern wall (D-3 and D-4) may get benefit from having UV protection screens because the lacquered surfaces get direct sunlight for a significant amount of time of each day.





Figure 93: Sectional drawing of the temple wall showing the conceptual installation of outdoor UV protection screens outside lacquered window shutters.

Ground/ land



Figure 94: Proposed translucent UV protection screens at the exterior walls.



Figure 95: Proposed translucent UV protection screens at the exterior walls.

Summary

Temples or '*Wats*' play a significant role in Thai culture and tradition. *Wat Kampang* temple has a rich history of serving as a religious center, built to pay tribute to sacred Buddha. Built in late Ayutthaya period, Wat Kampang temple is regarded as one of the most important religious sites in Bangkok. Till today, *Wat Kampang* temple offeres a place for communal worship, meditation and reflection while also attracting visitors, irrespective of religious beliefs. Visitors comes to admire and appreciate the rich heriage building and its landscape, the intricate art works on the walls and the ceiling, and the spiritual significance of the space. While there are many aspects of this temple that needs research and study for the preservation of the temple, this master thesis tried to present the examination done on the aluminum framed acrylic sheet protection system that is installed for safeguarding the *Lai rod nam* lacquer work on the wooden door and window shutters.

To ensure the preservation and to know the conservation needs of the lacquerd door and window shutters, it is important to study intensely the materials, techniques and conditions of the lacquerwork. For the sake of a comprehensive understanding of Lai rod nam lacquer work, the traditional technique has been studied and presented as a reference. There has been attempts to protect this precious art through aluminum framed acrylic sheets. This research has evaluated the current protection system at *Wat Kampang* temple and some of the downsides of the same. Upon evaluation of the vulnerabilities of lacquer art and the damages that occurred on the lacquered surfaces at Wat Kampang temple, it is realised that the direct and long exposure to the sunlight (UV radiation) is the most dominating deteriorating factor for the lacquered door and window shutters. The existing protection system, comprised of aluminium frame and acrylic sheets, installed on the lacquered designs, does not guarantee the safety and wellbeing of the lacquered surfaces from light induced damages. Rather, as discussed in different chapters of this research, the damages that occurred in the acrylic sheets and the aluminium frames are posing more threats to the lacquer work. This research focused on proposing some options to address the existing problems that relates to the acrylic protection systems and some new conceptions to prevent damages to the lacquer art. To do that, the context of the temple, in terms of the available resources, and the current management of the temple by the monks, has been considered and therefore the solutions that were proposed are all low cost, low tech, low maintenance and locally available. However, proposing any conservation intervention for the lacquer design was out of the scope of this research.

This lacquering technique was applied extensively on doors and windows of many religious buildings and palaces in Thailand that were built in Ayutthaya period. These buildings have great importance in the Thai heritage lists. lacquered doors and windows are highly distinctive architectural elements for Thai tradition. The type of protection system described here is a typical approach which have been followed to similar other cases at different temples and palaces. This research and the proposed alternative solutions are hoped to eventually contribute to design a more appropriate protection system that may serve as a solution for *Wat Kampang* temple as well as other similar sites.



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