## International Journal of Asian Pacific

# Heritage Studies:

## Sustainable Conservation of Cultural Heritage

International Journal of Asian–Pacific Heritage Studies: Sustainable Conservation of Cultural Heritage

> 아시아-태평양 문화유산 연구: 문화유산의 지속가능한 보전

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1. Survey Research Papers on Materials and Techniques in the UNESCO Chair Programme

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## Research on Khmer Sastra in Cambodia

Research on Materials and Techniques in Asia-Pacific Regions

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#### Abstract

Transcription refers to the result of the copying process after the original Buddhist scripture is made. Among the various materials and forms, especially Pae-yeopgyeong, a palm-leaf manuscript, provides an overview of the manuscript before paper supply. Many palm-leaf manuscripts were also produced in Cambodia, but many artifacts were destroyed in the Khmer Rouge and the civil war in the late 1960s and 1970s. Even though surveys and studies to preserve them have been conducted by UNESCO and overseas institutions since the 1990s, it is difficult to find information about materials, production processes, and technologies used for making Buddhist manuscripts. In particular, the manuscripts of Cambodia were mainly produced by temple monks, and many of them were sacrificed during the Khmer Rouge, making it difficult to find specimens and preserve them. Therefore, it was deemed necessary to have a systematic record of the production process and use of materials for the continuous preservation and succession of traditional transcription. Among Cambodia's traditional manuscripts, the subject was limited to Sastra, and it was planned to investigate traditional technology and materials

through local surveys, but due to COVID-19, various materials were reviewed and compiled based on literature and Internet data. The missing information was added by examining cases from India, where the *Sastra* originated, and neighboring countries sharing the same form of Buddhist manuscripts. However, there was a limit to obtaining accurate and detailed information on various materials and tools used in the production of Sastra other than palm leaves and carving knives. Although researchers from Cambodia, local institutions, workshops, and overseas researchers were contacted and requested to provide information, no answers were received as of February 2021. It is believed that networking and co-operation with the Korean National Commission for UNESCO and other related organizations is necessary in order to advance research.

### I. Introduction

#### 1. Purpose of research

Buddhist scriptures are preserved records of sermons of the Buddha. They were handed down through generations and disseminated among Buddhists. Buddhism began in India and spread through China and Korea to Japan. This paper discusses the copying and transcription of the original scriptures. Before the use of paper became common, the sermons were transcribed on leaves and tree barks. A palm-leaf manuscript is called *Paeyeopgyeong*. The existence of the transcriptions on the leaves of the Palmyra palm tree provides evidence of the aspects of the scriptures before the paper supply.<sup>1</sup>



Figure 1. *Pae-yeopgyeong*, Academy of Buddhist Studies Dongguk University

This paper focuses on "Sastra" in Cambodia, which refers to Buddhist scriptures transcribed on palm leaves. This is one of the types of transcription that was practiced in ancient India, Cambodia, Thailand, Laos, and other Southeast Asian regions. Although it has not been confirmed that palm-leaf manuscripts were

Moon, Sun-Hee, "A study on Frontispiece of Lotus sutra(「妙法蓮華經」) copies in the Goryeo dynasty", (Master, Hongik University, 2005) p. 8.

commonly produced and there are very few artifacts reported in Korea, it is known that transcription is a long-standing tradition. Notably, in 2020, the company designated *"Sagyeongjang"* as a new category of intangible cultural assets, emphasizing the value and the importance of maintaining it. Therefore, It is believed that an understanding of the shape, materials, and method of manufacturing of palm-leaf manuscripts can be used as basic data for the conservation research on traditional transcription methods.

During the Cambodian civil war (1967-75) many ancient ruins and relics were destroyed and more than 1,000 royal palaces near the temple were looted and destroyed. In addition, the Khmer Rouge outbreak in the late 1970s killed more than a million people. At this time, intellectuals and monks were massacred, which made Cambodia's traditional crafts and techniques hard to be preserved and passed on to experts and craftsmen.

Since the 1990s, movements have been initiated to preserve and conserve traditional cultural heritages in Cambodia, and UNESCO has supported them. In the case of transcription, investigations and research were conducted by UNESCO and overseas organizations. However, it is difficult to identify the materials, the manufacturing process, and technology used in the production of *Sastra*. Since only a few monks possess the techniques of making *Sastra*, it was determined that systematic information on the process and materials of *Sastra* should be recorded for the complete preservation and succession of *Sastra*.

#### 2. Method of research

In 2020, due to COVID-19, the research team faced difficulties in conducting local surveys. Accordingly, the contents of the Cambodian *Sastra* were summarized based on the literature and online data. First, the history, cultural heritage, and various materials of Cambodia were reviewed to select a subject related to Cambodia's transcriptions. Based on the review, the theme of *"Sastra,"* which is scriptures written on palm leaves, was selected and the traditional techniques and methods were investigated.

Many studies on traditional Cambodian transcriptions such as *Kraing* and *Sastras* conducted by various research institutes and researchers were found. The researchers were asked to provide relevant data, but no answers were received as of February 2021. Therefore, most of the contents related to *Sastra* in Cambodia are composed of information obtained through online articles and organizational websites.

Contents	Detail	
Subject	Khmer <i>Sastra</i> in Cambodia	
data	May, 2020 – December, 2020	
Participant	Korea National University of Cultural Heritage,	
	Graduate School of Cultural Heritage,	
	Department of Heritage Conservation and Restoration.	
	Sang-Hyun Lee(Professor in Dept. of Heritage Conservation and Restoration)	
	Se-Hee Song, Jee-Yeon Kim(Senior Researcher)	
	Sun-Hyoung Lee, Whee-Jin Ma, Sin-A Lee, Ji-Young Lee, Soog-Young Park,	
	Sung-Jin Kim(Researcher)	

Table 1. Outline of research

Content	Detail	Subject and Method
Information for transcription	• Types of Cambodian Transcription • Types of Korean Transcription	· Subject of Study
History of the Sastra of Cambodia - National Museum of C Sastra - National Library of Ca		- National Museum of Cambodia - National Library of Cambodia
Manufacturing Process	<ul> <li>Sastra production process</li> <li>Materials and Tools</li> </ul>	<i>- Ecole française d'Extrême-Orient</i> (EFEO)
Current Research Situation	• <i>Sastras</i> Institution • Research in Cambodia • Foreign Research	• Subject of Method Literature and Online Data
Preservation Situation and Plan	• <i>Sastra</i> Preservation Status • <i>Sastra</i> Preservation Direction	

Table 2. Method of research

Time	Monthly Details	
April. 2020	Survey on Cambodian cultural heritage and selection of subjects	
May	Investigate types of Cambodian transcription and organize general information	
June	Survey of the origin and history of Sastra	
July	Survey of Sastra research institute and researcher / Request related information	
August	Investigate materials and fabrication process / Prepare interim reporting	
September	Survey on the Sagyeongjang and the trascription of Korea	
October	Investigate Sastra preservation plan	
November	Interim reporting of survey and research findings	
December	Finalize the investigation and writing the report	
Jan-Feb. 2021	Writing and submitting the report	

Table 3. Monthly schedule of research

#### 3. Range of research

Cambodia was chosen for the 2020 UNESCO Asia-Pacific Research on Traditional Materials. Although the on-site survey was not carried out due to COVID-19, subject selection and a preliminary survey on Cambodia's traditional culture were completed. As a result, the subject of Sastra in Cambodia was selected. It was found that the capital Phnom Penh (where the National Library of Cambodia is located), Angkor Wat, and Siem Reap (where the Sastra's workshop is located) are locations of research.

#### 1) Brief information on Cambodia

Cambodia (Kingdom of Cambodia) is located in the southeastern Indochina peninsula in Southeast Asia. It borders Laos in the northeast, Vietnam in the east and southeast, Thailand in the north and west, and Siam Bay in the southwest. The capital is Phnom Penh, the political, cultural, and economic center of Cambodia. Cambodia has a typical tropical monsoon climate, divided into the rainy season in mid-May and early October and the dry season in mid-October and early May. The dry season is divided into relatively cool November-February and hot March-May. Thus, many tourists usually visit Cambodia in December-January.







Figure 3. Royal arms of Cambodia



Figure 4. Geographical location of Cambodia (Source: Google Maps)

Basic Information	
Name	Kingdom of Cambodia
Location	Southeastern Indochina Peninsula in Southeast Asia.
Capital	Phnom Penh
Ethnic groups	Khmer(97%), other(Chams, Chinese etc.)
Official languages	Khmer
Official Religion	Buddhism

Government	Constitutional monarchy
	(Unitary dominant-party parliamentary elective)
	- King : Norodom Sihamoni
	- Prime Minister : Sen Hun

Table 4. Cambodia Basic Information

Cambodia is a constitutional monarchy, but the king *Norodom Sihamoni* currently plays only a symbolic role and the prime minister *Hun Sen* has been in power for a long time since 1985.



Figure 5. South Korean President *Moon, Jae-in* (right) with Cambodian Prime Minister *Hun Sen* at *Cheong Wa Dae* in Seoul on February 4, 2020. (Yonhap)

The Khmer people are the majority (97%) ethnic group in Cambodia. Most of the Khmer population is now living in Cambodia. The Khmer people also live in Thailand, Vietnam, and other parts of Cambodia. In order to avoid the civil war and genocide in Cambodia in the late 20th century, many Khmer people moved to the United States and France. The Khmer Empire (*Kambujadesa*) was a country that existed between the 9th and 15th centuries and is the predecessor of the presentday Cambodia.<sup>2</sup> In addition to the current territory of Cambodia, Kambuzha also included Thailand's northeastern region, Laos, and Vietnam. The official language of Cambodia is the Khmer language

<sup>2.</sup> Khmer Empire, Wikipedia, accessed Dec,21,2020. https://en.wikipedia.org/wiki/Khmer\_Empire

(90%) spoken by the Khmer people. The Kingdom of Cambodia, which had previously lost sovereignty to the border countries of Vietnam and Thailand, sought French protection and became France's protectorate in 1863. Since then, it was under French colonial rule (1863–1953) for about 100 years and adopted French as an official language, but today the use of English is gradually increasing.

Cambodia's official religion is Buddhism (95%). Buddhism as practiced in Cambodia has its own unique religious form. Ancient Cambodia was heavily influenced by India, and Buddhism in Cambodia is now harmonized with Indian Hinduism and indigenous beliefs. This blending of faiths can be seen in Angkor Wat, Cambodia's most famous historical site. Angkor Wat was built in the early 12th century as a temple of Brahminism, the predecessor of Hinduism, but it became a Buddhist temple when a Buddhist statue was built here. The harmony between the characteristics of Hindu temples and Buddhist temples has led to Angkor Wat's unique style. For example, Angkor Wat has a number of Buddhist statues, and the main gate of Angkor Wat temple faces west as the Hindu doctrine states that there is an afterlife in the west where the sun sets.



Figure 6. Angkor Wat



Figure 7. Buddha statues in Angkor Wat (©getty images)



Figure 8. "Monthly Cultural Heritage" June 2019 -Cambodia Preah Pitou restoration article. The Cambodian civil war destroyed many of Cambodia's ancient ruins and relics. According to UNESCO's 1982 census, more than 70% of Angkor Wat, Cambodia's most famous heritage monument site, was destroyed, and 1,000 artifacts from the royal palace near the temple were stolen and destroyed. In addition, more than 1 million people were killed in the late 1970s when the Khmer Rouge broke out. At this time, intellectuals, monks, and craftsmen were massacred and therefore, much of the knowledge about Cambodia's traditional crafts and techniques was lost.

Since the early 1990s, Cambodia has carried out about 50 projects through the Official Development Assistance (ODA) with the participation of a total of 17 countries in 2016. The most notable achievement in Korea's cultural heritage developing country cooperation project is the "Cambodian Angkor Preservation Restoration Project," which includes Cambodia's Preah Pithu temple restoration project. In addition, Korea's National Research Institute of Cultural Heritage runs an invitation training program for Asian cultural heritage preservation science(ACPCS) to strengthen and exchange expert capabilities in the field of Asian cultural heritage, and tries to exchange expertise and establish a regional network.

In the case of Angkor Wat, countries around the world are participating in the restoration project today. In 2015, 16 countries including France, Germany, and the United States participated in the restoration of Angkor Wat, and Korea was the 17th country. Efforts to restore damaged cultural assets as well as to protect fast-disappearing crafts and techniques began in Cambodia in the 1990s, and research on cultural assets and traditional crafts and materials is underway with UNESCO's support.



Figure 9. Angkor Wat Digital Restoration Map - Institute of Electronic Buddhist Text & Cultural contents, Dongguk University.



Figure 10. President Jae-in, Moon visit Angkor Wat, 2019 (*Cheong Wa Dae*)

### ${\rm I\!I}$ . Contents of research

#### 1. Traditional transcription in Korea

Before the invention of printing, religious texts were handwritten. A series of works were carried out to copy the original. This manual transcription of Buddhist teachings is called *Sagyeong*.

In Korea, it is believed that Buddhism was introduced in the second year (372), by *Goguryeo*'s king *Sosurim*. The reading of scriptures and the production of Buddhist transcription began at the same time. The oldest surviving transcription in Korea is National Treasure 196, *Silla Transcription of Avatamsaka Sutra (The Flower Garland Sutra), Zhou Version, in Ink on White Paper, Volumes 1-10 and 44-50.* It is made in the form of a scroll that is 1390.6 cm long and 29 cm wide. The account of publication reveals that a Buddhist monk named *Yeongi* started working on the print in 754, 13th year of the reign of King *Gyeongdeok* of the *Silla* dynasty, and completed in the following year.<sup>3</sup>

3. Sun-hee, Moon.,Op.Cit.,p.10



Figure 11. National Treasure No.196, Silla Transcription of Avatamsaka Sutra (The Flower Garland Sutra), Zhou Version, Ink on White Paper, Volumes 1-10 and 44-50, (Leeum, Samsung Museum of Art). (Source: Cultural Heritage Administration)

Traditional Korean Buddhist transcriptions are categorized according to the type of binding. A scroll is called *Kwonja-bon*(卷 子本) and a folding screen is called *Jeolcheop-bon*(折帖本) or *Cheopjang-bon*(帖裝本).



Figure 12. *Kwonja-bon*(卷子本), National Treasure No.210, Transcription of Amoghapasha kalparaja Sutra (Infallible Lasso's Mantra and Supernatural Transformations: King of Ritual Manuals), Silver on Indigo Paper, Volume 13, (Leeum, Samsung Museum of Art).



Figure 13. *Jeolcheop-bon*(折帖本), National Treasure No.211, Transcription of Saddharmapundarika Sutra (The Lotus Sutra), Ink on White Paper, (Horim Museum)

#### 1) Sagyeongjang (Transcription Maker)

Sagyeongjang refers to a master craftsman skilled in transcribing Buddhist scriptures. Production of the transcription consists of three main steps: transcription, illustration, and cover art. In detail, it goes through about 10 processes, including gold powder coloration, glue making, paper surface treatment, cutting, connecting, penciling, transcription, cover drawing, and surface treatment with gold powder. It requires skilled ability in calligraphy, Chinese characters, Buddhist doctrines, paintings, etc. Also, since there can be no typos in the transcription, the writing process requires a high amount of concentration and a lot of time.

In 2020, the Cultural Heritage Administration (Director Jaesook, Jeong) designated the "Sagyeongjang" as a new category of intangible cultural heritage, No. 141 and recognized Sagyeongjang Kyung-ho, Kim (born in 1963 in Seodaemun-gu, Seoul). He is a craftsman who has been working on transcription for more than 40 years. In the past, many experts participated in the production of transcriptions as a national project, but now one person, Kyung-ho, Kim, is in charge of preparing materials, transcribing, and painting. He studied the materials, forms, and contents of historical landscapes through literature and artifacts for a long time and sublimated them into technology. He was awarded the grand prize at the 1st Buddhist transcription contest held by Jogye Order in 1997, and was selected as the transmission of the Korean Traditional Transcription Skill (designated by the Ministry of Employment and Labor, No. 2010-5) in 2010. In addition, he taught lectures on transcription at various educational institutions and wrote professional books based on years of research. Kyungho, Kim is not only appreciated for his masterful reproduction of traditional transcription writing, but he is also praised for his detailed cover drawings.<sup>4</sup>

Sagyeongjang, Cultural Heritage Administration, (accessed Dec,21,2020.) http://www.heritage.go.kr/ heri/cul/culSelectDetail.do?pageNo=1\_1\_1\_1&ccbaCpno=1271101410000



Figure 14. Kyung-ho, Kim is making a transcription.

#### 2) Transcription production process and material

Production of the transcription consists of three main steps: transcription, illustration, and cover drawing. If dyeing paper is used in the transcription, dye the paper at the paper fiber stage and then dye the paper again or apply it to the surface. Afterwards, apply mucus extracted from a glue plant on the dyeing paper surface and rub the surface with jade or agate.

To improve the color of the letters, remove foreign substances from the gold and silver powders and use them for penciling in the manuscript and the cover art. As an adhesive, use a glue solution made from a croaker's air bladder. Generally, the production of the transcription is carried out in the sequence of penciling, transcription, and cover drawing. When the production work is completed, the surface of the dry gold powder is rubbed with jade or agate to improve the coloration and to help the gold powder attach more firmly to the paper by applying frictional heat.



Dying the paper with surface application method.

Applying mucus extracted from a glue plant on the dyeing paper surface (Ibid,,p. 77)





Preparing the natural glue

Mixing the gold powder with the glue



Penciling(Ibid, p. 79)

Drawing Illustration(Ibid,, p. 82)



Cover drawing(Ibid,, p.83)

Mounting-folding screen form (Ibid,, p. 87)

Table 5. The way to make a traditional Korean transcription (Source: So-Woo, Kang., "A Study on Traditional Method of Copying Buddhist Scriptures" Master,Dongguk University,2015,pp 61-100)

#### 2. Cambodian Sastra

#### 1) Types of Cambodian Traditional Manuscripts

Cambodian traditional manuscripts are written in Pali (archaism of Khmer) or Khmer and can be classified into three types: Sastra, *Vean*, and *Kraing*. *Sastra* and *Vean* are manuscripts written on palm leaves, whereas *Kraing* is a foldable manuscript written on mulberry barks.



