Rajakudakan Wat Chotikaram: From Ruins to The Reconstruction of The Grand Stupa, Wat Chedi Luang, Chiang Mai*

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[*Abstract*]

The Grand Stupa is mentioned in historical text as 'Rajakudakan', which means a royal building with a multitiered superstructure. This Grand Stupa is the principal construction of Wat Chedi Luang, and marks the center of the Chiang Mai City Plan.

This study argues that the Grand Stupa was built in 1391 during Phaya Saen Mueang Ma's reign, possibly inspired by the construction of Ku Phaya in Bagan. Thereafter, in 1545, the Grand Stupa's superstructure collapsed after the great earthquake, resulted in the irreparable damage since then. Therefore, a survey using a 3D laser scanner is conducted to collect the most precise data on the current condition of the Grand Stupa, yielding an assumption of its reconstruction.

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Other simultaneous stupas or those that show a close architectural relationship (e.g. stupas in Wat Chiang Man and Wat Lok Moli and the stupa of King Tilokaraj in Wat Chet Yot in Chiang Mai) are also employed as research frameworks for the reconstruction. As a result, the architectural research on the Grands Stupa, compared with simultaneous stupas, yields a fruitful argument that the pre-collapse superstructure form of the Grand Stupa marks the most architectural similarity to the stupa of Wat Chiang Man.

Keywords: Wat Chedi Luang, Lanna, point cloud images, heritage building information modelling, reconstruction supposition

Ⅰ. Research purpose

This study has three main purposes:

(1) to carefully survey the current condition of the Grand Stupa with a 3D laser scanner;
(2) to conduct a comparative study from the aspects of architectural relationship and measurement of other simultaneous stupas in complete condition in Chiang Mai City for yielding the reconstruction of the pre-collapse superstructure form of the Grand Stupa;
(3) to analyze and reconstruct the complete architectural form of the Grand Stupa and to generate its 2D computer model and the 3D model for the purpose of interpretation.

Ⅱ. Brief historical information of the Grand Stupa

Chiang Mai is a province in northern Thailand. Its geography features basin plains in valleys. Historically, Chiang Mai was the capital of the Lanna Kingdom, which was an important ancient civilization and was contemporary with other outstanding kingdoms, such as Sukhothai, Ayutthaya, Ava and Rakhine. Notably, at that

time, these kingdoms were rapidly prosperous after the fall of Southeast Asian great empires (e.g. Bagan, Angkor and Dai Viet) and the emergence of traditional states, including Chiang Mai <Fig. 1>.

Chiang Mai City was established by King Mangrai in 1296 on the hugely abundant lowland flanked by Mae Ping River and Suthep Mountain, featuring a perfect location of an urban settlement <Fig. 2>. The city was given a convenient canal journey through Mae Ping River and the lowlands of the east, suited for the traditional irrigation of dikes and irrigation systems (Mueang Fai), which were typically invented by Tai-speaking people to divert river for farming. Considerably, this traditional irrigation contributed to the security of food and administration that Chiang Mai was able to centralize a huge group of traditional states of 'Lanna'.

Meanwhile, the mountainous areas in the north and the west (Thanon Thong Chai Range) provided a natural defensive feature to prevent the city from enemies and a significant headstream as a lifeline of the city.

Moreover, Suthep Mountain, as part of Thanon Thong Chai Range, significantly embodies the special status of the sacred mountain of Chiang Mai, given that the relics of Lord Buddha are enshrined in Doi Suthep Temple at the top of this mountain, as recorded in the White Elephant legend. Therefore, King Mangrai selected this location for Chiang Mai in 1296 instead of living in previous cities of Hariphunchai and Wiang Kum Kam (Ongsakul 2009: 120).

Remarkably, the physical characteristics of Chiang Mai City Plan can be separated into two sections; the square plan and the earthen rampart in the east and the south of the city <Fig. 3>. Firstly, the square plan is almost exactly square, which measures 1.6 kilometers long in each side, and entirely involves the surrounding brick walls and moats. Secondly, four main fortresses are located in

the four corners of the city walls, including the five city gates, serving as a single gate at each direction; only the south wall features two gates. Remarkably, the Chedi Luang (the Grand Stupa) marks the center of the Chiang Mai City Plan and was established in the late 13th century as the spiritual and physical center of Chiang Mai.

The Grand Stupa was historically named after an old name of Wat Chedi Luang, 'Chotikaram Vihara,' which means 'the temple with illuminated light' where the hair of the Lord Buddha was enshrined.

The inner area of the temple is the place where the Grand Stupa is located. It has been known as 'Rajakudakan,' which means 'a royal building with a multitiered superstructure.' With its elegance and height, the complete Chedi Luang is so tall that it can be seen from a four-kilometre distance.