Figure 15. Examples of Kraing, Vean, and Sastra

#### (1) Sastra (Long-format palm-leaf manuscript)

*Sastra* contains the contents of the Buddhist sutra from India and indigenous doctrines of the Indochina Peninsula and is a local sutra format that encompasses Thailand, Laos, Vietnam, and mainly Cambodia. Most were prepared by drying the leaves of Talipot palm tree (Latania palm tree; corypha lecomtei), which has been used as material for documentation since the 5th century BC in the Indian Peninsula and Southeast Asia. This method gradually spread from South Asia to other places. As it's also called ola leaf, another name for *Sastra* is ola book.



Figure 16. Corypha lecomtei (© Giuseppe Mazza)

Its dimension is about 5cm in width and 50-60cm in length. Sometimes a single leaf was used as a manuscript, but two to ten leaves were usually bound together as one *Sastra*. Multiple holes were made to tie the leaves together. The cover is made of wood to protect the manuscript and it's sometimes decorated or a wrapping cloth is used for storage.



Figure 17. Palm-leaf manuscript in Laos



Figure 18. Palm-leaf manuscript in India



Figure 19. Palm-leaf manuscript in Thailand



Figure 20. Palm-leaf manuscript in Vietnam

#### (2) Vean (Short-format Palm-leaf manuscript)

*Vean* is also a palm-leaf manuscript, but shorter than *Sastra*. It was used as a manual of ritual. The length varies from 10 cm or less to 50 cm, and the width is about 5 cm like *Sastra*.

#### (3) Kraing (paper manuscript)

*Kraing* is a manuscript of Buddhist countries in Southeast Asia in the form of folding sheets like an accordion. It can also be easily found in Cambodia, Laos, Thailand, Sri Lanka, and Myanmar. It is known as *Samut khoi/Samut thai* (สมุดข่อย/สมุดไทย) in Thailand, *Khoi* books (สะฒุดz่อย) in Laos, and *Parabaik* in Myanmar.

Snay paper, which is the material used for *Kraing*, is made from a mulberry bark called *Streblus asper* (ដីស្ថនាយ ក្ខរដាយ ក្ខរដាស). It can be black or white paper. *Kraing* is easier to make because it is written with ink rather than engraved. Unlike narrow palm leaves, it is wide enough and extends over the folds so that it can be written in large letters. Therefore, traditionally, it included drawings or patterns so that several people could read it at the same time during a ritual. There is a shortage of *Kraing* manuscripts in pagodas across Cambodia. At the time of the Khmer Rouge genocide, 80% of the pagodas were damaged, and only about 2% of the *Kraing* remain. Therefore, remaining traditional *Kraing* of the Khmer Empire are very precious.







Figure 21. Streblus asper

Figure 22, 23. Drawings in Kraing

	Sastra	Vean	Kraing
Other Names	<ul> <li>Long-format Palm-leaf</li> <li>manuscript</li> <li>Ola books</li> </ul>	· Short-format Palm-leaf manuscript	<ul> <li>Khmer Buddhist Paper manuscript</li> <li>Khmer (paper) books</li> <li>A type of folding-book manuscript</li> </ul>
Medium	<ul> <li>Palm tree leaf</li> <li>Corypha lecomtei palm tre</li> <li>Corypha umbraculifera, ta</li> <li>(Tréang in Khmer)</li> </ul>	ee lipot palm tree	• Snay paper(made of bark of mulberry tree)
Main Contents	· Religious · Secular (Edict, literature)	· Manuals of rituals	· Religious
Language	· Khmer · Pali	· Khmer · Pali	· Khmer
Location	• The National Museum • The Old Royal Library • Wat Ounalom's library	· Wat Ounalom's library	<ul> <li>National archives</li> <li>Wat Ounalom's library</li> </ul>

Table 6. Types and Distinctions of Cambodian Traditional Manuscripts

#### 2) Features of Sastra

Sastra is a copy of Buddhist scriptures on palm tree leaves and is known in Korea as *Pae-yeopgyeong*(貝葉經), *Pae-yeop* is a word from *Padara*(貝多羅), which is the sound of the Sanskrit word "Pattra", and refers to the large and thick palm leaves used to engrave the scriptures.<sup>5</sup> Although the timing is unclear, it is presumed that Sastra creation began in India after Gautama Buddha's death.

In *<sup>®</sup>Oju-yeonMun-jangjeon-sango*(五洲衍文長箋散稿)』, which was written by *Gyu-Gyeong*, *Yi,Pae-yeopgyeong* is described as follows:

我東京畿道長湍府寶鳳山華藏寺。有貝葉經。麗釋懶翁。師西域僧指空大師持來。 經長古尺半。廣四寸許。其色白。理如樺皮。厚薄如之。皆印梵字。一葉六七行。 竝蠅頭約千餘葉。穴其上下貫以紉。外挾以板。

<sup>5.</sup> So-Woo, Kang., "A Study on Traditional Method of Copying Buddhist Scriptures" Master, Dongguk University, 2015, pp 22.

"There is a *Pae-yeopgyeong* in *Hwajang* temple of *Bobong* Mountain, *Jangdan-bu*, *Gyeonggi*-do, Korea. This is the trascription brought by monk *Naong* of *Goryeo* when he returned from his visit to the monk *Jigong*. The length of the transcription is about a half with a 布尺(=15.15cm), the width of it is about four 寸(=12.12cm), its color is white, the texture of the pattern is like birch bark, and its thickness is also the same. There are six to seven lines of Sanskrit characters written on each leaf. and there are about 1,000 leaves including small-letters on."

*Pae-yeopgyeong* is commonly referred to as *Sastra* in Asian countries that do not belong to the Chinese characters culture. *Sastra* is a *Sanskrit* word commonly used in India, the Philippines, Sri Lanka, Indonesia, and the Indochina Peninsula, which means "education, knowledge, and rules". This general usage was expanded to refer to Buddhist or Hindu texts, and it also means "a transcription of scriptures (*Sastra* transcription)"



Figure 24. Pae-yeopgyeong in the University of Mississippi

The oldest surviving record of the Sastra-related literature is the *The Customs of Cambodia*(真臘風土記) by *Zhou Daguan*(周達觀,1266-1346) of *Yuan* Dynasty. Based on this, it is estimated that *Sastra* was produced in Cambodia latest by the 12th century. *Sastra* contains Buddhist scriptures from India and the doctrines peculiar to the Indochina Peninsula, and was produced in the Khmer culture that

encompasses Thailand, Laos, and Vietnam, mainly in Cambodia.<sup>6</sup>



Figure 25. The first page of The Customs of Cambodia (真臘風土記)

Sastra was produced by the monks of the *Khmer* temples and kept in the temple's library, called Pagoda, which still functions as a library today. Literary works were kept here along with various kinds of transcriptions. It is made of wood, has a multi layered roof and is also built in the middle of a small pond to protect the documents from insect damage.

In tropical climates, palm-leaves are highly vulnerable to fungi, insects, moisture, and weather. Because of this environment, the main way to preserve the Khmer scriptures was to create new copies from time to time. As a result, most of the existing Khmer transcriptions are presumed to have been produced in the 19th century, as replicas of the transcriptions that were made before them.

The transcriptions from the mid-19th century to the 20th century remain mainly in Cambodia and France. Two of the transcriptions, which are the oldest surviving Cambodian transcriptions, were produced in 1830 and are housed in the British Library.<sup>7</sup>

<sup>6.</sup> khmer sastra, Wikipedia, accessed Dec, 19, 2020., URL: https://en.wikipedia.org/wiki/Khmer\_sastra

<sup>7.</sup> NEH SASTRA KON CHAO, owned by The British Museum, is believed to have been produced around the 18th-19th century, and KACCAYANA VYAKARANA, owned by the same museum, is believed to have been produced around the 20th century.

#### 3) Conservation and research of Khmer Sastra

#### (1) Storage status

During the Cambodian civil war in the 1960s and 1970s, and the Khmer massacre, about 80% of Cambodian Pagoda libraries were destroyed and many monks died. This led to the disappearance of more than half of Khmer's legacy by 1975. The remaining Khmer scriptures are kept in various institutions around the world, including the Cambodian Pagodas, The National Library of Cambodia and the national library of France.



Figure 26. The National Library of Cambodia

Currently, the National Library of Cambodia keeps 305 manuscripts or palm-leaf scriptures, which have been recorded on microfilm.<sup>8</sup> The Cambodian National Museum holds 477 Khmer *Sastras*, made around the 19th century, which can be seen in the artifact list included.

Since the 1980s, many institutions in Cambodia and abroad have been working to preserve the Khmer scriptures for the future, with many ancient manuscripts being digitalized. However, these efforts only involve the preservation of existing Khmer scriptures, and do not address technology inheritance or preservation of the techniques of making scriptures. Through preservation,

<sup>8.</sup> National Library of Cambodia, Accessed Dec, 19, 2020., URL: https://en.wikipedia.org/wiki/National\_Library\_of\_Cambodia

the lifespan of surviving scriptures can be prolonged. However, documenting the production process and techniques used for making the scriptures can help conserve the art and craft of copying scriptures and pass them on to future generations.



Figure 27. Bra sāstrā



#### (2) Conservation Research

Research is also being conducted to preserve the Khmer Sastra in Cambodia. A representative project is the Cambodian Manuscript Publishing Fund (Fonds pour l'Édition des Manuscrits du Cambodge; hereinafter EFEO-FEMC) sponsored by the French National Institute for the Far East (EFEO-FEMC) (École française d'Extrême-Orient; hereinafter EFEO).

The EFEO-FEMC project began in 1990. It was also started based on research funding outside of Cambodia. The condition of the Khmer Sastra, which was kept in the collections of temples and archives was investigated, and a photographic investigation was conducted to obtain an image of the current Khmer Sastra. Besides, the project has been undertaken since 1993 with the support of the Cambodian royal family. It is known that the investigation was completed in 2011. As a result, all Khmer Sastra images in Cambodia were photographed and stored in digital media and restored after the photo was taken. The database of project results can still be searched on EFEO's homepage.



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According to an article from June 2019, Leng Kok-An (or Leang Kok An) is the only Cambodian who has dived into the restoration of the manuscript. He also worked as a project manager for EFEO-FEMC. Also, it is known that a small number of researchers related to EFEO are active in Cambodia as Khmer Sastra research personnel. EFEO's library is located in Wat Ounalom, Phnom Penh, and is open to researchers. The Cambodian Khmer *Sastra* conservation and research projects have been carried out in close relationship with French researchers.



Figure 31. Leang Kok An, researcher

Even before large projects such as EFEO-FEMC, the Khmer Sastra was investigated and preserved. In 1989 Cornell University conducted an investigation and preservation project for Khmer *Sastra*.<sup>9</sup> This project was carried out in a short period of over three weeks. The condition of the collections at the National Library of Cambodia and National Archives of Cambodia was investigated. The preservation was done at the National Library of Cambodia.

Institutions outside Cambodia have also contributed to the restoration of Khmer *Sastra*. In 2017, the workshop "Cultural and Textual Exchanges: The Manuscript Across Premodern Eurasia" covering basic bibliographic knowledge of Khmer *Sastra* was held at the University of Iowa, USA. This workshop was a one-time seminar funded by the Andrew W. Mellon Foundation. In this workshop, an event was held to imitate a craft for Khmer Sastra. The reproduction of the Khmer Sastra was under the guidance of Jim Canary, a Tibetan scholar and head conservator of Lily Rare Books Library of Indiana University.<sup>10</sup>

Trent Walker is a notable researcher in Buddhist studies in Southeast Asia. His doctoral thesis focuses on the function of the Cambodian ritual folding books (leporello), which is tangential to the preservation of the Khmer *Sastra*, the subject of this project. However, as part of the introduction on types of manuscripts in Cambodia, the overall survey about the origins and material forms of the Khmer *Sastra* was helpful in carrying out this project.<sup>11</sup> Besides, it seems that the field survey Trent Walker conducted was also possible due to the active support of EFEO.

<sup>9.</sup> John F. Dean, 1990, "The Preservation of Books and Manuscripts in Cambodia," in American Archivist, pp. 282-297.

<sup>10.</sup> Records of the workshop site can be found on the Melon Seminar website (https://eurasianmss.lib. uiowa.edu/tag/cambodia/). In addition, the entire photographic record is also available in the shared folder(https://www.flickr.com/photos/151901014@N05/albums/72157685556184865)

<sup>11.</sup> Trent Walker, 2018, "Unfolding Buddhism: Communal Scripts, Localized Translations, and the Work of the Dying in Cambodian Chanted Leporellos," U.C. Berkeley, Ph. D. Dissertation, pp. 22-26.

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Figure 33. *Sastra* workshop at the University of Iowa



Figure 34. Trent Walker, Researcher

#### (3) Sastra Artisans

Today, only a small number of professional artisans are trying to preserve palm-leaf manuscripts. Phoeun Phavy, a young craftswoman from Siem Reap learned her crafting skills from her father, and she has been practicing her crafting techniques since the age of 13.<sup>12</sup> She noted that her father was one of the few Cambodian artisans making palm-leaf manuscripts, and she learned the technique from him. "When I was a girl, my father taught only my brothers to keep going," she said. Traditionally, making palm-leaf manuscripts was a male-only tradition and was mainly practiced by monks. But Phavy's brothers were not interested in it, so Phavy took it upon herself to learn it and keep

<sup>12.</sup> The Phnom Penh Post article "Palm leaves preserving history", The Phnom Penh Post, (2015.11.19.), URL: https://www.phnompenhpost.com/post-weekend/palm-leaves-preserving-history

the craft alive. Phavy devoted herself to her work. When she was working in 2015, Phavy sold her manuscripts for \$250 each. However, in 2017, the Cambodian Prime Minister Hun Sen declared that to preserve her manuscript-making skills, he would buy as many copies as possible at double the price.<sup>13</sup>

Also, in December 2019, the "Phnom Penh Post" featured another manuscript craftsman, Lorth Loeng.<sup>14</sup> Loeng was also working to preserve manuscript-making skills. Like Phavy's father, he wants to pass down his skills to his children.



Figure 35. Phoeun Phavy

Figure 36. Lorth Loeng

#### 4) Production process and materials

#### (1) Sastra making process

The following Sastra production process is a capture and summary of video materials shared by Sri Lanka.<sup>15</sup> Sri Lanka is a country with Buddhist culture. It also has the tradition of creating *Kraing* and *Sastra* like Cambodia.

 <sup>&</sup>quot;Artist gets powerful patron", The Phnom Penh Post, (2017.03.02), URL: https://www.phnompenhpost. com/national/artist-gets-powerful-patron

 <sup>&</sup>quot;Preserving the ancient craft of making palm leaf manuscripts", The Phnom Penh Post, (2019.12.01.), URL: https://www.phmopenhpost.com/lifestyle-arts-culture/preseving-ancient-craft-making- palmleaf-manuscripts

https://youtu.be/IG7Nd5Y6UCE(Traditional Palm Leaf Manuscripts Preservation Project, Rangiri Technical Centre, Dambulla, Sri Lanka in 2009); https://www.youtube.com/watch?v=iAlkMkmLFPQ&fea ture=share.
#### ① Collecting palm leaves

The *Sastra* is made by carving the contents of the scripture with a carved knife on rectangular leaves of palm trees (*Corypha lecomtei*). Young leaves are preferred for this. The process is as follows. Select a tree from which leaves are to be collected, clean up the area, and hold a memorial ceremony before cutting down leaves. After the memorial ceremony, climb up the tree and cut off the branches. Wrap the cut palm branches with a clean cloth and transport them to the temple.



Corypha lecomtei tree





Cutting off the branches

Table 7. Collecting palm leaves

Transporting the branches

② Cropping palm leaves

Split the collected palm branches and divide the young leaves into appropriate sizes first. Trim the edges and vein of divided leaves to give them the same thickness, leaving only the soft part, then roll them up.



Splitting the palm branches

Trimming the edges and veins of leaves



Removed veins of leaves



Roll the leaves

Trimmed palm leaves



Palm Leaf Roll

Table 8. Preparing palm leaves

3 Boiling palm

The trimmed palm leaves are rolled up and tied into a bundle. Put the herbs (see Table 9) in a large pot of water, then put a bunch of moistened palm leaves in it, then cover it with herbs again. Move the pot over the bonfire to boil the palm leaves.



The herbs used for steaming



The rolls boiled in a por with medicinal leaves for 5 hours.

Crushing herbs



Putting the herbs

Putting rolled palm leaves on herbs



Boiling

Table 9. Boiling palm

④ Palm leaf drying and surface processing

Spread the boiled palm leaves long and dry them in a cool place for 7-8 days. When the leaves are dry, two people must hold both ends of each leaf and rub it against a wooden post to smooth out the surface.



Drying the stretched leaves in a cool place



Surface processing

Table 10. drying and surface processing

#### ⑤ Cutting

Cut the dried leaves into appropriate lengths and overlap 50-100 palm leaves between the wooden boards. While the overlapping palm leaves are firmly fixed, the part that is taller than the wooden board is trimmed with a knife to adjust the size. The edges of leaves are trimmed with heated iron to form a *Sastra* shape. Finally, perforate one or more holes in the palm leaves after edge arrangement.



Cutting the leaves



Heating the iron





Arranging the leaves

Perforating holes

Table 11. Cutting

<sup>(6)</sup> Engraving letters

On the leaves of the palm trees that are ready, use a carving knife to engrave letters. A wooden stylus with a metal nib (*Dek Char*) is heated over the fire to engrave. After carving, apply black ink and oil so that the color sticks. Finally, rub rice bran on the surface to remove the remaining ink.



**Engraving letters** 



Applying the ink

Applying the oil



Rubbing the rice bran

Completion of engraving

Table 12. Engraving



Figure 37. Engraving stylus<sup>16</sup> (*Ghantam, Dek Char*)

The stylus for carving comes in many forms. In the basic shape, the front side is easy to move on the leaf. Wood with metal nibs is called *Ghantam* (writing stylus, *Dek Char*). It is made of copper or silver, and has decorative uses.

#### Binding

The palm leaves that have been engraved are tied together with a wooden board. Fasten one side by passing a cotton string through a pre-made hole. Wooden board may have decorations, and may be stored with a wrapping cloth for protection.



Tying With Cotton Strings



Completed Sastra





Decorated wooden board

various sizes of Sastra

Table 13. Binding

### II. Conclusion

#### 1. Results

Cambodia is a Buddhist country with a Buddhist majority. Its culture is deeply connected with numerous temple traditions and Buddhist scriptures are an important part of its cultural heritage. Various forms of Buddhist scriptures have been preserved to this day. Most of the scriptures in Cambodia are written in Pali (predecessor of Khemer) or Khmer, and are classified into palmleaf manuscripts (Sastra, Vean) and paper manuscripts (Kraing) depending on the material and shape.

However, during the civil war in the 1960s and 70s, many heritage monuments, relics, and scriptures were destroyed. Many of the monks who had traditionally made scriptures were killed or injured, as a result of which the knowledge of scripturemaking was largely lost. Like other types of transcriptions, Sastra is an important cultural property that can explain the history and culture of Cambodian Buddhism, and it was determined that more research was needed for documenting the techniques used for production of Sastra. This study aimed to investigate and document the complete production method of Cambodian Sastra. However, due to COVID-19, the most important field investigation was not carried out. The relevant data were collected and organized based on various literature, research papers, and online resources. Basic information on the types, production methods and materials, and conservation status of the Cambodian traditional manuscripts, studied by Cambodia, France and the United States, was obtained. Furthermore, missing information was added by examining cases from India where the Sastra originated and from neighboring countries sharing the same form of Buddhist manuscripts. In particular, for the Sastra production process and technologies, some video materials shared by Sri Lanka were referred. However, information on materials and tools

other than palm leaves and carving knives that were used for making scriptures could not be acquired.

#### 2. Future research plan

The research and conservation of Sastra in Cambodia is led by the National Library of Cambodia and the French Institute of East Asia (École française d'Extrême-Orient, EFEO). Traditional workshops to preserve the Sastra have also been conducted in Cambodia. Interviews and information were requested from local Cambodian institutions, workshops, and overseas researchers working on Sastra, but no answers were received until February 2021. Therefore, networking and co-operation between institutions such as the Center for International Exchange and Cooperation; Korea National University of Traditional Culture; Korean National Commission for UNESCO; Asia-Pacific Intangible Heritage Center in Jeonju, Korea; and Cambodian National Commission for UNESCO to continue preliminary research in Korea is necessary considering that field work is not possible presently. Through this measure, it is expected that detailed and accurate data on various materials and tools used in the production process can be collected and recorded as basic data for the conservation of Sastra.



Figure 38. Networking through domestic institutions

#### 3. Application plan

Currently in Cambodia, research on the conservation of cultural properties and traditional crafts and material is being conducted with the support of UNESCO and other advanced countries. However, it is difficult to identify production materials, methods, and techniques used in *Sastra* making, because only few monks know the method of making *Sastra*. Therefore, the documentation of the entire production knowledge is required for conservation and passing down the knowledge to future generations.

Meanwhile, the palm-leaf manuscript, which is called *Pae-yeopgyeong*, is owned by *Beopheungsa* Temple in *Yeongwol* and *Donghwasa* Temple in *Daegu*. The information of these transcriptions can be seen on the temple's website and the Encyclopedia Folk Culture of Korea, but the status of the relics and the status of conservation cannot be found.

If research is continued in the future, it can be helpful in gaining more insights into the craft of making and conserving *Pae-yeopgyeong*. This could also lead to cultural exchanges between Korea and Cambodia, as well as exchanges of conservation and restoration techniques of paper-based cultural properties. In addition to this, it is believed that such conservation methods can be used as reference material for research on the conservation plan of two pieces of *Pae-yeopgyeong* (in *Beopheungsa* Temple in *Yeongwol* and in *Donghwasa* Temple in *Daegu*) in Korea.

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Figure 39. Pae-yeopgyeong in Donghwasa Temple information

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## Scientific Analysis & Survey of Conservation Materials for Stone Cultural Heritage in Cambodia

Research on Materials and Techniques in Asia-Pacific Regions

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#### Abstract

In this study, the preservation treatment status of Angkor Wat, Terrace of the Elephants, and Preah Pithu in Cambodia was investigated to check the traditional preservation treatment materials and application techniques of stone cultural properties, and to find out the domestic preservation treatment materials and application techniques.

The rocks that make up the stone cultural properties of Angkor monuments are identified as sandstone and laterite. Among the sandstone types, gray-yellow sandstone is the most common sandstone in the Angkor sites, while red sandstone and green mixed sandstone have been used in some of the ruins. The laterite in Angkor sites was mainly used in the packaging of foundation stones (surfaces and interior), peripheral columns, and floor surfaces, and is divided into two types: porous laterite and duolith laterite, based on rock-based materials.

Angkor Wat was composed of gray-brown Mesozoic sandstone, and weathering was carried out by contour delamination; structural, multi-layer delamination; follicle delamination; and cortex. No damage by trees was found, but cracks by biological weathering were identified. Bulging, delamination, and globular decomposition has been identified in Terrace of the Elephants. There is no visible serious biological damage, and rather, it is judged that the direct sunlight prevents biological growth. The Prea Pithu is mostly made up of gray sandstone, and a few parts are mixed red and green sandstone. Gray sandstone has developed a linear structure that is clearly visible to the naked eye, and stratum delamination and globular decomposition have been confirmed.

Scientific analysis suggests that sandstone weathering at Angkor Wat is due to environmental factors such as the rainy-dry cycle and water-soluble salts from guano of bats.

The movement to preserve Angkor monuments began in 1907 at the French Far Eastern Academy (EFEO) in Cambodia, and countries and institutions such as Germany (GACP) and Japan (JSA) participated in the restoration of Angkor sites and other temples.

Out of the 517 state-designated stone cultural properties, 21 (80.4%) are located in Korea. Scientific surveys such as petrological surveys and evaluation of the application of preservation treatment agents were conducted in the Yeongyaong area where many sandstone stone cultural properties are distributed.

The adhesives and fillers used for cracks in domestic stone cultural properties are mainly epoxy resin. However, since epoxy resin is vulnerable to ultraviolet rays and may cause yellow dust caused by photothermal heat, the National Institute of Cultural Heritage and Punglim Industries Inc. have developed and used L-30, L-40, and L-50 to resolve this problem. On the other hand, reinforcement and water treatment for stone cultural properties has been steadily attempted since the late 1980s, but currently, verification of their effects has been difficult and passive in processing them.

There are various methods of scientific investigation of stone cultural properties in Korea, but they can be largely classified into provenance study of stone, weathering diagnosis, and conservation environment investigation. For the effective repair and restoration of stone cultural properties, it is important to use rocks similar to the original rocks based on systematic and scientific techniques, and therefore a provenance study of stones is conducted. Methods for estimation of provenances include geological surveys such as magnetic susceptibility measurement and gamma spectrometer analysis, X-ray diffraction analysis, and compositional mineral analysis such as polarized light microscopy. The weathering diagnosis is an important guideline for establishing directions and methods for weathering diagnosis and conservation treatment by checking the weathering and damage status of stone cultural properties. Weathering damage maps, hyperspectral imaging (hyperspectrum), infrared thermal imaging analysis, eco-tip hardness measurement, ultrasonic measurement, colorimetric measurement, and observation of stereoscopic microscope and scanning electron microscope are used. The conservation environment survey shall serve as an important basis for creating or improving the environment for the preservation and management of stone cultural heritages. It measures the climate environment such as temperature, humidity, air pollutant concentration, and comprehensive weather environment.

Keywords

stone monuments in Cambodia, Angkor sites, sandstone, laterite, conservation material, conservation technique

## I. Introduction

The stone cultural heritage of the Angkor region of Cambodia is a very important Southeast Asian site along with the sites in Myanmar. Angkor Wat in the Angkor region was built between 1113 and 1150 by Surya Barman II. The 12th century Khmer architects used sandstone, not brick or Laterite, as their main building material, and laterite was used for outer walls and hidden structures (Kim, 2012). The Preah Pithu is presumed to have been built by early researchers in the early 12th century like Angkor Wat (Park et al., 2017).

Stone cultural properties made of rock are exposed to the elements and are weakened by weathering that occurs over centuries. Therefore, damaged members are extensively preserved and restored in traditional ways using a variety of materials and techniques. In the case of Angkor Wat, large areas were cleaned in the 1990s, and acrylic resin (polymethyl methacrylate) was applied to the surface. As a result, moisture blocking caused softening of the stone layer behind the acrylic resin or delamination of the surface near the stone layer, and the acrylic resin applied to the stone surface was discolored from gray to gray in appearance (APSARA Stone Conservation Unit, 2011). The Preah Pithu is also reported to have undergone three emergency and simple restorations around 1920 (Warrack, 2013). Preservation treatment materials were used in various of these areas until recently, and surface reinforcement agents of polymers was used a lot in the 2000s. Reinforcement agents used for various purposes are widely used on the surface of the stone, which should also be similar to the main ingredients of the stone and increase its physical strength by increasing its responsiveness. Therefore, the various types of rocks that make up the local masonry heritage must be identified and the appropriate preservation treatment materials must be selected, and the technology and process must vary depending on the current state of the masonry (APSARA Stone Conservation Unit, 2011).

After the emergency restoration or preservation in 1920, further preservation projects were carried out at stone cultural properties in Cambodia's Angkor region and various preservation and restoration materials and technologies were applied. However, comprehensive survey data on actual application and use cases have not been established. Therefore, through information exchange with the head of APSARA and advanced countries, we will investigate materials and technologies that were used for preservation and restoration of the stone cultural properties, collect and analyze materials to secure basic data for building a comprehensive database, and prepare systematic data for preservation of stone cultural properties in Cambodia.

# II. The Preservation Process of Stone Cultural Properties in Cambodia

#### 1. Status of Historic Sites

Cambodia is the official name of the State of Cambodia and its capital is Pnompenh. It has an area of 181,035 square kilometers and a population of 15,708,756 (2015). The official language is Khmer, the ethnic group consists of the Khmer people (90%), the Chinese (5%), and others (5%), and 95% of the people follow Buddhism. The Unification Kingdom of Kampucia was established in the 6th century, and the Angkor Kingdom flourished from the 9th century (Korean National Culture Department, Korean Studies Central Institute). Located on the Indochina Peninsula with Vietnam, Thailand, Laos, and Myanmar, Cambodia has long been registered by neighboring countries and was also ruled by France for almost a century (Kim, 2012).

Angkor sites are a major legacy of the former Khmer Empire, located in the Siem Lip province of Cambodia, in a region called Angkor Tom, which is home to a relatively large number of Angkor sites, including Terrace of the Elephants and Preah Pithu. Angkor Wat is located about 1.5 km from Angkor Tom. In the 1970s and 1980s, Angkor sites were in serious danger due to internal unrest in Cambodia. They remained defenseless from theft and looting, and in many areas, serious damage such as collapse occurred due to natural erosion. After internal stability was restored, the Cambodian government called on the international community to rescue the Angkor sites, which led to the launch of the international campaign "Save Angkor." From that point onwards, the international community began working together to protect Angkor sites (Park and Shin, 2014).

#### 1) Detailed status of the sites

#### (1) Angkor Wat

It is located about 1.5 km south of Angkor Tom and was built in the early 12th century. Angkor means "wangdo" and Wat means "temples." At that time, the Khmer people believed that if the king and the royal family died, the king would unite with the god he believed in. Thus, it was a custom for the king to build a temple of God. Suriah Barman II, who ruled during the heyday of the Angkor dynasty, built a temple to unite with Vishnu. As later on Buddhists destroyed the sacred image of Baramoonism and enshrined the Buddha statue, the temple came to be known as a Buddhist temple, but it follows the style of Baramoonism in all aspects, including buildings, decorations, and relief (Doopedia, 2020).



Figure 1. Location map of Cambodia's Angkor Wat and Terrace of the Elephants (Google Maps).

#### 2) Main composition of the Angkor Wat

The rocks used in the Angkor sites are sandstone and laterite, and the use of bricks is confirmed in relatively early sites built in the 9th and 10th centuries. Since the survey of compositional rocks across the site in the late 1990s, studies have been conducted to identify weathering conditions and detailed material properties. The characteristics of the local rock were summarized in the research conducted by Etsuo Uchida et al. at Waseda University in Japan.

#### (1) Sandstone

Sand stone is a natural stone made of spherical or polygonal material particles or rock fragments. A million years ago, the particles were separated, transported, deposited, and finally compressed into natural stones. The sandstone contains several sizes of quartz particles ranging from 0.063-2 mm, and the stratum, an array of layers of rock components, is the result of the deposition process. The quartz is the main component of sandstone and is resistant to weathering and is relatively stable. Thus, quartz particles can fall from the parent rock without being destroyed during the sandstone generation process. Other particles are also compressed and joined by natural binders such as clay and lime. In addition to quartz, feldspar, clay minerals, brightly lit white clouds, green rust stone, red iron stone (Fe2O3), and colored iron compounds such as chaffstone (FeOOH) can be present in sandstone.

Sandstone is divided into four main types, depending on the mineral composition.

Quartz arenite (or quartz arenite) is a sandstone composed of more than 95% quartz. Feldspar sandstone is a sandstone composed of more than 10% feldspar, and litharentie is a rock sandstone containing more than 25% disintegrated volcanic rock fragments. Greywacke is a sandstone containing at least 15% of the separate substrate consisting of rusty stone, cotton wool, siltsized quartz, and feldspar. In Uchida et al., the sandstone used in the Angkor sites was divided into three types, depending on color, compositional minerals, and organization:

The grey to yellowish brown sandstone is the most common sandstone in the Angkor sites. The red sandstone was used in the Banteay Srei, and was partly used in the south and north of Khleangs. Greenish greywacke was used only in the sanctuary of Takeo.





Figure 3. Major compositional minerals of Angkor sites (Panchuk, 2018).

1 Grey to yellowish brown sandstone: feldspar sandstone

Gray-yellow sandstone was used in all parts except Banteay Srei. This sandstone exhibits a variety of colors ranging from gray to tan. Color diversity is particularly evident only in historical sites that date back to the late 12th century. Lamina structures (such as very thin, flat plates or layers) are commonly observed. Grayyellow sandstone consists of septum or neutral (0.1-0.3 mm) quartz, feldspar (bossstone or alkali feldspar), black cloud wool, pomegranate (garnet), greenstone (epidote), zircon, and electric stone (tumalin). Clavitic particles have angular edges, subaccharide or classification, and correspond to feldspar sandstone. Black and white clouds have preferential orientation (a relatively large aggregation of small crystals parallel to their split surfaces), which is one of the causes of weathering of sandstone. Black clouds tend to change into rust and sedimentary stones. The yellowish-brown color of sandstone is indicated by the sedimentary stone.

When this type of sandstone is represented, dark colors are distributed along a constant line. This indicates that gray sandstone has changed to tan sandstone as the presence of black clouds causes the fresh grey sandstone to turn greenish. Therefore, tan sandstone is presumed to have the same origin as gray sandstone.

The metabolic rate of gray-yellow sandstone was measured. Based on the results, the rocks on the site, excluding those in Banteay Srei, were divided into eight groups. This indicates the possibility that the rocks were sourced from different quarries at different periods of time.

The stones in Ta Prohm, Preah Khan, and Banteay Kdei are believed to have been sourced from two different quarries.

#### 2 Red sandstone: quartz sandstone

The red sandstone is red-yellow. It consists mainly of serrated quartz with a diameter of 0.1-0.2 mm and a small amount of rock (mainly chit), which corresponds to quartzite sandstone. The corners of the clavicle particles are rounded and well-classified. Serip's red and yellow iron stones spread small cracks in the clavitic particles. The color of red sandstone is attributed to red ironstone. Additionally, the caolinite was identified by the XRD analysis. It was observed that to the south of Khleang, columns and door frames consisting of red sandstone were gradually changing from red to yellow. The yellowishred part contains a small amount of sediment instead of red iron. The red sandstone does not exhibit weathering patterns; therefore, the relief carved in red sandstone was well-preserved.

#### 3 Greenish greywacke

Green miscellaneous rocks were used only in the sanctuary of Takeo, and are particularly characterized by higher hardness than other sandstones. No relief has been identified above the green miscellaneous rock, apparently due to the hardness of the rock. No particular weathering pattern appears. Green miscellaneous rock consists mainly of feldspar (boss stone, alkali feldspar), quartz, rock fragments, black cloud cap, and white cloud cap. Clavitic particles have angular edges and are poorly classified (<0.5mm). Green miscellaneous rock is a rock-based miscellaneous rock.

#### (2) Laterite

The laterite of Angkor sites was mainly used in the packaging of foundation stones (surfaces and interior), peripheral columns, and floor surfaces. Laterite is a type of sedimentary rock formed by long-lasting rock weathering processes in tropical climates with high temperatures and high precipitation. As the moiety is continuously deposited by the superiority, the elimination of minerals and the dissolution of the elements, such as Fe or Al, are left in the rock. Typical laterites have large voids that occur as a result of the weathering process in which rock components are removed. The main minerals of the Angkor sites, are laterite, are sediment, red iron, gale, and quartz, formed by the weathering of sandstone and conglomerates. The distinctive dark coloration of red-brown is attributed to the double-tipped iron ore (yellow), red iron ore (red), and its content. The fresh laterite of the quarry is low in hardness and easy to process, but it starts to harden as it dries after being collected from the surface.

The laterites of Angkor sites are divided into two types, the porous laterites and the pisolitic laterites, based on the rock-geometric tissue. Porous laterite has huge voids of several centimeters on the surface. These voids were originally filled with old stones, but they are presumed to have been washed away by rainwater. Duolith laterite consists mainly of two stones with a diameter of 5-10 mm (a spherical crystalline particle with a diameter of more than 2 mm), and is relatively homogeneous compared to porous laterite. Typical DuSeok laterite is found in the base stone of the Takeo. There are also laterites with intermediate tissues of porous and dusolated laterites. Both stones are also found in porous laterites, and gravel is commonly observed in both types of laterites.





**Pisolitic laterite** 

Figure 4. Laterite of Angkor Wat.