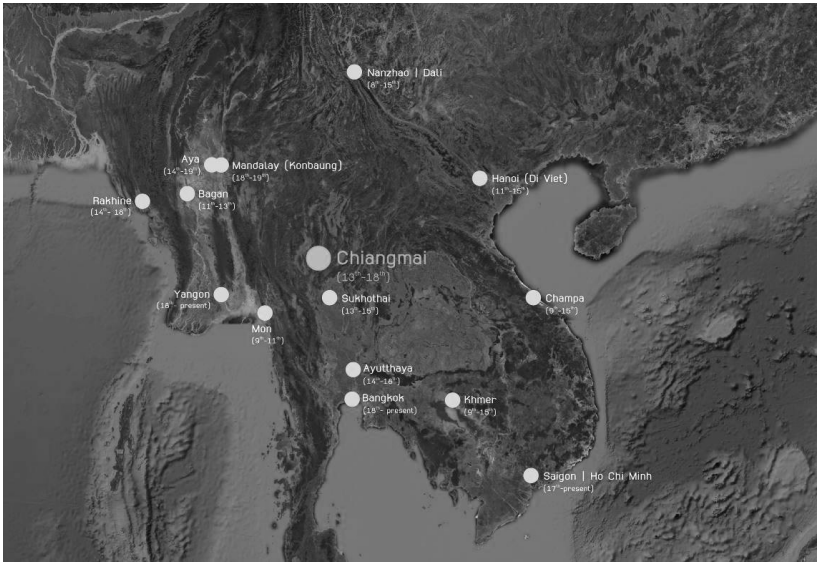
Historically, the Grand Stupa was built in 1391 during the reign of Phaya Saen Mueang Ma (Ratanapanya Thera 2011: 185) The background of the construction of the Grand Stupa was conveyed through a myth that a merchant traded with Chiang Mai and the Irrawaddy river basin. On his trade route, he once dreamt about the late Phaya Kue Na that his soul was not at peace. Rather, his soul still resided in a huge Banyan tree on this trade route; the soul also extremely wishes his son, Phaya Saen Mueang Ma, to establish the Grand Stupa as a dedication to the soul of Phaya Kue Na. Thus, Phaya Saen Mueang Ma patronised the establishment of the Grand Stupa (The Committee for the Revision of Chiang Mai Chronicle 1995: 53).

Notably, as conveyed in the legend, assuming that the architectural form of the Grand Stupa during the reign of Phaya Saen Mueang Ma was a stupa with a multitiered superstructure and was somehow inspired and derived from the Bagan art was

reasonable.

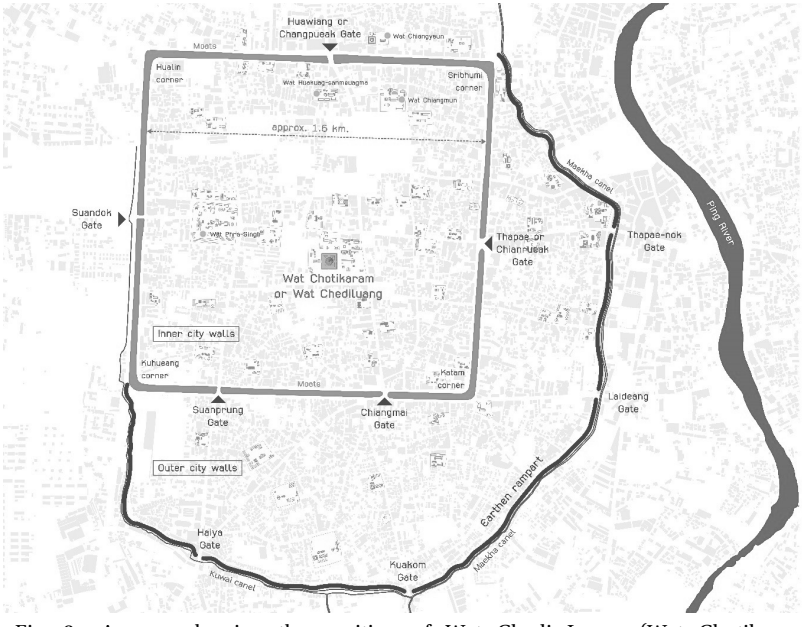
The further construction and reform of the Grand Stupa were executed; coincidentally, the Emerald Buddha image was enshrined at the east chamber of this Grand Stupa during the reign of King Tilokaraj in the 15th century, resulting in the adjusted proportions and forms as seen at present (Ratanapanya Thera 2011: 201).