Porous laterite

Style	Period	Monument	Used sandstone	Magnetic suscept. (10 <sup>-3</sup> SI Unit)	Bedding plane (vertical%)
Preah Ko style	last quarter of the 9th cent.	Preah Ko(879)	g. to y. brown ss."	1.71(0.84)	40
120355040225555		Bakong (881)		1.97(1.11)	26
		Lolei (893)		2.12(1.19)	
Bakheng style	end of the 9 <sup>th</sup> cent. to early 10 <sup>th</sup> cent.	Phnoe Bok	g. to y. brown ss.	5.97(3.91)	53
		Phnos Bakheng		5.64(4.48)	48
		Phnom Krom		4.52(1.93)	>50
		Prasat Kravan(921)		2.99(0.99)	
transitional stage	t second quarter of the 10 <sup>th</sup> cent.	Baksei Chamkrong	g. to y. brown ss.	2.53(0.93)	
		East Mebon (952)		2.62(1.43)	45
		Pre Rup(961)		2.20(0.81)	46
Banteay Srei style	late 10th cent.	Banteay Srei(967)	red ss.	0.10(0.04)	
Khleang style	end of the 10th	North Khleang	g. to y. brown ss.	1.51(0.45)	47
	cent. to early 11 <sup>th</sup> cent.		red ss.	0.08(0.04)	
1		Ta Keo	g. to y. brown ss.	1.56(0.67)	40
			greenish greywacke	0.16(0.06)	
		South Khleang	g. to y. brown ss.	2.01(1.25)	47
			red ss.	0.09(0.04)	
ALCONTRACTOR AND A		Phineanakas	g. to y. brown ss.	2.23(0.92)	32
Baphuon style	middle to late 11" cent.	Baphuon	g. to y. brown ss.	1.84(1.02)	47
		West Mebon		1.60(1.17)	33
Angkor Wat style	end of the 11" cent to early 12" cent.	Angkor Wat	g. to y. brown ss.	3.68(1.26)	8
		Thomanon		3.07(1.41)	11
		Banteay Samre		3.47(1.56)	9
Bayon style	second half of the 12 <sup>th</sup> cent. to early 13 <sup>th</sup> cent.	Prasat Suor Prat		3.29(1.21)	
		Ta Prohm(1186)	1	2.47(1.45)	12
		Preah Khan(1191)	1	1.83(1.33)	6
1		Banteay Kdei	g. to y. brown ss.	1.66(1.33)	9
		Entry Towers of Angkor Thom		0.88(0.69)	
		Bayon (1st stage) (2nd stage) (3rd stage)		0.84(0.48)	
				1.21(0.48)	
9				1.57(1.03)	7
		(4th stage)		2.23(1.43)	8
2		Terrace of the Elephants		1.89(0.99)	6
		Terrace of the Leper King		2.02(1.16)	

\*grey to yellowish brown sandstone \*\*1 $\sigma$  standard deviation in parentheses

Table 1. Average magnetic susceptibility of sandstone by historical site (Uchida et al., 1999)

#### 3) Preservation status by historical site

#### (1) Angkor Wat

The stone used in Angkor Wat's architecture is a gray-to-yellow mesozoic sandstone. Rock and geochemical studies have shown that they were quarried at the foot of Mount Phnom Kulen, about 40 km from Angkorwat. There are also laterite bricks beneath the base and central surface of the temple, and they are stacked without mortar or other fillers. Many of the rhombus' surfaces have weathered, and the weathering still continues. In particular, rapid deterioration and weather conditions were observed in more than 350 statues of the goddess Absara. The weathering of Angkor Wat is largely physical, chemical, and biological.

The types of physical weathering found in Angkor Wat can be divided into contour delamination, structural multilayer delamination, and follicular delamination. Contour scalings occur at the interface of the rigid area of the stone and are parallel to the surface of the stone. If the surface is flat, the contour peel is also called spalling. Angkor Wat's outline is a few millimeters to a few centimeters long. Many of the buildings already have empty sounds or missing when walls and aids are separated and tapped. Structural multi-layer delamination (Exfoliation) is a phenomenon in which several thin layers (several centimeters) are separated almost parallel to the stone surface, and the layer is bent like an overloaded bookshelf. In Angkor Wat, this phenomenon is found in some sandstone with layers parallel to the rock surface, and most of these sandstone bricks are horizontal. Splitting is a crack that is formed along a stratum plane due to a load caused by fine cracks or penetration cracks along a weak plane, such as clay or mass, when the components of a structure are vertically located. In Angkor Wat, it occurs in thin structures like a gate pole or a pillar. Follicular peel refers to the occurrence of a thin plane or curved scale-shaped peel of mm thickness, arranged like fish scales. In Angkor Wat, multiple layers of peeling occur parallel to the surface

of the stone. This is a phenomenon in which delamination occurs again on the already delaminated surface.

A crust is a deposit that is tightly bonded to the surface of a stone, usually containing a deposit attached to the surface. An external deposit combined with the material from the stone is also included. Although the cortex is mainly dark (black) in color, it also appears bright and has uniform thickness, which can be similar to the surface of the stone or uneven in appearance, preventing interpretation of the surface of the stone. Depending on the amount of pollutants in the atmosphere, it may appear bright or dark. Bright cortices are often found on the round ceiling of the Angkor Wat corridor, and sometimes they appear at the top of the wall. The shape of the cortex on the wall indicates the amount of water flowing or falling. In some ways, there are some cases where the cortex occurs.



Figure 5. Sketch of the weathering zone in Angkor Wat main space.

Efflorescence and subflorescence are frequently observed in areas where weathering occurs, such as temple delamination. External crystals are crystals formed in the shape of a white powder or bed on the surface; they are generally weakly adhesive and consist of soluble salts. In the case of internal crystalline salt, it indicates the presence of salt crystals inside the stone. In Angkor Wat, sediments of external and internal crystals are observed not only on the back of the delamination area, but also among the small pieces that have undergone delamination.

Unlike other temples, Angkor Wat does not have deterioration caused by the growth of trees over centuries. However, biological colonization occurs frequently on sandstone surfaces by microbes such as moss, algae, fungi, bacteria, and cyanobacteria. These biological settlements can also cause cracks due to changes in temperature and humidity. Artificial weathering of stone was carried out in some sections of Angkor Wat due to artificial influences such as civil war. In addition, cracks due to structural causes are occurring in certain areas where structural stress is applied.

#### (2) Preah Pithu

The sandstone of the Preah Pithu is the most common gray sandstone found in the Angkor sites, with a rare mixture of red and green sandstone. Gray sandstone has developed a line structure that is clearly visible to the naked eye. Usually, stone with advanced line structure is somewhat restricted to be used as a building material due to structural vulnerabilities. However, it is interesting that the sandstone stone used in the Preah Pithu does not show the intended consistency between the laminar and stress directions. Gray sandstone is usually composed of serif or neutral quartz particles, but it varies widely in elevation, protuberance, rock content, confluence minerals, minerals, and chemical composition. Red yellow sandstone has constant guartz particles around 0.1 mm in diameter, and SiO2 accounts for most of its composition at approximately 90 wt%. The quartz particles are filled with kaolinite. The properties of green sandstone are different from the previously described grey sandstone and greenand-yellow sandstone. It is close to the mineral composition of the Wake. The diversity of sandstone stone at the Preah Pithu encompasses all the stone materials used in the main temples of the 9th and 14th centuries in the Angkor region, and the quarry also exhibits extensive locality (Kim, 2017).

Temple T consists of a sanctuary, a wall, and a terrace, where outer members were pushed outward due to which the appearance was completely relaxed and distorted. The fence was partially restored by the French EFEO, but it is still unstable due to severe deformation of Gopura. The sanctuary exhibits the departure of the stone from the base, and the crisscrossed central sanctuary is particularly cracked and worn, with globular decomposition and delamination of the stone (Kim, 2019).

There is a partial collapse in Temple U in the central sanctuary and the remaining stone is severely loosened. The stone was placed in an unbalanced state, resulting in cracks and delamination due to concentrated loads. Temple X is built on a large base and looks stable overall, but the base edge stones are slightly pushed outward, and cracks, isolation, and crushing are observed. Most of the corners were reinforced with concrete by the French EFEO, but the mating faces are often separated, requiring re-preservation treatment (Kim, 2019).

Temple V is not mechanically damaged, but there is relaxation and damage to the central sanctuary stones. In particular, corner members have been reinforced with concrete, but they seem to require re-repair. Temple Y is constructed on a higher ground than the surrounding area, with members leaning disproportionately, with a large amount of cracks and crushing. Physical damage is more advanced than in the other employee sanctuary, and a thorough investigation of the cause of damage and ground stability is required (Kim, 2019).

If the damage status is divided into physical damage, chemical damage, and biological damage, the Preah Pithu has the most significant physical damage. Cracks, crushing, loss, separation, delamination, and changes to characteristics of the stone itself due to structural problems or mechanical damage (such as wood conduction) are major damage phenomena. In addition, the hollow characteristics of the stone, the elution of the compositional components, and the inflow of salt components caused the stone to break apart into a powder. This major damage is rarely found in red and green sandstone and is mostly found in gray sandstone. Red yellow sandstone appears to be relatively resistant to natural weathering due to its high quartz content, and green sandstone is also believed to have shown similar resistance to weathering. Unlike neighboring Bayon and Angkor Wat, Preah Pithu had a high rate of bio-clothing in stone because the fabric of plants had an advantageous environment surrounded by trees and moats (Kim, 2019).

#### 2. Scientific analysis and preservation treatment of local rocks

#### 1) Scientific analysis of Angkor Wat stone

#### (1) A Study on the Weathering Aspects of Laterite

A study of the production technique of laterite, one of the main composition rocks of Angkor Wat ruins, aimed to investigate laterite in Laos, Hongnangshida temple, and the nearby laterite quarry.

Laterite at the Hongnangshida temple was observed to have red discoloration in the voids caused by iron oxide. The periphery of the pore consists of yellow clay, which is caused by deposits of yellow soil material in the pore. The XRD analysis confirms kaolinite, quartz, and goethite, with the highest sensitivity of quartz compared to Wat Pu temple and quartz quarries. The laterite of Wat Pu temple in Laos is Hongnangshi. Microstructures similar to the laterite of the temple are observed. The XRD analysis confirms kaolinite, quartz, and goethite. Laterite recovered from a nearby quarry had partial red-black appearances of porous or mineral materials, and the elution of quartz and the cohesion of iron oxides were under way. The volume ratio is 2.4 to 2.6 which is higher than that of Wat Pu temple and the Hongnangshida laterite. An XRD analysis identified kaolinite, quartz, and goethite. The black discoloration of the laterite shows a low sensitivity of quartz and goethite as the main prize. For red discoloration, quartz appears high, goethite is low, and hematite has higher sensitivity. As a result of analysis of the amount of concentration, weight reduction and absorption reactions are common near 300°C. The weight reduction rate was the highest at 14% for quarry laterite. The red discoloration has a low weight reduction rate of about 7%. The weight reduction and absorption reaction and weight reduction occur near 510°C and 550°C. The component analysis showed that Fe is higher for discoloration, black discoloration is higher, and Si is less than red discoloration.

#### (2) Analysis of weathering factors of sandstone

Angkor Wat's climate is tropical with rainy and dry seasons. The average monthly relative humidity is about 75% during the dry season and 80–90% during the rainy season. The average monthly temperature is above 20°C throughout the year and rises to 30° C during the rainy season. Open galleries and towers have been providing habitat for countless bats for centuries, and their feces have formed thick guano layers on the floor in the past. Even if the floor is cleaned frequently, some temples can smell strong.



Figure 6. Ultrasonic Detection.



Figure 7. Drilling resistance measurement point.

The expansion perpendicular to the layer was always higher than the expansion rate parallel to the layer. The difference in data between samples is explained by the difference in content and size of function silicates such as monmorillonite. When we look at the ultrasonic velocity graph measuring up to 1.5 m high at the bottom of the column, we show that the ultrasonic velocity decreased significantly at a height of 0.35 to 0.4 m perpendicular to the layer. The drilling resistance measurement was performed by dividing the measurement points, and the values of the structurally stable and unstable parts differ. The isotope analysis showed that the most likely cause of soluble salts in Angkor Wat's classification is leaching of bat guano by rainwater and condensation during the rainy season. In some parts of the building, expansion during wetting and contraction during drying causes stress on the sandstone structure, causing cracks from the end, and cracks along the stratum due to anisotropic behavior. The difference in drying time between the surface and the inside of the stone creates shear stress, causing the stone to expand, leading to contour scaling. This weathering occurs even without the action of salt. According to these findings, the most common causes of sandstone weathering in Angkor Wat temples are environmental factors caused by the rainy-dry cycle and water-soluble salts from bat guano.

#### (3) Biological Damages

Two Angkor Wat temples exposed to different environments were examined for visible biological damage. Looking at one prior study, NIr showed extensive green algae cell distribution between substrates, with an average penetration depth of 0.26 mm. N2b confirms physical decomposition of substrate. Cyanobacteria cell infiltration was observed. Aluminum, iron, and silicon were detected due to chelate activity of microorganisms. N3b, N3a, and K3c showed three moss communities: Leprarietum, Cryptothecietum, and Pyxinetum.



Figure 8. Biological group studied in the research.



Figure 9. Comparative analysis of each biological group.

N4 m is presumed to be a moss of the genus Fissidens. Physical weathering caused by moss roots was observed, and a penetration depth of about 2.46 mm was measured. Comparative analysis showed penetration, diffusion area, and cohesion. N4m has the highest penetration depth, cohesion, and diffusion in the stone, and N1r showed relatively low results.

The author argued that the surrounding climate should be stabilized for better preservation of Angkor Wat stone monuments.

Such stabilization, which would be carried out considering the ecological impact on the community, would prevent the negative effects of overheating and ventilation and also prevent the growth of certain organisms in the temple rocks.

#### 2) Trends in preservation process by country (by institution)

The move to preserve the Angkor Wat ruins began in 1907 at the French Far Eastern Academy (École française d'Extrême-Orient [EFEO]), which was established in Cambodia by the French government. The EFEO conducted the excavation, research, and conservation of Angkor Wat, but the project was halted in 1975 due to the civil war in Cambodia. The project was resumed in 1992 after the end of the civil war, and Angkor Wat was listed as a UNESCO World Heritage Site. In 2004, it was excluded from the list of endangered World Heritage Sites, and the Angkor Charter was enacted in 2012.

#### (1) France (EFEO)

In 1389, the Kingdom of Angkor was defeated by its rival Dai. French explorers in the 19th century rediscovered the ancient city that was almost forgotten. In 1907, the Far Eastern Research Society of France first started the restoration of the ruins of Angkor. Their work continued after Cambodia gained independence from France in 1953. The French Far Eastern Research Society led various conservation and restoration projects for Angkor temples, including the restoration of the Baphuon and the West Mebon. The Baphuon temple was completely dismantled, while the West Mebon temple was protected by the embankment and drainage pipe work. A synthetic polymer (geogrid) was used for protective embankment work at Mebon Temple, which was installed between the stones to prevent sand loss.

#### Han Min Su



Figure 10. Baphuon temple dismantling(left), repairing(right)



Figure 11. Western Mebon temple with protective embankment.

#### (2) Germany (GACP)

In 1997, the German Absara Conservation Project (GACP) was responsible for the construction of temples in the Angkor complex and other areas. By preserving stone, sculpture, and appearance styles, it officially began to participate in the preservation of Angkor temples. Major activities include preservation of the Absara statue and the Vishnu statue, and restoration of the Vishnu statue. After securing photo records, emergency measures were taken by writing a risk app, and investigation and processing were conducted for preservation restoration. Photographic records accumulate high-resolution black-and-white photographs, slit scans, and digital materials. The risk app was visually classified into Class 6 and the degree and type of damage was indicated. First aid was given to the delamination area using reinforced fiber, epoxy resin, and emergency bandages. Ultrasonic diagnosis was done, and drilling resistance and absorption were measured through pre-treatment investigation. Preservation treatment eliminates soluble salts and PMMA. When molting and ethyl silicate are used, concentrations and tools are applied differently depending on the degree of damage.



Figure 12. Applying mortar for conservation.

#### (3) Japan (JSA)

In 1994, a Japanese government team (Professor Takeshi Nakagawa of Waseda University) was formed as a project of the UNESCO Trust Fund for the Preservation of World Heritage. More than 680 experts participated in conservation and restoration activities. The JSA was involved in developing local human resources along side the actual work of preservation and restoration. The main activities included a master plan for the preservation and repair of Bayonne Temple and the dismantling of the northern library. The JSA conducted pre-preservation investigations using digital images and 3D laser scanning, and restored internal structural reinforcement and repair members using renal materials such as epoxy resin and stainless steel pins.



Figure 13. Restored Angkor Wat North Library.


Figure 14. Bayon temple Library before restoration(left), after restoration(right).

## II. Preservation of Stone Cultural Properties in Korea

## 1. Domestic Stone Cultural Heritage Preservation Processing Manual

The National Research Institute of Cultural Heritage is a national institution that studies, discovers, preserves, and restores cultural heritage, and was established to investigate and study Korean traditional cultural heritage. Since universities and general institutions are officially responsible for carrying out projects that are difficult to implement at the national level, the survey was conducted based on the manual issued by the Cultural Heritage Research Institute.

The most recently published preservation treatment manual, "Guidelines for Preservation Processing," summarizes the preservation treatment methods and materials of each cultural asset material based on the research conducted at the Cultural Heritage Conservation Science Center under the National Cultural Heritage Research Institute. In the case of stone cultural properties, general preservation treatment methods and materials are described without setting specific targets for shape and material. Additionally, a manual for all preservation treatments of stone cultural properties is provided in the order of pre-treatment status investigation, dismantling, bonding, charging, reinforcement, processing, and finishing.

The pre-treatment status survey is a basic conservation treatment survey to find and remove weathering factors and pollutants of stone cultural properties through actual measurement, photography, weathering drawings, and nondestructive field surveys. Decommissioning refers to the process of dismantling members based on the results of a pre-processing condition investigation. Cleaning can be divided into dry and wet cleaning, and it is a process that preserves the original form and reduces further damage by removing surface debris and pollutants. The process of reinforcement of the contact/recharge/fruit part restores the original form through bonding, and improves physical strength by charging the void part developed inside according to the material characteristics of the rock. The reinforcement of the fruit part is reinforced by using synthetic resins or the same stone. Reinforcement treatment reinforces areas where the binding force between compositional minerals is weakened. Post-processing recordings and finishes produce a report detailing the results of the preservation status investigation and the preservation process, and presentation and follow-up management guidelines for future monitoring of the stone cultural properties.

## 2. A Study on the Preservation of Korean Sandstone

The majority of Korea's stone cultural properties are silicate granite cultural properties, while some sandstone cultural properties have also been identified. Of the 517 state-designated stone cultural properties (80.4%), the total number of sandstone cultural properties is 21. A rock-based survey of sandstone cultural properties was conducted around the nutrition area where many sandstone stone cultural properties were distributed. An evaluation of sandstone properties before and after the preservation treatment was done and nearby sandstone rocks were given preservation treatment.



Pagoda in Sanhae-ri, Yeongyang (National Treasure No. 187)

Pagoda in Hwacheon-ri, Yeongyang (Treasure 609)



Figure 15. Korean designated stone cultural heritages, sand stone pagoda in Yeongyang area.



Petrological Investigation

Performance Evaluation



Insitu Evaluation

Figure 16. Studies on conservation plans of stone cultural heritages in Korea.

## 3. Preservation treatment of stone cultural properties in Korea

#### 1) Three-story Stone Pagoda at Seungansa Temple in Hamyang

A thorough visual observation of the rockological features of the components was conducted through pre-treatment surveys. For the study of the compositional materials, an all-amplitude measurement was performed on the stone pagoda compositional rock. The instrument used SM30 (Magnetic susceptibility tester) model with a measurement limit of 10-7 SI units, and the units of the ratio were expressed as 10-3 SI units. The collected analytical specimens were polarized microscopic observation and X-ray diffraction analysis for the precise sympathization of the crude rock and the mineral characteristics of the stone pagoda composition. The polarizing microscope used here is Nikon's Eclipse E600W equipped with an automatic counter, and the X-ray diffraction analyzer used the Rigaku agent D/Max-IIB. For a comprehensive diagnosis of weathering and damage conditions, a comprehensive damage map was prepared based on the factual drawings. The program used to create the defaced drawing was Adobe Illustrator, a 2D graphics professional application.

The three-story stone pagoda at Seunghansa temple site in Hamyang has been severely damaged due to the inhabitation of intellectual clothing and sunflowers across the front, and cement molding is also observed in some of the foundation stones. In addition, the stone railings surrounding the pagoda are too high, damaging the landscape of the pagoda. This stone pagoda exhibits severe delamination and elimination of its members, centering on the corners of the roof stones on each floor. In addition, tan and black discoloration is prominent around the upper and lower parts of the roof stones, and biological pollution caused by algae, intellectual clothing, and adipose is added to the top and bottom of the roof stones. The three-story stone pagoda is composed mainly of neutral or sequential black cloud-moisturized steel and granite, with a mixture of geostatic horseshoe rocks on the base, white cloud-shaped rocks on the second floor, and double-legged rock on the upper side and petroglyphs of enghwa. Black cloudmoisturized steel rocks are partially formed with pegmatite cemac, and granite is conveniently observed by the arrangement of black cloud-moisturized steel.

The preservation process was first carried out with surface cleaning to prevent damage to the stone, and wet cleaning was done as the second step. Dry cleaning was carried out using a soft brush and a wooden knife, and the parts that were not removed well, such as clothing and contaminants, were removed with wet cleaning using distilled water. In addition, the guard rail was reinstalled and the ground was cleared. The existing guard rail was dismantled and re-installed to a suitable height considering the distance from the stone pagoda. The ground around the stone pagoda was laid with masato and repaired. In addition, natural gradients were placed around the outside of the guardrail to facilitate the drainage flow.

## 2) Three-story Stone Pagoda of Bulguksa Temple in Gyeongju

The cause of cracks and damage to weathering were investigated prior to treatment, and the estimation of stone property sites was conducted. Structural material research was conducted after analyzing surface contaminants and conducting ultrasonic investigations, maintenance, and ground non-destructive investigations by member. Afterwards, the construction and status of the construction were investigated and the members were dismantled for dismantling. In the preservation treatment, the dismantled members were cleaned, bonded, and charged, and additional work was carried out before surface processing and solid color treatment. After assembling the dismantled members, the eight-way lecture was renovated and monitored through measurement investigation and on-site inspection of earthquake damage.



Figure 17. Conservation process of the Three-story Stone Pagoda at Seungansa Temple in Hamyang

Figure 18. Conservation process of the Three-story Stone Pagoda of Bulguksa Temple in Gyeongju

## IV. Materials and Technologies for Preservation Processing of Stone Cultural Properties

## 1. Preservation treatment materials

## 1) Current status and characteristics of preservation treatment materials

## (1) Status and characteristics of adhesives and fillers

The most representative adhesive and filling agent of stone cultural properties is epoxy resin. It is used for various purposes such as charging, breaking, and reinforcement of cracks in stone cultural properties due to its superior adhesive strength and stability in contraction- expansion compared to other resin. Usually, it is responsible for the function of adhesion and filling at the same time, and depending on the purpose and condition, it can be used by adding diluents, viscosity adjusters, filling agents, etc. It can also be preserved for long periods of time, regardless of climate or temperature, without the addition of a curing agent, and is typically used as a thermo-hardening substance. There are various types of curing agents that react to epoxy themes, including fatty amines, aromatic amines, polyamide amines, polyamide, and acid anhydrous water systems, but the curing agents used to repair stone cultural properties are hardened at room temperature and are relatively less toxic.

Epoxy resin is the collective name of a resin with two or more reactive epoxy groups in the molecule, induced by the reaction of bisphenol A and epichlorohydrin. In the case of curing agents, polyamide amines, which have less room temperature hardening and toxicity, are the most common, but are used considering the temperature at use and the physical characteristics after curing. However, caution is required as it is particularly sensitive to ultraviolet radiation and may cause yellow dust and cracks. Therefore, in actual use, additives are added to the purpose.

Due to its excellent chemical resistance, including water resistance and drug resistance, and the advantage of adding a large amount of fillers when used, it has already been used as a versatile restoration material for cultural properties since the 1950s. In particular, following the sinking crisis following the construction of the Aswan Dam in 1960, the emergency relief preservation of the Ramses II temple in Abu Simbel, Egypt, cut two temples, drilled a 1.5cm diameter hole, added an epoxy resin, reinforced the iron core, and moved them to a third location.

In Korea, it has been widely used to repair wooden and stone cultural properties since it was used for the renovation of Songgwangsa Temple's Chimgye-ru in 1978. It has been used every year as a repair restoration material for stone cultural properties for more than 10 cases, including the adhesion and restoration of the Baekjangam Three-story Stone Pagoda at Namwon Silsangsa Temple, which was damaged by thieves in 1980.

In the past, epoxy resin was purchased from the international

market. For example, Araldite was widely used. However, due to problems such as yellow dust and cracks and having to rely on imports, the National Institute of Cultural Heritage developed and actively applied six types of epoxy resin (L-30, L-40, L-50 and M-40) in cooperation with the Punglim industry. In addition to epoxy resin, other adhesives and fillers that are used include polymer cement and urethane foam.

Polymer cement is a mixture of cement and polymer that, unlike conventional cement, forms a polymer film on the surface to prevent the evaporation of the net. It is highly resistant to freezing and melting, has excellent adhesion and acid resistance, high tensile strength and flexural strength. In addition, it has the advantage of being able to work regardless of the width of the gap because it is easy to adjust the viscosity. But it is pointed out that its expensiveness and the volumetric changes that occur during hardening are its disadvantages.

It is charged with urethane foam, which is a foam made by mixing methylene diphenyl diisocyanate (MDI) and polypropylene glycols (PPGs), surfactants, and other additives. It has a low absorption rate, excellent compressive strength, and high resistance to water, acids, solvents, and microorganisms after curing.

# (2) Status and characteristics of reinforcement and precipitation agents

In 1861, the German chemist August Wilhelm von Hofmann first proposed Alcoxicilan for the preservation of the House of Parliament in England. The material is low in viscosity, allowing penetration to the inside of rocks, and Si-O-Si, which is formed by a condensation reaction with water, is the same as the main ingredient of most stone-free fires distributed in Korea. In addition, it has been widely used as a reinforcement agent for stone cultural properties since it has been stabilized against major weathering factors such as ultraviolet rays, acids, and heat.

Alcoxicilane enhancer is also being studied for the development

and application of organic synthetic resins such as epoxy and acoryl due to their weak effects on rock strength and hardness. However, the development of inorganic binders such as lime water, nanorime, and ivory reinforcement agents that combine presence and absence are under way because they do not have satisfactory effects in adhesion and penetration.

Alcoxicillin penetrates through the rock's capillary tube and forms silicon dioxide through the atmosphere or through the internal moisture and reactions of the rock. During this process, ethanol evaporates and therefore does not block the air gap in the rock. In particular, silicon dioxide has chemical homogeneity with quartz, most of the rock components distributed in Korea, so it does not cause side effects from treatment and is stable against heat or oxidation. In the most representative TEOS (synonym: tetraethyl northosilicate, ethyl silicate, tetraethyl silicate) the following reactions form silicon dioxide.

#### Si(OC2H5)4 + 4H2O → SiO2 + 4C2H5OH

Silicon dioxide is divided into silanes and siloxanes according to composition, and the silanometer is often used as a penetrating agent for dense structural areas. Thus, permeability is the most important quality here. Examples of silane include isobutyl ethoxy silane and isoctyl ethoxy silane. The siloxane system is effective in relatively large pores as it plays a role in improving surface water resistance, and is mainly used for coating stone or concrete outer walls due to its excellent weather resistance.

The water-repellent agent is a liquid organic polymeric material that hardens inside the void when applied to the concrete sphere and gives it water-repellent properties, blocking water from outside. In the case of stone buildings, breathable water film is formed on the surface of the structure by silicon treatment, which can prevent departmenting without getting wet even if it rains. In addition, water intrusion inside the molar can be prevented, minimizing the damage of freezing and melting of the contained water. Silres BS 290, a representative water spray, has good penetration and high alkaline resistance.

Acrylic resins were widely used before the 1980s due to their excellent transparency, weather resistance, and acid resistance, and high resistance to ultraviolet light, heat, and climate. However, the large molecular weight makes it difficult to penetrate the microscopic voids of rocks, and the surface coating makes it impossible to circulate moisture in rocks, which can cause additional damage. Recently, active research has been under way, with the development of a trap treatment method through the sum of monomers to fix these shortcomings. MMA(methyl methacrylate), acrylic acid(AA), methacrylic acid(MA), ethyl acrylate(EA), ethyl methacrylate(EMA), methacrylic aicd(MA), butyl methacrylate(BMA) are typical.

Wacker and Remmers' products, which are represented by tempered resin, are most commonly used at home and abroad, and similar products like Tegovakon, Synton X-30 and SH are used. The water-soluble resin is represented by AD25, SS-101, DWR of the siloxane system, and Silres BS290L of the silane family, while acrylic resin products are Paralloid B-72, Eurostac, and Duracylplus.

# 2) Cases of the use of preservation treatment agents for domestic stone cultural properties

## (1) Adhesive and fillers

Partial cracks in stone cultural properties are filled with polymer organic adhesives to prevent further progress, while reinforcement of heat poles or damaged surfaces that can be structurally problematic due to physical weathering is carried out through filling. The treatment agents used are mainly epoxy resin, especially AW106, AY103, SV427, and L-30. However, resin alone is rarely used, and inorganic fillers such as talc, silica, citric, turquoise, wool, and stone are added. Charger is closely related to the viscosity control of resin and can compensate for the shortcomings of resin, but if it is excessive, it can cause poor adhesion due to decreased cohesion of resin, so choice of type and quantity is important.

In particular, Arladite AW106 and Hardener 953 are used in areas with relatively large breaks, and the reinforcement is secured by adding talc, limestone, and SiO2 powder. On the other hand, GY253 is used for a variety of materials and purposes such as wood, stone, and metal due to its excellent adhesion and low shrinkage during curing, and is also suitable for F.R.P. production. Araldite SV427 and Araldite XN1023 are also used to repair and preserve stone structures.

However, epoxy resin is vulnerable to ultraviolet radiation, which can cause yellow dust due to photothermal heat. To improve this problem, the National Research Institute of Cultural Heritage and Punglim Industries developed L-30, L-40, and L-50. The L-30 is a super-low viscosity type with very low viscosity compared to other epoxy resins, and it is easy to use, with very little sulphur mutation occurring. In the case of L-40, it was developed for charging with elasticity and is mainly used for adhesion and filling. The L-50 is a product that improves reaction heat and curing speed, which is a disadvantage of the L-30.

Polyurethane foam, which is used for filling, was used to preserve the Five-story Stone Pagoda in Topgok Maaebulsang-gun, Namsan Mountain, Gyeongju, and Jeongnimsa Temple Site, Buyeo, and the separation of the roof stones was used as a filling material. At the bottom of the gap, a support was made with polyethylene foam and polyurethane foam was fired. On top of that, it was charged with a waterproof silicone resin to fill the gap to prevent rainwater from entering, and the second batch of stone was charged to make it homogeneous with other stone surfaces.

The three-story stone pagoda at Gameunsa Temple Site in Gyeongju was filled with silicate resin from 2006 to 2007. The KSE 500 STE, which was used at this time, was used mainly in Europe, and was first tried in Korea. In such cases, prior experiments should be done to clarify the physical identification of the resin and its relationship to the rock.

## (2) Reinforcement and water-repellent agents

The siloxane bonds formed by alkoxicilane are stable in heat or oxidation and act as an internal binding agent for silicate minerals in rock voids. The biggest advantage of alkoxicilan is that it does not completely block the air gap inside the rock, inhibiting rapid changes in rock properties and allowing free access to water vapor. Paralloid B-72, an acrylic resin, was used in the past, but it is now rarely used because it has been found to promote weathering by forming a film on the surface. Therefore, the reinforcement of stone cultural assets and the resin for generation should be easy to evaporate internal moisture, making it durable. It would also not cause changes in the color of the rock surface after treatment.

Reinforcement and water treatment for stone cultural assets has been steadily attempted since the late 1980s, but it is currently passive in processing due to the difficulty in verifying the effects of reinforcement and water treatment. In the past, SS-101 from Caolcoat and DWR products from domestic development were mainly used, but recently products such as 290 from Wacker and SNL from Remmers have been tried.

Reinforcement agents fill the inside of the stone for mechanical improvements such as increased weight, reduced air gap rate, and restoration of binding force between rock particles, and the water spray acts as a protective film to prevent moisture from being absorbed inside, reducing absorption by flooding and capillary forces. The selection of treatment agents must take into account the characteristics and environment of rocks, as reinforcement and water treatment may damage the target of treatment. In particular, the durability is demonstrated through the promotional weather resistance and hydrochlorination tests and the presence of surface changes after preservation treatment.

The acrylic resin Paraloid B72 is a useful resin that is dissolved in solvents such as toluene, xylene, and acetone. It is possible to improve mechanical properties such as compression strength by forming a strong film on the rock surface, but it is difficult to penetrate inside due to its large molecular weight and high viscosity. Recently, research has been underway to develop reinforcement methods using acrylic monomers to compensate for these shortcomings.

## 2. Scientific Investigation Method of Stone Cultural Properties

### 1) Provenance study of stone

Most of the stone pagodas are exposed to the open air, making them vulnerable to various types of weathering. In particular, mechanical weathering caused by physical and chemical factors causes the member itself to weaken, with loss of rigidity and shape deformation. Furthermore, it can lead to breakage of members due to cracks, which can increase structural instability. In the case of stone pagodas with severe damage, repair and preservation treatment shall be inevitably implemented for structural stability and appearance restoration. To this end, finding a new stone similar to the original member for preservation treatment should take precedence. In conclusion, finding new rocks similar to original members based on systematic and scientific techniques is important for effective repair restoration. In line with this, since the 2000s, interest in the proper repair and restoration of stone cultural properties has increased, and it is also investigating the estimation of stone production sites.

Therefore, the rock that constitutes a stone cultural heritage should be accurately named through a thorough outdoor investigation and indoor research. Each rock has visual or lithological features, which are important clues to distinguishing it from other similar rocks in the stone cultural heritage. A general scientific survey of stone cultural properties is conducted. Topographical and geological surveys of the surrounding cultural properties, as well as on visual observations of color, organization, and mineral composition are carried out.

## (1) Geological Survey

In order to interpret the source of raw materials for rocks, which are components of stone cultural properties, a precise geological survey is conducted based on the results of rock-based analysis. First, the geological distribution of the surrounding area is identified by selecting a location and a topographical possibility around the mountainous area of rocks distributed around it. Various investigations are conducted to identify the rockological and geochemical homogeneity of rocks produced in these different locations. The geological survey provides data on the estimation of mountainous areas by conducting micro-diagonal and gamma spectrometer measurements of rocks.

### 1 Magnetic susceptibility measurement

Magnetic susceptibility refers to the magnetization strength of an external magnetic field and is defined by I(magnetic strength)=k(magnetic strength) and H(magnetic field) (Sharma, 1976). Rocks have specific magnetic fields depending on their environment at the time of formation, making them easier to identify. It is also effective in investigating stone cultural properties because it is a non-destructive analysis method.

The Magnetic susceptibility tester is easy to carry, so it can be used regardless of the environment. Measurement shall be made at least five times along the flat surface, as close as possible to the member. The measured values shall be arranged in Excel and compared and analyzed with frequency graphs.

## 2 Gamma-ray spectrometer analysis

A gamma spectrometer is a single-channel analysis system that measures the content of K, U, and Th among radioactive levels in country rock (wall rock). In this system, four windows selectively record: (1) the total number of counts above a certain threshold, (2) the number of counts over a K window, (3) the number of counts over a U window, and (4) the number of counts over a Th window. Each figure is an environment-specific value at the time of rock production, making it easy to identify rocks. It is also effective in investigating stone cultural properties because it is a non-destructive analysis method.

Gamma spectrometer measuring devices are easy to carry and easy to measure. The measurement is based on repeated measurements of three times for three minutes on the same flat surface that can be as close as possible, and the measured values are arranged in Excel and compared and analyzed with frequency graphs.



Figure 19. Measurement of whole rock magnetic susceptibility.



Figure 20. Non-destructive analysis instrument survey and whole rock magnetic susceptibility frequency graph.



Figure 21. Gamma Spectrometer Measurement.