Thereafter, in 1545, the superstructure of the Grand Stupa collapsed after an earthquake during the reign of Queen Jiraprap <Fig. 4>. Remarkably, it resulted in the irreparable damage of the Grand Stupa's superstructure since then (Ongsakul 2009: 177).



<Fig. 1> A map showing the location of Chiang Mai City and ancient cities in Southeast Asia

<Fig. 2> Geography of Chiang Mai City flanked by Mae Ping River in the east and the Suthep Mountain in the west



<Fig. 3> A map showing the position of Wat Chedi Luang (Wat Chotikaram), centrally located in the square city plan of Chiang Mai

<Fig. 4> Current architectural condition of the Grand Stupa with its damaged superstructure, Wat Chedi Luang

Ⅲ. Research Methodology

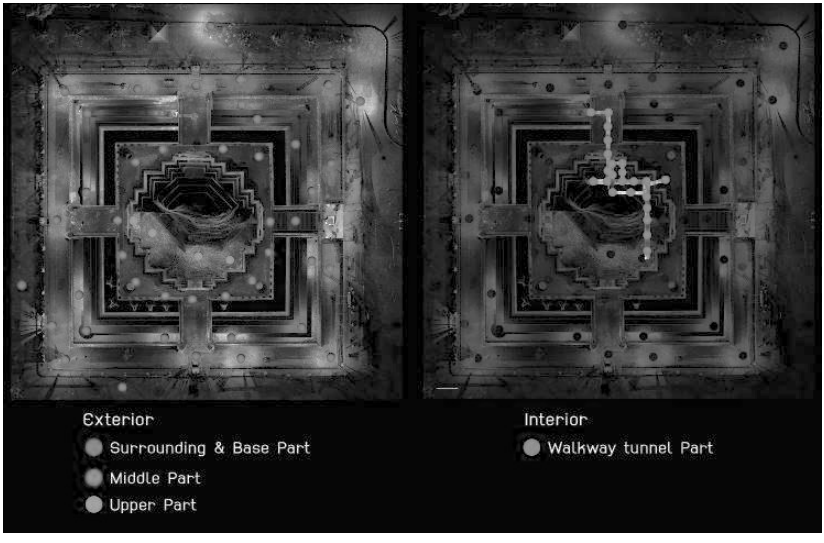
This study employs an architectural survey of the Grand Stupa with a 3D laser scanner, which effectively yields the most precise and correct data of the ruin with a rapid and convenient operation. The obtained data can be merged with architectural tools and knowledge to further reconstruct the original architectural form of the Grand Stupa. Finally, the heritage building information modelling (H-BIM) is used to provide a virtual information model of the Grand Stupa's reconstruction and its interpretation.

The research methodology can be divided into six steps: (1) a survey with the 3D laser scanner; (2) the data processing and connecting of the scanned data; (3) the creation of point cloud images; (4) the creation of the current architectural condition; (5)

the historical analysis and comparative study; (6) the reconstruction of the architectural form and the summary.

The 98 spots of scanning positions are set by the surrounding exterior to cover the entire three main parts of the Grand Stupa; bases, chambers and superstructures, including the interior space at the walkway tunnels underneath its bases <Fig. 5, 6>.

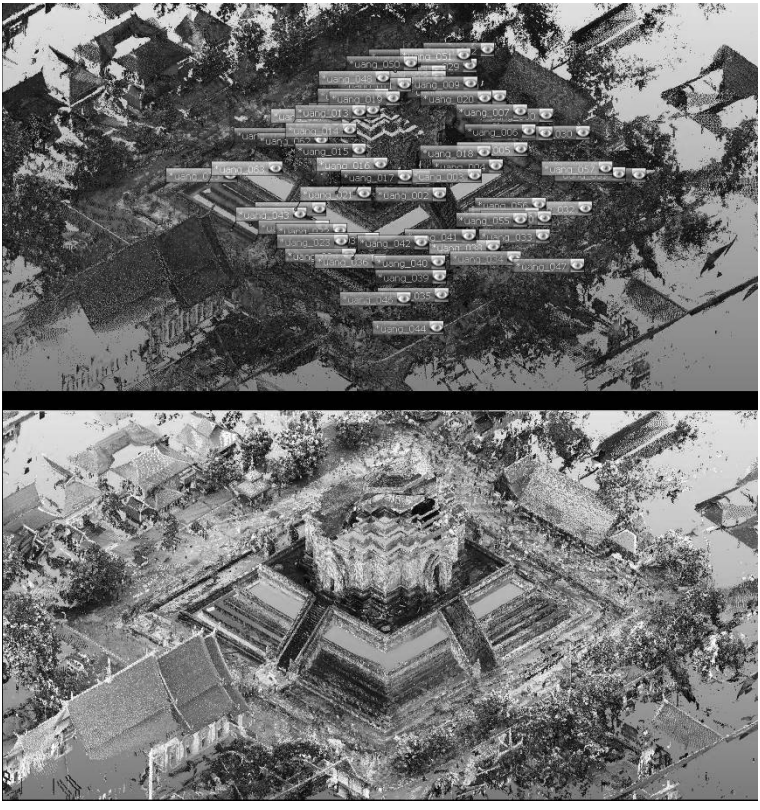
From the abovementioned data collection plan, the unmanned aerial vehicle (UAV) is used to record the details of the superstructure of the stupa; then, such data are generated into a format of photogrammetry. However, given that UAV is not permitted to be operated within nine kilometers from the Chang Mai International Airport, the survey with the 3D laser scanner is used instead.