Figure 22. Gamma spectrometer result graph.

③ Provenance study: National Treasure No. 77, Five-story Stone Pagoda in Tamni-ri, Uiseong

The Five-story Stone Pagoda in Tamni-ri, Uiseong was constructed using tuff, and the base was mixed with serrated granite. Based on the analysis, the coagulation rock used in the stone pagoda was broadly classified into molten coagulation, lapilli coagulation, and coagulation. Among them, the yumun rock family of nuggets consists of a semi-precision of K-stone and quartz, compressed piame, and a small amount of rock on a dark-green or green-grey glass substrate. Rheological rock-like nuggets occupy 90.3% (178 pieces) of the total members, and the size of the rock is less than 1mm to 10cm. This rock is partly well classified and stratified.

Based on this result, the rock distribution of the pagoda was found in Geumseong-myeon, where the pagoda was located. There were sedimentary rock layers of the Cretaceous period, volcanic rock layers covering it with maladaptation, and penetrating floodgates. In this area, volcanic rock forms the Bibongsan–Geumseongsan Mountain in the center, with a maximum layer length of approximately 400 m (Jang et al., 1981). Therefore, the geological distribution of rocks around the Geumseongsan Mountain was investigated to estimate the mountainous area of the rock's main composition of the stone pagoda. Mineral and rock analysis were conducted.

First, outdoor close examinations were conducted on the rheological coagulation rocks distributed in the area of Mount Geumseong along with the measurement of the pre-amplitude and gamma spectrometer on exposed old rock. Gamma spectrometer measurements are used to obtain the content of K, U, and Th in rocks and soil and the activity of the entire gamma-ray, and are characterized by similar content of K, U, and Th in homogeneous materials. Observations of the old head distributed around Geumseongsan Mountain confirmed that it was similar or of the same type as the stone pagoda, which was identified as a rheological rock.

The total cancer rate measurement showed that the values of 0.03 to 3.32 (average 0.94) (abbreviated below) were approximately the same compared to the stone pagoda's rate of 0.03 to 3.27 (average 0.74). This indirectly dictates that the rocks that make up the Five-story Stone Pagoda in Tapri-ri, Uiseong, and the Yumun Rock-type Cohesion Rocks in Geumseongsan Mountain were created in the same adult process.

The gamma spectrometer measurements were taken three times at a three-minute interval at one point to ensure the reliability of the measurements. As a result of the measurement, the eU(ppm) and eTh(ppm) values are somewhat wider in the stone pagoda and the rocks of Mount Venus compared to K(%). The K, eU, and eTh measurements of the Venusian rock have some higher values than those of the stone pagoda, but are mostly distributed within the range of the measured values of the stone pagoda. Taken together, the meteorite coagulation of Mount Venus exhibits nearly the same level as the whole rock magnetic susceptibility and gamma spectrometer measurements of the stone pagoda composition rocks, which is recognized for their similarity between the two.



Figure 23. Measurements of the whole rock magnetic susceptibility (A) and gamma spectrometer (B) of rocks distributed around Uiseong Topri-ri Five-story Stone Pagoda and Geumseongsan Mountain (Lee *et al.* 2012)

## (3) Compositional mineral analysis

The compositional mineral analysis can identify the rockological and mineral properties, allow comparative analysis of circular members and collected samples, and can also be used to estimate stone production sites. Analysis of compositional minerals in rocks mainly involves X-ray diffraction analysis and thin-film observation using polarizing microscopes.

## ① X-ray diffraction analysis (XRD)

The X-ray diffraction analysis analyzes the crystal structure using the changes in the specific X-ray strength and diffraction angle scattered by the type or structure of the crystal, which can show the result values in a linear graph.

The collected samples are then processed in powder form, and the analyzed result values shown in linear graphs are qualitatively classified of minerals according to each particular diffraction angle. Diffraction patterns are available for quantitative analysis.



Figure 24. X-ray diffraction analysis process.

2 Polarizing microscope

Polarized light microscopy is an optical microscope that uses polarization to observe various optical properties of minerals. Natural light oscillates in all directions perpendicular to the direction of progress, but when passed through the polarization plate, it becomes polarized light that vibrates only in one direction. Polarizing microscopes differ from ordinary biological microscopes in terms of having two polarization plates, Bertrand lenses, and rotating wealth. The lower polarizer is called the lower polarizer, and the upper polarizer is called the upper polarizer, and the direction of vibration of the two polarizers should be arranged so that they are perpendicular to each other.

The main components of the polarizing microscope are light sources from below, lower polarization plates, lower parts of the property table, property table, mass lens, upper polarization plate, and folding lens. The lower polarization plate converts natural light from the light source into polarization. Folding lenses and mass lenses serve to expand the object of observation, and the hoard on which the thin pieces are placed can be rotated. The upper polarization plate can be inserted and removed in the path of light. The state of observation without the upper polarization plate is called open nicol, and the state of observation with the upper polarization plate is called crossed nicols. The optical properties of minerals observed in open and orthogonal nicole states are as follows.

- Open nicole: the transparency, color, polychromaticity, crystalline, particle size, splinters, etc. of the mineral can be observed in the open nicole state. Most tidal minerals, such as quartz and feldspar, pass through light, which means they are transparent. On the other hand, most metal minerals such as magnetite and sulfurite cannot pass through light, making them opaque minerals. Transparent minerals are again subdivided into colorless minerals and colored minerals.
- Orthogonal Nicole: In orthogonal nicole states, light, optical isotropy, anisotropy, and interference colors can be observed. The phenomenon of looking dark because there is no light passing through the upper polarization plate is called light absorption. Optical isotopes always show light because there is no light passing through the upper polarization plate even if the asset is rotated in an orthogonal nicole state. However,

when optical anisomers are placed between two polarization plates, the two oblique rays interfere with each other, creating a new color, which is called interference color. The color of interference changes when the goods are turned.



Figure 25. Thin film observation using polarizing microscope.



Figure 26. Petrological Survey and Analysis.

## 2) Weathering diagnosis

## (1) Weathering Damage Map

The weathering damage map of stone cultural properties is actively applied to domestic and foreign stone cultural properties as it can provide important data on condition diagnosis and preservation treatment in a way that can facilitate the comprehensive examination of all phenomena caused by weathering and damage. The process of producing damage maps will be divided into preliminary and on-site investigations. A preliminary investigation shall prepare a computerized drawing based on a fact-finding drawing of the target cultural heritage. If there is no drawing, full use of precise photographs should be made. An on-site investigation shall establish appropriate legends and symbols for the reporting after closely observing the damage status of the target cultural heritage. The distribution of damage patterns shall be accurately recorded on the actual drawings based on visual observation. Computerized and digital drawing preparation shall be completed by comparing damage maps and high-resolution photos prepared on-site, setting the scope of each damage type on the drawings, and inserting legends for each damage type.



Figure 27. Legend and symbol examples by type of damage.



Figure 28. The Weathering Damage Map and damage rate of Stele for King Taejong at Heolleung Royal Tomb, Seoul (National Cultural Heritage Research Institute, 2014).

## (2) Hyperspectral Imaging

Monitoring stone cultural properties using digital image analysis can efficiently identify changes in the damage state for a large number of cultural properties. Hyperspectral images have a large number of bands with narrow spectral widths, with continuous spectral characteristic curves and very high spectral resolution. In addition, digital image analysis has the advantage of detecting light transmitted from various locations to obtain spectral characteristic curves for every pixel that makes up the image. Spectroscopic reflection curves can acquire data by spectroscopy of the light reflected from the medium by wavelength. Because hyperspectral sensors can acquire spectroscopic data for each coordinate of the measurement target through a scan mirror or slot, they can acquire images by acquiring a large number of spectroscopic reflection curves for each location of the target in a short time. Because surface contaminants identified on the surface of stone cultural properties represent specific spectral reflection curves depending on the type of damage, the damage status can be determined by statistically calculating spectral data for each type of damage and image classification that clusters the same section.



Figure 29. Hyperspectral Image Acquisition Principles.



Figure 30. Results of Hyperspectral Image analysis for Five-story Stone Pagoda of Muryangsa Temple, Buyeo (Modeling and Damage Rate).

## (3) Infrared thermal imaging

Peeling, one of the major types of damage to stone cultural properties, is produced in the lower layer of the surface, so it is not easy to visually identify the location and area of occurrence. Infrared thermal imaging analysis is a representative method of detecting such delamination, and rapid and accurate status diagnosis is possible even for large surfaces, such as stone cultural properties. An infrared thermal imaging camera is a device that detects radiant energy radiating from an object's surface in the form of infrared wavelengths and provides the strength of the object's surface radiant energy as a thermal image. Visual observation and thermal imaging acquisition maximizes the relative temperature difference between the sound and peel parts with infrared halogen heaters after visual observation, photography, and seismic investigation of the subjects of analysis. The temperature distribution curve is prepared to distinguish the boundary between the sound part and the peel part, and the critical temperature and the dotted line are set. Regarding monochromatization of delamination parts, for drawing purposes only the delamination area is marked as a contour plot based on the minimum critical temperature, and monochromatization is carried out in consideration of relative damage. Drawings shall be produced using thermal images of peel parts, and the degree of damage shall be evaluated by calculating quantitative areas and damage rates for temperature colors classified according to relative damage.

### (4) Measuring the hardness of an eco-tip

Eco-tip rebound hardness tester was first developed as a nondestructive method of measuring rebound hardness and test quality in metals. The hardness index L is calculated by measuring the rate at which the impactor containing the spherical test tip is fired toward the surface of the test material with constant elasticity, compared with the rate at which the impactor leaves the test. It can be used as a non-destructive measurement because the impact device is only 3 mm in diameter, has a striking force of approximately 11 N / mm, and there is no limit to the direction of measurement.

The exposed stone cultural properties undergo surface weathering due to various climatic changes, which affects the measurement of equotip hardness. Therefore, comparison and correction factors of equotip hardness values according to surface roughness of rock is calculated. For measurement, four types of rough surfaces were produced.



Figure 31. Rock surface according to surface roughness

As a result of equotip measurement according to surface roughness, it was found that even the same fresh rock, regardless of the type of rock, is inversely proportional to the less equotip hardness value as the surface roughness of the rock increases. In addition, as the roughness of the rock surface increases, the rate of decrease in the hardness of the equotip increases, and the correction factor also increases.

## (5) Measurement of ultrasonic properties

The measurement of ultrasonic properties in the weather damage assessment techniques of stone cultural properties is very efficient and useful because it is a non-destructive analysis method that can quantitatively evaluate surface properties of stone cultural properties. Ultrasonic velocity is closely related to the elasticity coefficient and density of the medium, and the speed of ultrasonic waves decreases as rocks weaken. Therefore, the speed of ultrasonic waves can be used to measure the properties and weathering of rocks composed of stone cultural properties.

Ultrasonic waves are vibrations with frequencies between 200 MHz and above the audible frequency domain. Ultrasonic waves have better orientation due to their larger frequencies and shorter wavelengths compared to other sound wave zones. Ultrasound generated by the medium proceeds in the form of longitudinal waves (P waves), transverse waves (S waves), and surface waves, and the speed of ultrasonic waves in the same material is characterized by a certain characteristic. There are various types of ultrasonic detectors used for non-destructive inspection of buildings and stone cultural properties at home and abroad, and they are selected and used according to the site conditions. The probe used for measuring ultrasonic wave velocity is selected and used depending on the intensity of the frequency and the situation of the target. In measuring the ultrasonic velocity of outdoor stone cultural properties, probes in the 54 kHz area with relatively wide wavelengths are mainly used.

The order of progress for evaluating the weathering diagram includes a total of four stages, followed by calculating the correction factor, measuring the ultrasonic wave velocity, calculating the weathering index, and recording the weathering diagram. Ultrasonic materiality measurements are divided into direct, semi-direct, and indirect methods depending on the arrangement method of the probe. The direct method of identifying the exact nature of stone cultural properties is the direct method, but large stone cultural properties require the indirect method. When measured by indirect method, the ultrasonic wave transfer speed is reduced compared to the direct method due to differences in the direction of the ultrasonic wave's gaze and reception sensitivity. Therefore, in order to measure the ultrasonic speed of stone cultural properties, calibration according to the measurement method is necessary. The correction factor is the rate of ultrasonic waves by direct method divided by the rate of ultrasonic waves by indirect method, which varies depending on the stone.



Туре	Factor	Туре	Factor
거창화강암	1.52	공주섬록암	1.58
익산화강암	1.52	충주반려암	1.38
남산화강암	1.51	보령사암	1.62
양주화강암	1.49	완주석회암	1.69

Figure 32. Differences in ultrasonic wave velocity depending on the measurement method.

Table 2. Types of rocks and ultrasonic correction factors.



Figure 33. Case of ultrasonic measurement (Three-story Stone Pagoda in Hyeon-ri, Yeongyang, Treasure No. 610).

## (5) Measuring chromaticity

Surface discoloration provides useful information for understanding damage mechanisms, including factors that have degenerated into one of the patterns of stone cultural property damage. To this end, visual discoloration is classified and written in the field, but comparable information using color standards is needed to express the degree of discoloration more accurately than verbal descriptions. Therefore, we investigate color information to classify discoloration in the field and then record it as more objective and quantified information. First, the color range is checked based on the standard color scheme (fresh parts, brown discoloration, black discoloration, etc.) after classification by visual discoloration at the site. The Munsell color scheme is a standard color scheme widely used internationally in a reasonable way of representation. The three properties of color consisting of the color spaces of Hue, Value, and Chroma, which are symbolic of color, are recorded in HV/C order when a color is represented by a distant cell symbol. The Munsell symbol can be converted to various color information figures through the program. In addition, to record the numericalized spectroscopic color information, we record the numerical color information in the field with a colorimetric meter (National Research Institute of Cultural Heritage, 2014). CIELAB is the reference used by the colorimetric system.

A color space is defined by CIE based on the opposite color theory of yellow-blue and green-red where humans detect color, as a result of research to approach human sensibility. The Munsell color system is the most widely used in the world because it is easy to guess the error range and direction of the color when coloring.

- L\*: Reflection rate (an indication such as human vision) and may be expressed in steps from 0 to 100 as low as 100 decimal places.
- a\*: The chromatic diagram shows +a\* in red and -a\* in green direction.
- b\*: Colorimetric diagram, +b\* indicates yellow and -b\* indicates blue direction (Park, 2007).

## (6) Measurement of roughness of stone surface

Some researchers use roughness as a measure of surface quality. There are several measurement methods, but most are not related to "field" measurements because the height range of the technique is too small to be applied to fine-grained materials (Alvarez et al., 2011). The best cleaning conditions for masonry work were selected in various areas of the Segovian Cathedral (Spain) using a portable optical surface roughness meter. Portable tectonics can measure micro-relief amplitudes from 0.5 to 6 mm (Dabski, 2014). Laser 3D scanners have also been used to characterize the 3D contours of stone walls and art object surfaces (Gomez-Heras et al., 2008).

## (7) Observing actual microscopes and injection microscopes (identifying the pattern of weathering)

### 1) Stereoscopic microscope

The color and tissue deterioration of the surface discoloration can be observed visually in the field, but for more precise observation, the microorganism of the surface is determined through image analysis after observing on-site using a portable digital microscope. The stereoscopic microscope consists of a pair of binocular alternative lenses and a mass lens, as shown below. Because the light scattered from the sample is carried out separately with each alternative lens, the appearance of mineral crystals can be observed in three dimensions. By observing the crystals of minerals using a microscope, the appearance and color of the crystals can be identified, and it can also be used to find out whether or not there is a nest trapped inside the crystals. A microscope does not require complicated preprocessing of samples to observe the determination of minerals. Thanks to these features, stereoscopic microscopes are often used for examining expensive jewelry (Kim, 2014).



Figure 34. Stereoscopic microscope (Source: Korean Geological Society).

① Scanning Electron Microscope

A scanning electron microscope (SEM) allows the analysis of three-dimensional microforms, microstructures, chemical composition, and elemental distribution of surfaces by injecting microbeams into a specified area of the specimen. Mineral species, morphology, aggregation, voids, soil micro-minerals, micromicrobial fossils, and micro-structure of the surface of the mineral can be observed. It is possible to observe the decomposition and generation of minerals common in geological processes. By making and observing the abrasive thinning of the specimens, one can observe more clearly the microstructure inside the mineral, the chemical composition changes, and the sequential generation of the mineral (Geology encyclopedia, unknown).

① Weathering diagnosis: Gyeongcheonsa ten-story stone pagoda Lee Chan-hee and two others used polar microscopy and injection electron microscopy (i.e., SEM) to observe the semiquantitative mineral composition, relative content, mineral symbiosis, tissue and weathering of rocks comprising the material properties and weathering conditions. The model of the injection electron microscope is the ISI-SX-40 of Shimatzu, equipped with LINK's energy-dispersive X-ray analyzer (EDXA, PV 9100/60). The analytical specimens were made of double sheaths of carbon and gold. SEM-EDS analysis was conducted by collecting some samples of raw materials and kidney materials to find out the rough chemical composition of crude rock minerals and compositional materials. As a result of observing and analyzing the injection electron microscope and qualitative analysis of raw materials, it was possible to observe the cross-section in which the dexterous crystal of the interfering stone grew, and the qualitative chemical composition was also analyzed. This result shows the common characteristics of most calcified surrogate. Likewise, obstructive stones (CaCO3) were detected in renal materials and partly gypsum was observed. Sulfur (S) was detected in some samples of renal material, which is believed to be caused by the air environment factors. The carbon (C) detected in all samples is determined to be the effect of carbonate components and the cladding used in the analysis (Lee et al., 2006).

## 3) Survey on preservation environment

The climate environment plays an important role in expanding the understanding of weathering and damage phenomena based on the material characteristics and damage status of stone structural rocks and in solving fundamental problems of weather damage. In addition, it is the only controllable one compared to other factors, which serves as an important basis for creating or improving the optimal environment for continuous preservation and management of stone cultural properties.

## (1) Cultural Heritage and Climate Environment

The main factors influencing the weathering and damaging effects of stone cultural properties include composition rocks, time, and climate. Among them, the material properties of compositional rocks play an important role in determining the type of weathering, and time affects the rate of weathering, while the climate environment is a major factor in advancing the degree and speed of weathering of rocks.