<Fig. 5> Position of the 98 spots of the 3D laser scanner, placed around the Grand Stupa and its interior, Wat Chedi Luang

Apart from the architectural survey of the exterior form of the Grand Stupa, this research also conducts a survey of the walkway

tunnels inside the stupa, which can be accessed only at the side of the Naga ramp in the north direction. Yet, the entrances of the walkway tunnels are presumed to be under the ramp at all directions.



<Fig. 6> Operation of scanning points, linking the 98 spots of scanning positions to generate the point cloud images of the Grand Stupa, Wat Chedi Luang

Ⅳ. Measurement Result and Data Collection

From the survey of the walkway tunnel in a particular part under the exterior ramp, the design was clearly rendered in a form of a steep slope; and its sloping sides join at the ridge, which is exactly

related to the stair slope and designated by the exterior ramp form. In addition, the formation of the bricks of this tunnel was systematically arranged, and each riser of the stairs relatively changed its height according to the levels of the ceiling (No.1). The next part is a straight line of tunnel (No.2), intersections-ending at T (No.3). The junction to the right is a short distance thoroughly closed by compacted rubble and clay (No.4). Heading to the left (No.5) approximately 2 meters can meet another higher tunnel on the left (No.6). This left subordinate walkway (No.5) features a sharp turn (No.6), and its floor is so compacted that people cannot stand this area, as ceiling are low (1.5 meters). The end of this subordinate walkway (No.7) is fully compacted with rubble and clay <Fig. 7>.

Turning back to the mouth of the tunnel (No.6), this walkway connects to another higher tunnel, featuring identical stairs (No.7) to the stairs at the entrance (No.1), and slightly leads to a sharp turn and a dead end. Moreover, a further dug tunnel, which deviates from the circumambulatory terrace of the upper exterior stupa, is found. This additional tunnel is later dug; it also features marks of breaking bricks and laterites, possibly left after the archaeological excavation and the conservation by the Fine Arts Department to create a connecting tunnel to the circumambulatory terrace above the outside of the stupa (Phetpradap 1986: 18).

Notably, based on the survey, the formation of the bricks of the first-level tunnels is more systematically arranged than the second-level tunnels. A fruitful outcome is also evaluated from the results of the 3D laser scanner, and the tunnel survey reveals a significant engineering problem that the tunnels bear massive-dead loads, resulting in their great collapse during the earthquake due to unstable bases with interior tunnels.

Furthermore, the Grand Stupa shows a similar construction technique to Ku Phaya in Bagan, which reflects that the chief engineer got inspiration and might have learned the engineering knowledge from Bagan. Historically, this proposition is congruent

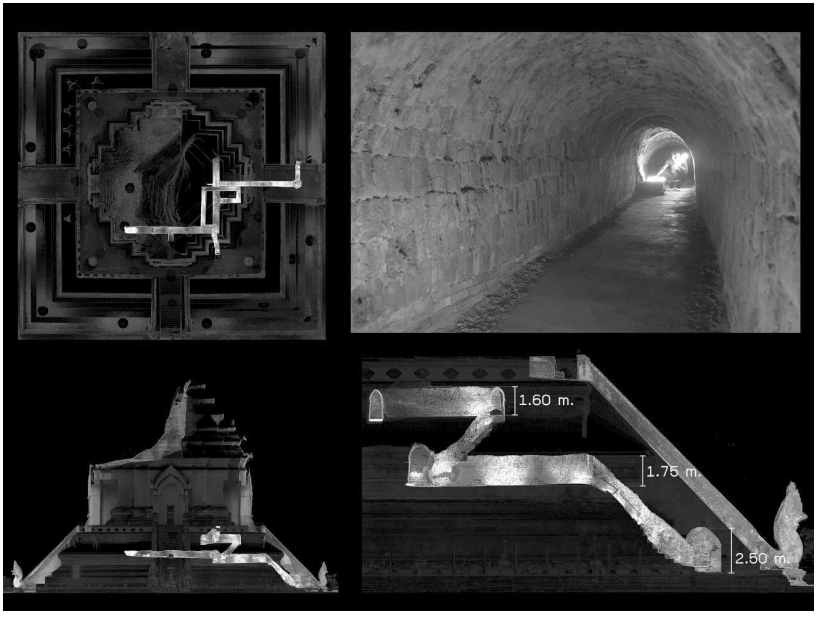
with the cultural and religious relationships between Lanna and Bagan during that time, even the powerful political center of the Irradwaddy basin, Bagan, thoroughly collapsed due to the invasion of the Mongol.

However, by studying the architectural structure of Ku Phaya in Bagan, the tunnel planning of Ku Phaya is parallel with the line of wall. Looking through its cross section, the walls are double-layered. The outside walls cover tunnels and prevent them from the weight of the superstructure of the stupa; thus, the outside walls of the tunnels are free from the dead load of the superstructure.

Moreover, the design of the lotus petal-shaped arched walkway tunnel (the pointed arch) enables its own structure to support the interior structure of the entire stupa whose cross section demonstrates the similarity to the buttress of the Gothic architecture.

Meanwhile, the tunnel planning of the Grand Stupa features a horizontal alignment toward its core, bearing massive-dead loads, rather than being parallel with the line of walls similar to the Bagan structure. Significantly, the chief engineer, who designed the Grand Stupa, got inspiration from and was impressed with 'the phenomenology of space and construction' and the construction technique of the pointed arch of Bagan but lacked the full engineering knowledge of its structural accuracy in the tunnel planning. Thus, the construction of walkway tunnels inside the Grand Stupa failed and was unfunctional as planned.

Therefore, the architectural form of the Grand Stupa features the typically self-developed architectural style of the Lanna Kingdom. Intriguingly, its inspiration was influenced from the Bagan stupa as proved by an effort to construct the interior walkway tunnels like the tunnel planning of Ku Phaya in Bagan.



<Fig. 7> Walkway tunnels inside the Grand Stupa, Wat Chedi Luang

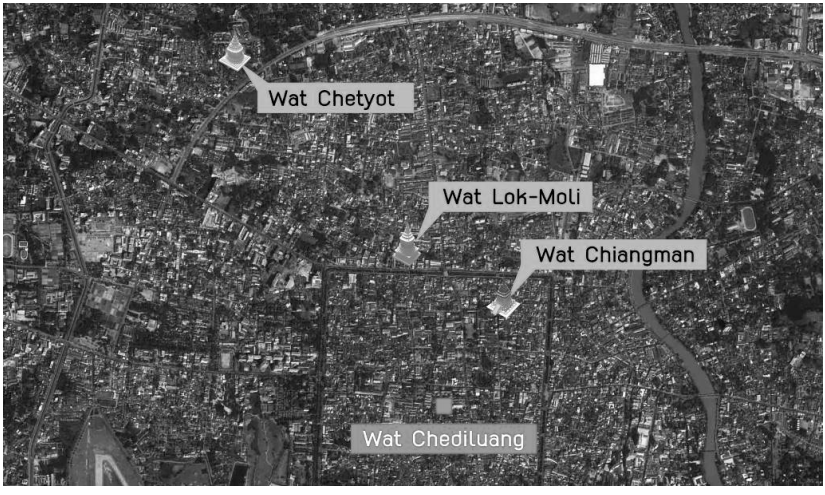
Ⅴ. Reconstruction of the Grand Stupa of Chiang Mai

The reconstruction of the Grand Stupa of Chiang Mai is extended from the results of the architectural survey and the creation of point cloud images based on the existing condition of the Grand Stupa. Intriguingly, the reconstruction of the pre-collapse superstructure form of the Grand Stupa has been controversial for a long time, resulting in great curiosity in our society.

Consequently, the process of the Grand Stupa's reconstruction of its pre-collapse form can be performed through the analogy of the stupa with its multitiered superstructure by comparing three great stupas in Chiang Mai City <Fig. 8>; the principal stupa of Wat Chiang Man, the stupa of Phra Meang Ket Klao in Wat Lok Moli and the stupa of King Tilokaraj in Wat Chet Yot. Admittedly, these stupas bear different strengths and weaknesses to be employed as

guidelines to reconstruct the complete architectural form of the Grand Stupa.

This study employs the new technology of survey with the 3D laser scanner to yield the most precise data, to generate point cloud images effectively and to create BIM for analyzing the volume of form and for evaluating the derived forms of the Grand Stupa.