Figure 35. The climate environment of stone cultural properties and the process of rock weathering.

## (2) Importance of a conservation environment survey

Most of the stone cultural properties have been exposed to the outdoors and have been weathering and damaged by changes in the climate for a long time. This damage is easy to overlook over a long period of time, and cultural properties are quickly lost due to sudden weather changes (tropical winds, floods, landslides, earthquakes, etc.). In particular, the preservation environment investigation is very important in preserving stone cultural properties because rocks that make up stone cultural properties are constantly affected by the microclimate of the surface under various local conditions and are soilized by weathering.







온 · 습도 측정장치

미세먼지 측정장치

휴대용가상관측장치

Figure 36. Devices used for Conservation Environment Survey.

## (3) Major methods of investigation of preservation environment

Temperature, Humidity, and Rock Surface Temperature Measurement: To identify the temperature and humidity environment, which are the most influential factors in preserving stone cultural properties, select a representative point where cultural properties are located, and use data logger to predict condensation.

Measurement of the concentration of air pollutants on gas: To determine the atmospheric distribution of sulfur dioxide (SO2) and nitrogen dioxide (NO2), which are gas pollutants that are adsorbed to the surface of stone cultural properties, and affect salt production, it is measured with an automatic air quality meter.

(SO2 : Ultraviolet Photography, NO2 : Chemical Light Method, to measure the ambient concentration in real time)

Measurement of the concentration of air pollutants in particulate matters: In order to determine the distribution status of air pollutants in particulate matters that adsorb the surface of stone cultural properties and penetrate between micro-poles, fine dust concentrations are measured in real time.

Comprehensive weather environment measurement: To identify comprehensive climate environmental factors (temperature, humidity, wind direction, wind speed, solar radiation, rainfall, and air pressure) that reflect the location of stone cultural properties, the surrounding environment of specific cultural properties is measured using an automatic weather monitor (AWS).



주기적 담수 침수에 의한 훼손 국보 제285호 울산 대곡리 반구대 암각화



대기오염물질에 의한 표면변질 국보 제2호 서울 원각사지 심충석탑



백화 및 생물서식에 따른 표면변질 보물 제66호 경주 석빙고



태풍에 의한 문화재 파손 위협 보물 제423호 남원 신계리 미에여래좌상



지표수 생물 서식에 따른 생물오염 사적 제312호 화순 운주사지 내 석불



신사태에 의한 마애불 하부 암반 붕괴 경북 시도유형문화재 제248호 영주가흥리암각화

Figure 37. Weathering and damage of stone cultural properties according to climate change.

## V. Conclusion

Angkor sites are a major legacy of the former Khmer empire, located in the Siem Reap province of Cambodia, in a region called Angkor Thom, which is home to a relatively large number of Angkor sites, including Terrace of the Elephants and Preah Pithu. Angkor Wat is located about 1.5 km from Angkor Thom.

The rocks used in the Angkor sites are sandstone and laterite, and the use of bricks is confirmed in relatively early sites built in the 9th and 10th centuries. The grey to yellowish brown sandstone is the most common sandstone of the Angkor sites. The red sandstone was used in the Banteay Srei, and was partly used in the south and north of Khleangs. Greenish greywacke was used only in the sanctuary of Takeo.

The laterite of Angkor sites was mainly used in the packaging of foundation stones (surfaces and interior), peripheral columns, and floor surfaces, and is divided into two types: porous laterite and pisolitic laterite, based on rock-based materials.

Angkor Wat was composed of grey-green to yellowish mesozoic

sandstone, with contour, structural, multilayer, follicle, crust, efflorescence, and subflorescence weathering. No damage by trees was found, but moss, algae, fungi, bacteria and cyanobacteria have been identified, and structural stress-induced cracks have been produced. Terrace of the Elephants has been confirmed to have undergone bulging, delamination, and globular decomposition of the auxiliary part; there is no visible serious biological damage, as biological growth is made difficult by the direct sunlight. Preah Pithu is mostly made of gray sandstone, and a small amount of mixed red and green sandstone. Red and greenish-gray sandstone is relatively weather-resistant. Gray sandstone has developed a linear structure that is clearly visible to the naked eye, and stratum delamination and globular decomposition have been confirmed.

Scientific analysis suggests that the sandstone weathering factor at Angkor Wat temple is due to environmental factors caused by the rainy-dry cycle and water-soluble salts from bat guano. A comparative analysis of laterite collected from a quarry in nearby Laos and laterite used in temple construction confirmed discoloration by iron oxide. Red discoloration by Fe has been observed, with black discoloration having a higher Fe component and less Si component than red discoloration. According to an analysis of the damage to stone cultural properties caused by biological factors, it was found that the penetration depth, cohesion, and diffusion of moss roots were the most serious weathering factors.

The move to preserve Angkor Wat began in 1907 at the French Far Eastern Academy (EFEO), which was established in Cambodia by the French government. Countries and institutions such as the EFEO (France), GACP (Germany) and JSA (Japan) have been involved in the conservation and restoration of Angkor sites and other temples in other regions.

A total of 21 out of 517 state-designated stone cultural properties (80.4%) were made of sandstone. Scientific surveys such as petrological surveys and evaluation of the application of preservation treatment agents were conducted in the Yeongyang area where many sandstone stone cultural properties were located.

The adhesives and fillers used for cracks in domestic stone cultural properties are mainly epoxy resin. However, since epoxy resin is vulnerable to ultraviolet rays and may cause yellow dust caused by photothermal heat, the National Institute of Cultural Heritage and Punglim Industries have developed and used L-30, L-40, and L-50 to solve this problem. On the other hand, reinforcement and water treatment for stone cultural properties has been steadily attempted since the late 1980s, but currently, verification of their effects has been difficult and not being carried out actively. There are various methods of scientific investigation of stone cultural properties in Korea, but they can be largely classified into provenance study of stone, weathering diagnosis, and conservation environment investigation. For the effective repair and restoration of stone cultural properties, it is important to use rocks similar to original members based on systematic and scientific techniques, so a provenance study of stones is conducted. Methods for estimation of provenances include geological surveys such as magnetic susceptibility measurement and gamma spectrometer analysis, X-ray diffraction analysis, and compositional mineral analysis such as polarized light microscopy. The weathering diagnosis is an important guideline for establishing directions and methods for weathering diagnosis and conservation treatment by checking the weathering and damage status of stone cultural properties. Weathering damage maps, hyperspectral imaging (hyperspectrum), infrared thermal imaging analysis, eco-tip hardness measurement, ultrasonic measurement, colorimetric measurement, and observation of stereoscopic microscope and scanning electron microscope are used. The conservation environment survey shall serve as an important basis for creating or improving the environment for the preservation and management of stone cultural heritages. It measures the climate environment such as temperature, humidity, air pollutant

concentration, and comprehensive weather environment.

This study conducted a data survey on traditional and modern preservation restoration materials and technologies that were actually used for the preservation of stone cultural properties in Angkor, Cambodia. Through this study, we identified the current field technologies such as the type and selection method of conservation materials, and method. It could also be used as a basic data source for research and development (R&D) projects related to advanced conservation materials and technologies for preserving stone cultural assets in Cambodia. If scientific analysis of materials used for actual conservation process is conducted and systematic database is established, it is expected that it will be actively used to determine whether materials are used incorrectly.
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## Development of an educational program on the application of digital technology in the field of cultural heritage conservation

Research on Materials and Techniques in Asia-Pacific Regions

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#### Abstract

The purpose of this study is to develop educational programs to build a virtual museum for cultural heritage in the ASEAN region, and to help curators and cultural heritage practitioners in the ASEAN region understand and use virtual museums. We observed the use of digital heritage in domestic and foreign museums, and identified the current status of digital heritage in the ASEAN region, and whether it can actually be used for education. It was found that the current use of digital heritage was simply learning technology or combining existing forms with new content. Therefore, a new form of digital heritage education was produced and the contents were as follows. First, relevant experts in the ASEAN region are trained on how to create virtual museums in terms of conservation and utilization of cultural heritage. Second, they will produce a 'virtual museum for cultural exchange' that is not limited to one country. Third, the training method uses user experience-based techniques. This study proposes a three-day education program and makes a contribution to field of expert education on digital heritage planning.

## I. Introduction

#### 1. Background and purpose of research

In the 20th century, as museum information became digital and technology developed to enable sharing it, virtual museums appeared to promote museum collections and share information on relics. As virtual museums became more common with the development of network technology, museum and art galleries at home and abroad began installing virtual museums. In cooperation with more than 2,000 museums, Google has launched Google Arts and Culture website that allows viewers to enjoy works categorized according to era and artist in an online environment. Since 2009, the Smithsonian Museums have provided an Augmented Reality (hereafter AR) service that makes the user feel like he or she has actually visited the museum and allows visitors to select an exhibition room interactively and rotate the screen 360 degrees. The Vatican Museums offer a high-resolution 360-degree panoramic view of the museum's interior and external architecture on their websites.

In 2020, the importance of virtual museums, which are non-faceto-face cultural experiences, has increased due to the COVID-19 pandemic. However, due to the absence of educational resources on the subject, museum officials and curators around the world are struggling with understanding what exactly is a virtual museum and what is the process of establishing it. Therefore, we designed an educational program on how to build a virtual museum for cultural heritage in the Association of Southeast Asian Nations (hereafter ASEAN)<sup>12</sup> so that curators and cultural heritage workers in the ASEAN can understand and utilize virtual museums.

<sup>12.</sup> Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam

#### 2. Scope and methods of research

Most of the research on virtual museums so far is about evaluating users' experience of virtual museums and exploring the feasibility of building virtual museums. No research has been conducted to propose educational programs for planning and producing virtual museums for museum professionals. This study involves analyzing the current status of virtual museums, setting definitions and scope, and developing and assessing educational programs for the expansion and utilization of virtual museums.

#### 3. Expected effects of research

This study has the following expected effects. First, it can contribute to promoting exchanges in the field of digital heritage within ASEAN. Second, this study can help reduce the depression caused by the COVID-19 pandemic and satisfy the cultural needs of the general public by expanding virtual museums. Third, this study will stimulate the development of digital content authoring tools by raising interest in virtual museums. Fourth, this work will contribute to the interface and interaction design of digital content authoring tools. Fifth, this study will contribute to the use of cultural data available in virtual museums. Sixth, this study can promote cooperation between the fields of information and communications technology (ICT) and humanities related to cultural heritage and museums.

## I. A Study on Virtual Museums

#### 1. Definition and scope of virtual museum

#### 1) Definition of virtual museum

According to Virtual Museum Transnational Network (VSMM), the virtual museum is "a digital entity that draws on the characteristics

of a museum, in order to complement, enhance, or augment the museum experience through personalization, interactivity and richness of content."<sup>13</sup>

## 2) Scope of the virtual museum

- Virtual museums have various forms such as hyper-museums, digital museums, cyber museums, web museums, and online exhibitions.
- (2) Types of virtual museums can be classified as museum websites to share digital representations, virtual visits, and expertises.
- (3) Virtual museum contents include museum approach, practical information such as timetable, museum history information, permanent exhibition information, special exhibition information, and educational tools for public educational purposes.

## 2. Case Analysis of Virtual Museum

## 1) Analysis of domestic cases

- Research on national museums in Korea was implemented with a focus on the use of digital heritage, museum exhibitions, and educational programs on the museum websites.
- (2) In the case of domestic cases, 94% (47 museums) of the national museums have websites, and among them, 64% (30 museums) have virtual museums.

<sup>13.</sup> www.v-must.net/virtual-museums/what-virtual-museum



Figure 1. The proportion of national museums in South Korea having virtual museums

- 1 National Museum of Korea
- 10 websites are managed by the National Museum of Korea, which has the largest website among the national museums, and 9 of them use digital heritage.
- National Museum of Korea: Online Exhibition Hall (VR),
   Collection Search, Collection 3D View, Digital Rubbed Copies,
   Video Hall Video, Online Learning Video, Exhibition Video
- ·e-Museum: Artifacts, Image Graphs
- · Children's Museum: Learning Animation, Museum Guide
- Documents from the Museum of the Japanese Government General of Korea
- Oegyujanggak Uigwe<sup>14</sup>: Virtual Experience(VR) of the illustrations of the royal procession and major scenes of the royal event, scanned copy, original text
- Organization of online museums focused on special exhibitions
   —3D scanned online exhibition based on MatterPort
- Provision of mobile links for VR devices such as Google Cardboard and Samsung Gear VR
- 3D scanned collections can be rotated, enlarged or reduced in any direction

<sup>14.</sup> A collection of records of the preparations for and conduct of state-sponsored events and ceremonies involving key members of the Joseon royal family







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Figure 2. VR Content of Special Exhibition (www.museum.go.kr) Figure 3.3D View of Collection (www.museum.go.kr)

- e-Museum: Detailed search is possible based on the ownership, designated cultural heritage, nationality, era, material, classification, excavation site, etc. and one exhibition can be organized using the "I Am a Curator" function.
- Children's Museum: Produce an exhibition guide using moving animation to attract children's interest in addition to educational materials using learning videos and photographic materials.



Figure 4. Guide map of the Children's Museum of the National Museum of Korea (www.museum.go.kr/site/child/home/)

- Virtual Experience of Oegyujanggak Uigwe Banchado (a documentary painting of the royal family on a gigantic scale)
- the experiential multimedia content that reproduces Banchado which depicts the funeral of Queen Jang-ryul of King Injo in 3D and VR form
- ·a reproduction of the original Uigwe Banchado
- Manipulate mouse and keyboard to move eyes and change direction
- •There is a key map in the upper right corner that shows the location of the current field of view



Figure 5. Oegyujanggak Uigwe of National Museum of Korea – Virtual experience of Banchado(www.museum.go.kr/uigwe/)

- 2 National Folk Museum of Korea
- The National Folk Museum of Korea manages three websites and focuses mainly on academic materials other than the Children's Museum.
- National Folk Museum: Folk Archive, Daily Rituals of Koreans (a relics collection)
- Children's Museum: Cyber Playground Folk Playground (AR), Play Experience Center, Know Our Play, Know Our Culture, Data archive, Stay at home Folk Play, Multicultural Package
- Video-sharing platform Folk+people: Exhibition library, education, data resources, research, children, special planning
- Daily Rituals of Koreans a relics collection
- ·Interpretation of daily rituals such as placenta jar, men's

and women's practices, weddings, etc. is provided. A detailed description is given for each ritual. Users solve flash-based quizzes after viewing the collection.



Figure 6. The Daily Rituals of Koreans - a relics collection(www.nfm.go.kr/)

- Children's Museum Folk Play AR Coloring Book
- After printing and coloring the relevant folk game picture, the user's colored picture character becomes 3D and moves with sound.





Figure 7. Folk games in cyber playground – AR coloring Book (www.kidsnfm.go.kr/nfmkid/index.do/)

③ Seoul Museum of History

- The Seoul Museum of History operates four websites showcasing the distinctiveness and history of Seoul
- View the past special exhibitions using VR in the online exhibition hall
- Video and audio are added to some exhibition VRs for greater immersion.



Figure 8. Online Exhibition of the Seoul Museum of History – Trams in Seoul (https://museum.seoul.go.kr/)

- Website of Seoul Museum of History for children: Online learning space "Seoul and Play" provides a total of 11 educational contents and educational activities can be performed through dragging.



Figure 9. Website of Seoul Museum of History for Children - "Seoul and Play" (https://museum.seoul.go.kr/chd/index.do/)

(4) Gwangju National Museum

- Panoramic format
- Various types of views such as normal view, fisheye view, stereographic view, architectural view, pannini view, little planet view are applied.
- Krpano Program (Panorama-typed 360VR Production Service)



Figure 10. VR Exhibition Hall of Gwangju National Museum (https://gwangju.museum.go.kr/cyber)

## 2) Analysis of foreign cases

#### (1) Denmark National Museum - National Folk Museum

- ① Cyber Korean Gallery Program is part of the project of the National Folk Museum of Korea to install and improve the Arts of Korea Gallery overseas and is designed to systematically introduce Korean artifacts housed in the National Museum of Denmark
- ② The National Museum of Denmark has more than 900 Korean artifacts, 420 of which are selected and introduced in the Cyber Korean Gallery.
- ③ The offerings include the Cyber Korean Gallery, Kisan Gallery, a collection of genre paintings by Kim Jun-geun, data search for Korean folklore managed by the National Museum of Denmark, and special video theater that introduces collections with digital content such as flash videos.
- ④ Unfortunately, the quality of the video provided is not good, and the Korean Cyber Gallery cannot be visited on the National Museum of Denmark's website.



Figure 11. Online exhibition of the National Museum of Denmark

## (2) Peter the Great Museum of Anthropology and Ethnography (the Kunstkamera) – National Folk Museum

- Peter the Great Museum of Anthropology and Ethnography (the Kunstkamera)
- <sup>(2)</sup> The Korean objects collected by the Kunstkamera in Russia mainly consist of relics and photographs depicting Korea around 1900s. In particular, representative relics such as the incense burner of Carl Friedrich Theodor von Waeber who came to Korea as the first Russian diplomat, received from the Empress Myeongseong; the photographs of the construction process of the Russian legation building in 1890; and the panoramic view of Seoul including Gyeongbokgung Palace have considerable cultural value.
- ③ Korean relics and photographic materials from the Kunstkamera are classified by collectors so that they can be easily searched, and detailed information and detailed photos can be found by clicking on the collection.
- ④ It is regrettable that all objects and photographs on the collection list are provided in detail in Korean, Russian, and English, but video materials are not. Also, like the National Museum of Denmark, a web-book for Korean objects cannot be found on the online website of the Kunstkamera.



Figure 12. Kunstkamera-Korean objects(http://www.kunstkamera.ru/)

#### (3) Angkor National Museum

- The Angkor National Museum, one of Cambodia's national museums, deals with the cultural heritage of the Khmer Empire, including Angkor Wat. The webpage is available in Khmer and English, and it is very disappointing in terms of digital content such as archive collections.
- ② Only seven representative collections can be viewed with detailed photos and information on the webpage, and there is no function to search for other collections.