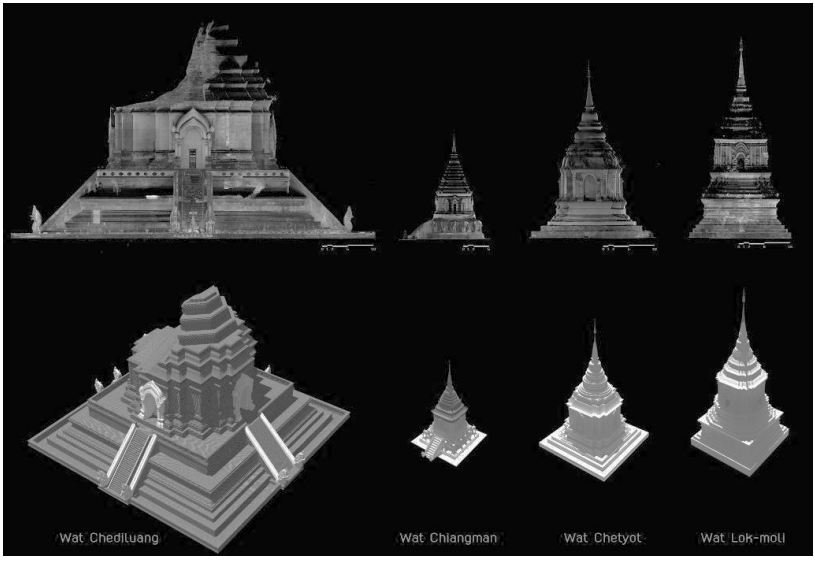
<Fig. 8> A satellite image showing the location of selected stupas -Wat Chet Yot, Wat Lok Moli and Wat Chiang Man- for the reconstruction of the pre-collapse superstructure form of the Grand Stupa

Remarkably, this research proposes that the stupa of Wat Chiang Man and the stupa of King Tilokaraj in Wat Chet Yot should be carefully examined as a simultaneous construction. That is, the Grand Stupa was greatly renovated during the reign of King Tilokaraj in the 15th century, simultaneously with the main stupa of Wat Chiang Man during the reign of King Tilokaraja in 1471. The stupa of King Tilokaraj in Wat Chet Yot (Wat Maha Photaharam) was built after his death; the stupa of Phra Meang Ket Klao in Wat Lok Moli was built 50 years later, marking irrelevant time to influence art on the Grand Stupa <Fig. 9>.

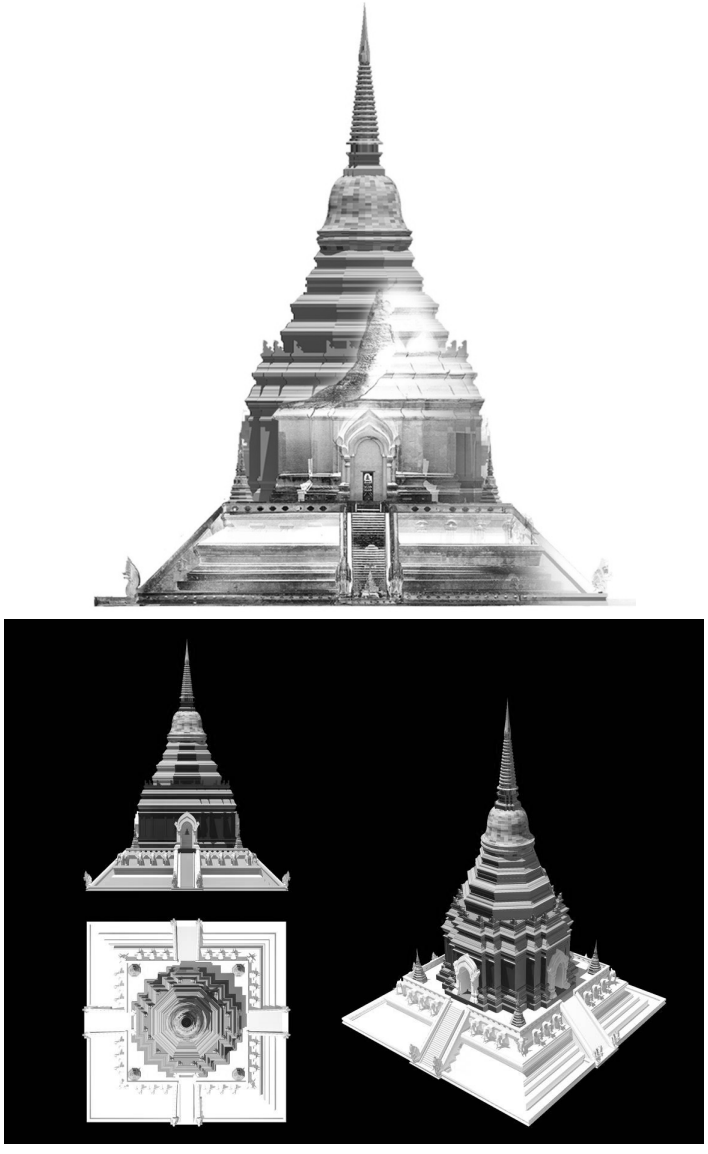
Notably, this study argues that the stupa of Wat Chiang Man marks the most relevance in terms of the architectural form and proportion to the Grand Stupa. Therefore, the architectural form of the stupa of Wat Chiang Man is employed as the basis of the reconstruction of the pre-collapse superstructure form of the Grand Stupa.

According to the architectural survey of the current condition of the Grand Stupa using the 3D laser scanner, the process of its reconstruction is created by the Architectural H-BIM and is based on the architectural form of the stupa of Wat Chiang Man.

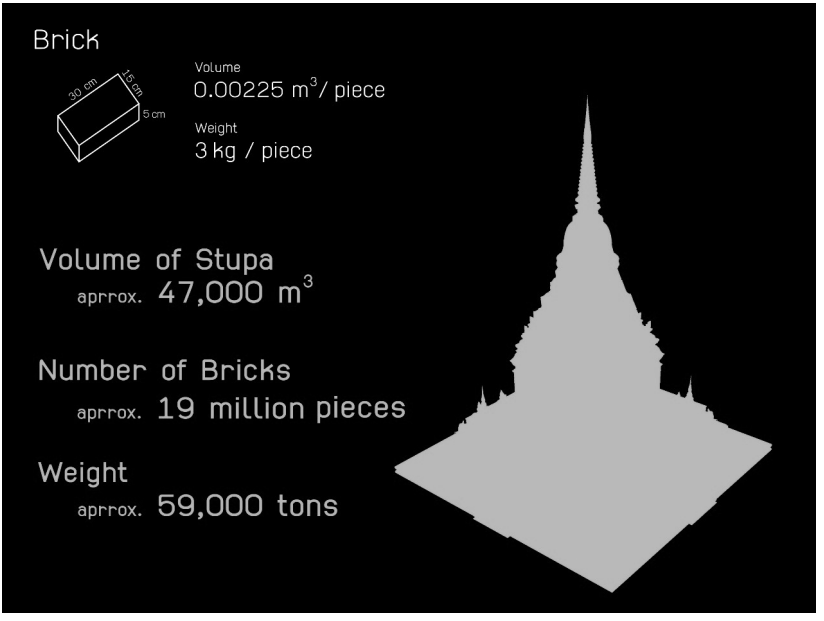
The completion of this process yields the total height of the Grand Stupa, which approximately measures 80 meters from the base to the top <Fig. 10>. After the creation of the H-BIM model of the Grand Stupa, its volume can be calculated by the weight and



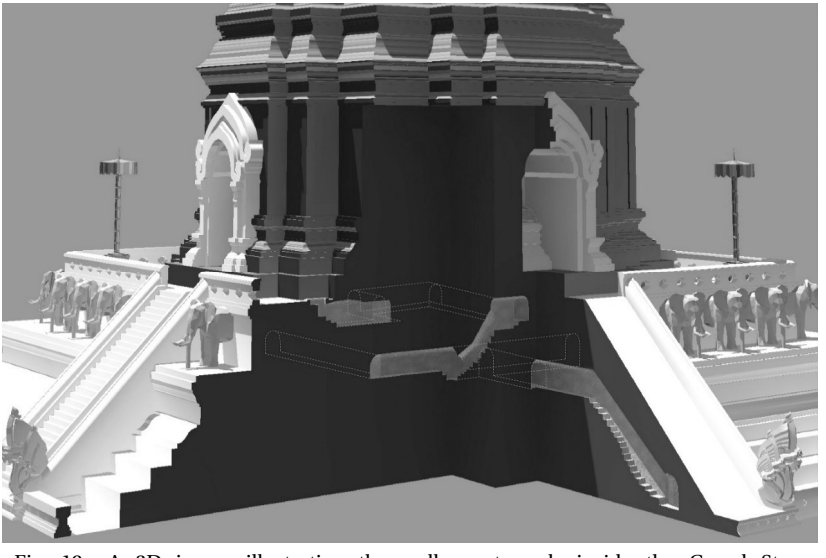
<Fig. 9> Size and proportion of point cloud images and 3D architectural models comparing the Grand Stupa of Wat Chedi Luang, the stupa of King Tilokaraj in Wat Chet Yot and the stupa of Phra Meang Ket Klao in Wat Lok Moli



<Fig. 10> Reconstruction of the pre-collapse superstructure form of the Grand Stupa of Wat Chedi Luang, employing the superstructure of the stupa of Wat Chiang Man as the basis of reconstruction



<Fig. 11> A total volume of the Grand Stupa**,** Wat Chedi Luang



<Fig. 12> A 3D image illustrating the walkway tunnels inside the Grand Stupa, Wat Chedi Luang

size of a single brick, which measures 15 cm in width, 30 cm in length, 5 cm in height and 3 kg in weight <Fig. 11>.

That is, the H-BIM model of the Grand Stupa can yield a total volume of approximately 47,000 cubic meters, which comprises 19 million bricks; its total weight is 59,000 tonnes.

Ⅵ. Cause of the great collapse

From the fieldwork, the construction of the first part of the staircase tunnel near the entrance features an elaborate work, but the inner part shows less delicacy. Walking to the deep inner tunnel enables us to clearly identify that that the tunnel's height becomes relatively low that no one can walk further. Moreover, the tunnel is not practically functional for walking up to the circumambulatory terrace above the outside of the stupa.

Thus, either assuming that the process of design and construction was not performed or the chief engineer who initiated this massive construction found difficulties due to lack of engineering knowledge and skilful experience to accomplish this unusual architecture is reasonable; thereafter, the chief engineer changed the construction plan and suspended the further construction of the tunnel.

This failure may be congruent with the political realms in the court of King Tilokaraja that mark the pressured historic event as the king forced Lampang Town to obtain the Emerald Buddha to be enshrined in Chiang Mai. King Tilokaraja might have realized that the east niches of the Grand Stupa suit to enshrine the Emerald Buddha as the latest restoration and for the elegance of the stupa. Therefore, the staircases at the east were built as a way to connect to the circumambulatory terrace. Meanwhile, other directions feature only the ramp without ladders.and thus may be the reason why

such complicated walkway tunnels were gradually ignored and finally suspended.

Another reason is that the limited engineering knowledge of the artisan in Chiang Mai had not been developed through such advancement, as opposed to the skill and sophisticated knowledge of the artisan in Bagan. That is, the Grand Stupa was unlikely durable as expected. Thus, its superstructure shook and entirely collapsed after the earthquake.

On the basis of this study, one can further assume that the reason why a heap of remains exist at the east, south and west of the Grand Stupa is because of the great collapse of its superstructure oriented southward.

Partially, the ancient chief engineer, who was in charge of following restoration, might have well recognized that a significant cause of the great collapse was the scant stability of the bases of the Grand Stupa as the alignment of the walkway tunnels.

Consequently, the further restoration of the Grand Stupa requires the strengthening of the tunnels beneath it. However, the spaces in the south, east and north are covered with rubble; the north tunnel is therefore the main way to reach the inner area of the Grand Stupa and is evidently observed as a compacted tunnel, but this process had not been finished yet or it was probably suspended by various difficulties <Fig. 12>. For example, since 1558 or 13 years after the great collapse, Chiang Mai had not been as prosperous as before for its kingdom was ruled by the royal court of the Irradwaddy Basin.

Ⅶ. Conclusion

The remarkable inspiration of a typical religious building was transmitted from Bagan to Chiang Mai. Unfortunately, the accurate

knowledge in design, calculation and construction had not been conveyed, resulting in an unused tunnel, which is an important weakness of the Grand Stupa. This defect was substantially activated by the great earthquake, causing the superstructure of the Grand Stupa to collapse in a southward direction. In their effort to restore the foundation of the Grand Stupa, it was compacted. The north tunnel became the main entrance since then as its least deterioration. Apparently, this great restoration was possibly suspended because of overload and the partially lacking freedom of the resource management from the political difficulties of the Lanna Kingdom ruled by the Burmese. This factor explains why the tunnels were incompletely compacted and the north tunnel was left, giving the authors opportunities to conduct this research further.

Above all, this article contributes the plausible reconstruction of the Grand Stupa, the Lanna's largest stupa, marking the spiritual and physical center of Chiang Mai. Despite the Grand Stupa's superstructure collapsed and resulted in the irreparable damage in 1545, employing the comparative art history, the new survey technology and the heritage building information modelling (H-BIM) arguably yield a significant reference, which other architectural heritage buildings can be applied for the purposes of conservation and reconstruction. Moreover, the outcome of this article can be applied in the architectural heritage interpretation to promote the cultural tourism in the future.

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