Figure 13. Angkor National Museum (http://www.angkornationalmuseum.com/)

Figure 14. Mini games to play on the website (http://www.angkornationalmuseum.com/)

#### 3) Sub-conclusion

- (1) Virtual museums are familiar with our environments in various forms and shapes.
- (2) It is predicted that virtual museums will gradually become more and more common. Virtual museums are known by many other names, which can be confusing. Therefore, it is necessary to use one standard term to refer to virtual museums. This will be very helpful while commercializing and promoting virtual museums.
- (3) Domestic case analysis showed that the virtual museum had the largest number of matterport-based 3D scan formats, and it is used in various formats such as Krpano program, HDVR, Cubic plate, etc.
- (4) Of the 30 virtual museums, permanent exhibition halls operated 42% (21 museums), special exhibition halls operated 38% (19 museums), both exhibition halls operated 24% (12 museums), permanent exhibition halls only operated 18% (9 museums), and special exhibition halls operated only 14% (7 museums).
- (5) In the case of foreign countries, the Angkor National Museum offered only simple digital contents in the form of minigames, and the Kunstkamera jointly operated the National Folk Museum and Digital Museum.





#### 3. Virtual Museum Research Analysis

#### 1) Analysis of domestic cases

The study began with literature review in related fields. Through keywords such as "cultural heritage," "cultural property," "digital," "education," "content," and "conservation," many prior studies relevant to the current study were found. The prior studies can be divided into three types as follows.

- Domestic and foreign status and case studies on the use of digital heritage
- (2) Research on how to utilize cultural heritage using various digital technologies
- (3) Linkage with various digital content

Although dealing with digital heritage, each case, technology, and content were slightly reinforced and studied. These were theses researching and analyzing the current status of each country and its cases in the context of the use of digital and cultural heritage. In the 2000s, various cases were investigated. In recent years, research on the use of various types of digital heritage has been increasing. Below, the prior studies found under each type are mentioned with a brief overview.

## (1) Domestic and foreign status and case studies on the use of digital heritage.

- ① Lee Nam-hee, 2005. "The Status and Prospect of Digitalization of World Heritage Sites in Southeast Asia"
  - Investigation of the current status of digitalization of world heritage in Southeast Asia
  - Presentation of Asian cultural heritage digitization work
  - Research on a website related to world heritage in the Philippines, Indonesia, Thailand, Vietnam, Laos, and Cambodia

- ② Park Min-seo, Choi Yeon-hwa, and Lim Soon-beom, 2008. "Use Cases of Digital Heritage Projects at Home and abroad"
  - Various cases of the use of digital heritage at home and abroad have been investigated.
  - Domestic cases include Hwangryongsa 9-story Wooden Pagoda, Jeonja Chongtong Gun, and Dream of Interactive Cultural Content Maitreya.
  - Overseas cases include the Digital Michelangelo Project, Bayon Digital Archival Project, European Research Network of Excellence in Open Cultural Heritage (EPOCH), and Agamemnon Project

# (2) Research on how to utilize cultural heritage using various digital technologies

There were many studies that applied to architectural cultural heritage in the use of digital heritage. As the research is diverse, it is possible to see examples related to architectural cultural heritage and various types of digital technologies.

- ① Park Jin-ho, 2008. "Cambodia Angkor Wat Digital Restoration"
  - Research in terms of digital restoration of the target site
  - Digital restoration of Angkor Wat 3D scanning process and results
- 2 Lee Ji-hyung, Kang Kyung-kyu, and Kim Jae-woo, 2014.
   "Experience system for assembling digital architectural cultural assets using absent miniatures"
  - Research on hands-on technology that crosses real and virtual spaces.
  - A study on a system that allows users to assemble cultural heritage monuments using miniatures in real space and connecting the results to digital heritage in virtual space
- ③ Jo Jung-hoon and Woo Yoon-taek, 2016. "Designing an Outdoor Environment Augmented Reality Authoring Tool for

Cultural Heritage Experience"

- Work on the AR of outdoor environment for cultural heritage experience
- Design a prototype of the authoring tool for Changdeokgung Palace
- ④ Lee Jong-wook, 2019. "A Study on the Education of Cultural Heritage through the Writing of Virtual Museum"
  - Proposed curriculum for planning and building virtual museums using virtual museum authoring software
  - Virtual Reality-based Architectural Heritage Education Application, Virtual Reality-based Excavation Experience Application

#### (3) Linkage with various digital content

These studies dealt with various kinds of heritage excluding architectural cultural heritage. The topics studied include costumes, Korean language, science, art, humanities, maps, and metal type. I felt these studies present a different angle to the application of digitization and VR to cultural heritage. Therefore, I included them in the literature review.

- Lee Myung-jin and Won Do-yeon. 2017. "A Study on the Utilization of Digital Contents of Iksan Baekje Cultural Heritage"
  - Discusses the link between digital technologies centered on stories.
  - It contains the story of relics or historic sites in virtual reality content centered on Mireuksa Temple Site in Iksan.

## 2) Analysis of foreign research

#### (1) San Francisco Museum of Modern Art, United States

- ① Exhibition: Rene Magritte The fifth season (2018)
- ② Augmented Reality (AR) exhibits compatible with

smartphones and tablets are offered.

③ Various sensors recognize visitors. The exhibition space is an interactive space meaning that it changes according to the gaze and movements of visitors.



Figure 16. San Francisco Museum of Modern Art, USA(https://www.starkinsider.com/)

## (2) Seattle Art Museum, United States

- ① Exhibition: Double Exposure (2018)
- 2 Visitors recognize works through smartphones
- ③ In addition to the description of the work, songs that match the person in the picture and the background are played, or dance or music videos are added to help understand the picture.



Figure 17. Seattle Art Museum, USA(https://youtu.be/O6JpWu78Nfs)

#### (3) Natural History Museum, London, United Kingdom

① Since 2010, various parts of paleoanthropology and primate and dinosaur exhibits have been presented through AR.



Figure 18. Natural History Museum, London, United Kingdom (https://youtu.be/5yBQ9adCHTo)

#### (4) The Smithsonian Museum of Natural History, United States

- ① Using the Skin and Bones AR application since 2015.
- ② Animal bones recognized as applications are reconstructed and augmented by reconstructing the model of living things, skeleton and muscle structure, or the augmented model of living things is shown as a 3D object.



Figure 19. Skins and Bones AR(https://naturalhistory.si.edu/exhibits/bone-hall)

#### (5) National Museum of Singapore

- ① The exhibition "Story of the Forest" has been on display in the permanent exhibition hall since 2017.
- ② It is displayed on the screen throughout the exhibition space, augmenting the objects in the video with 3D images and providing explanations.



Figure 20. National Museum of Singapore(https://youtu.be/OMv92Dpcgfl)

#### (6) United States Holocaust Memorial Museum, United States

 AR technology is used for photos that have been on display since 2018 to augment photos, videos, etc. of Jewish life at that time, or to provide information by establishing a database of people in photos.



Figure 21. United States Holocaust Memorial Museum, United States (https://www.ushmm.org/)

## 3) Sub-conclusion

- (1) Most of the digital heritage content in Korea is made available to tour museums in various views in panoramic form on the Internet. Or, it is utilized to offer virtual experiences in the form of special exhibition-oriented 3D scan online exhibitions and gamification.
- (2) The overseas cases listed in this article are divided into the digitalization status of Korean materials collected from overseas museums, various virtual museum contents exhibited in special exhibitions, and the remains of cultural heritage restoration projects through ODA projects.
- (3) The contents of virtual museums that were previously displayed in museums or art galleries in the United States or the United Kingdom should be applied to the exhibition in Korea and developed and used. Based on what we have learned, we need to think about how to continue to use digitalized heritage as content in ODA projects related to Southeast Asian cultural heritage.

## 4. Analysis of Digital Heritage Content in ASEAN

## 1) Restoration of Cambodia's Angkor Wat

- In 2006, the Virtual Angkor was implemented at a total cost of about 500 million won. The core of the project is that Angkor Wat is the world's first digital content and organized in a virtual space.
- (2) On the wall of Angkor Wat, there are a total of 1,870 goddesses of Absara, using the method of shooting a laser to hold the shape with a computer.

#### Jongwook Lee



Figure 22. 3D Modeling of Angkor Wat (Culture Technology, 2006)



Figure 23. Mapping of the Central Tower (Culture Technology, 2006)

## 2) Digitization Project of Imperial City of Hue, Vietnam

- (1) The 'Digitization Project of Imperial City of Hue, Vietnam' was implemented in 2007. It is a part of the ODA project for conservation of cultural heritage of developing countries at the Cultural Heritage Administration, UNESCO Korea Committee and KAIST Graduate School of Culture and Technology.
- (2) The Imperial City of Hue, located in the ancient city of Vietnam, is associated with the last dynasty of Vietnam, the Nguyen Dynasty (1802–1945), and was listed as a UNESCO World Heritage Site in 1993.
- (3) Existing imperial buildings such as Taehwajeon (太和殿) in which foreign envoys were greeted, and Omun (午門), the entrance gate of the Imperial City of Hue, were measured, and the shape of the building was scanned and modeled in 3D. In addition, a drawing of the existing building was produced, and the appearance of damaged halls such as Geunjeongjeon was produced as a 3D image based on literature data and photographs. Based on these data, 3D animations for use in the ruins were produced and provided to the Vietnamese government. In the future, 3D data of the Imperial Palace is planned to be used as basic data for restoration of the Imperial Palace in the future.



Figure 24. Imperial Place after digitigation (Culture Technology, 2006)

## 3) Borobudur, Indonesia 3D Scan

- (1) Borobudur, along with Cambodia's Angkor Wat and Myanmar's Bagan, is one of the world's top three Buddhist sites, attracting more than 2.5 million tourists every year. Although Borobudur has maintained its original form, digital restoration work has begun because volcanic ash is settling on the site every year and it is necessary to capture its current appearance precisely.
- (2) The original form of the temple was digitized by the Eurasia Digital Cultural Heritage Research Institute through 3D digital equipment and documentation.
- (3) The method is as follows. First, accurate data was obtained by measuring with a laser scanner, and then the Borobudur temple was captured through a 3D image camera. After that, digitally processed data is covered with gold, silver, and pigments that have disappeared after being buried in volcanic ash.

#### Jongwook Lee



Figure 25. Digitization of Borobudur (Culture Technology, 2006)



Figure 26. Panoramic view of Borobudur Temple (Culture Technology, 2006)

#### 4) Restoration project of "Hong Nang Sida" in Laos

(1) The ODA for the Hong Nang Sida in Laos is the first of its kind in Korea as a cultural heritage restoration project. It has been in progress since 2013, and is still in progress. The first project will be completed in 2020. The first project focused on the restoration of the ruins in order to prevent further collapse of the heavily damaged ruins and to promote structural stabilization. The key to the planned secondary project is to create a foundation for self-reliance in the recipient country through the use of well-preserved relics as tourism resources. Further, digital restoration is also being planned.

## II. Design Method of Virtual Museum Education Program

## 1. Introduction of Virtual Museum Authoring Tools – ARTSTEPS, UNITY

## 1) Virtual Museum Authoring Program

- (1) 3D Production Program: UNITY, Unreal Engine, Artsteps, TRADKY, etc.
- (2) Using Artsteps in educational programs

## 2) ARTSTEPS

## (1) Overview of Artsteps

- Web-based environment for creating virtual art galleries in 3D space
- Design realistic 3D spaces and display real or virtual artifacts

### (2) Advantages of Artsteps

- 2D artifacts (e.g., paintings, photographs, posters), 3D artifacts (e.g., sculptures or 3D-type artifacts), and streaming videos can be displayed.
- 2 Virtual exhibitions can be included into websites or blogs
- ③ SNS can be updated
- (4) Assessment, discussion, and sharing

## (3) Disadvantages of Artsteps

- 1 Limits of spatial composition
- 2 Due to size limitations, insertable objects are very limited
- ③ 3D models are limited in quality
- ④ Texture is not included when a non-3D model that is searched by the site itself is recalled.

#### 3) UNITY

#### (1) Overview of UNITY

- Web-based environment for creating virtual art galleries in 3D space
- Design realistic 3D spaces and display real or virtual artifacts

#### (2) Advantages of UNITY

- Professional tools available in games, automotive transportation and manufacturing, movies, animation cinematics, design, engineering architecture, etc.
- Ability to drive files in various formats such as 3D, BIM, etc.
- Develop good quality output quickly and easily.
- Various graphic elements can be represented.

#### (3) Disadvantages of UNITY

- Difficult to learn simply at the beginner's level
- Too diverse to use
- No platform exists for virtual museum display
- Must be built up from scratch

#### 2. Curriculum design method

#### 1) Similar education cases

- Topic: Development of Digital Heritage Content in 10 ASEAN Countries - Invitation to Education Programs & Seminars
- (2) Audience: Cambodia. Indonesia, Myanmar
- (3) Date: October 30, 2017 (Monday) to November 3, 2017 (Friday)
- (4) Organized by: ASEAN Culture House, Heritage Digital Archive Center(HDAC)
- (5) Highlights: To produce VR experience contents of ASEAN Culture House, which opened in Busan, Korea on September 1, 2017, a three-year cultural heritage production project was conducted for representative cultural heritage of 10

ASEAN countries, and an educational program and seminar were conducted as part of the project.

DATE	EDUCATIONAL CONTENT	LOCATE	
Day 1, Day 2	<technology program="" transfer=""> - 3D data and 4K video description built in 2017 - Database utilization training - VR experience equipment training - Free gift of deployed data and VR equipment (HMD 1set)</technology>		
Day 3	Visit the ASEAN Culture House	ASEAN Culture House, Busan	
Day 4	Attend the World Digital Heritage Expo	Gyeongju EXPO	
Day 5	International Conference on Archiving and Conservation of Cultural Heritage 'New Trend of Digital Archiving Through Various World Heritage Sites'	National Palace Museum of Korea, Seoul	Presentation of HDAC

Table 1. Timeline of similar training cases

# 2) Producing educational programs using user-centered techniques

#### (1) Persona techniques

- ① Curriculum practically available to curators
- Identify user needs by setting persona
- ③ Selecting the person who will actually use the virtual museum (target user)
- ④ Specifying the form of the museum saying, 'I write a virtual museum that persona can do.'



Figure 27. User-centered technique-persona setting stage

## (2) The idea of Nomadic Practices

- 1 Ideation and classification
- ② Steps corresponding to the generation of ideas in design thinking techniques
- ③ Analysis of various elements needed for virtual museums
- 4 Three types of analysis: content, method, and technology



Figure 28. User-centered technique- The Idea of Nomadic Practices

## IV. Proposal of virtual museum education program

#### 1. Training Overview

- 1) Target : Southeast Asian cultural institution workers
- 2) Content : Virtual museum content plan

#### 3) Objectives

- (1) Providing training related to virtual museums to Southeast Asian cultural institutions
- (2) Providing opportunities to promote Southeast Asian cultural heritage at home and abroad

#### 4) Expectations

- Through the cultural exchange-type exhibition of the two countries, the value of relics can be viewed anew from the perspective of cultural exchanges.
- (2) Learning the culture and history of both countries at once.
- (3) There is a possibility of varied exhibition planning beyond the existing exhibition planning framework.
- (4) It can be linked to exchanges and cooperation between museums of the two countries.
- (5) Visitors can enjoy the exhibition of a museum from far away without having to visit in person.
- (5) Increased understanding of the interpretation of exhibition commentary

#### 2. Direction of training programs

Currently, there are not many educational programs or resources related to the production of virtual museums. However, we found some educational resources on experiencing digital education and learning digital technology. The educational program produced in this study is not just technology; when combined with technology and cultural heritage, it can help create virtual museums that are not only visible but also more advanced.

The difference between existing educational resources and the program proposed by this study is that it involves a sort of cultural exchange and it is a curatorial participatory education. Utilizing the characteristics of virtual museums without time and space restrictions, it creates cultural exchange-type museums, and allows curators to see and experience various technologies and think about technologies to incorporate into the exhibition.

#### 1) Cultural Exchange type virtual museum

(1) Target : Korean and Cambodian officials

#### (2) Concepts

- 1 A virtual museum of cultural exchange beyond space and time
- ② A shift from converting offline spaces from scanned interfaces to directly produced virtual space interface by applying matterport, VR, UNITY, etc.
- ③ An exchange-style project that installs a Cambodian virtual museum on the Korean museum site and a Korean virtual museum on the Cambodian museum site

#### 2) Curator-participated training

(1) Target : Korean and Cambodian officials

#### (2) Concepts

- With participatory education, the curator comes up with an idea and conceives a digital museum.
- ② The curators are educated about digital technologies, following which they discuss which technologies are most suitable for their ideas.
- ③ Curators suggest cases to be applied.
- ④ Without focusing on either technology or artifact, two experts

naturally grafted it through discussion and ideation.

⑤ Production of the finished product after several prototyping exercises, rather than outputting at once.

## 3. Training curriculum

DATE	EDUCATIONAL CONTENT	LOCATE
Day 1	Guide of Virtual Museum Definition and Scope Advantages and disadvantages of virtual museums Introduction of Virtual Museum Case Introduction and Analysis of Virtual Museums for Cultural Exchange	
Day 2	<planning> Cultural Heritage 3D Data Experience Storyboard Planning Digital Storyboard Planning Group Sharing <building> UNITY and ARTSTEPS Training Produce Prototype 3D Model Selection &gt; Game Engine Installation and Operation &gt; Virtual Terrain Creation &gt; 3D Model Placement &gt; Information Panel Placement &gt; Interaction</building></planning>	٦
Day 3	Group prototype presentation Assessment and feedback	

Table 2. Schedule of Virtual Museum Production Training Program

## V. Conclusion

In this study, an educational program was developed to help curators and cultural heritage practitioners in the ASEAN region understand and utilize virtual museums. Existing research only categorized cases of digital heritage, simply combined technology and cultural heritage content, or combined new content into the original system. The COVID-19 pandemic increased the demand for digital heritage, and in line with this, ASEAN-related experts tried to develop education to understand virtual museums and create virtual museums themselves. Therefore, it is proposed to produce "educational programs for establishing cultural exchangetyped virtual museum." Through this program, ASEAN-related experts can understand virtual museums and learn how to use virtual museum authoring tools in a simple way. It also uses usercentered techniques to enable the students to participate directly and create storyboards. This study is significant in that it consists of expert education on digital heritage planning. It presents a basic framework for building a virtual museum in line with the fourth industrial revolution, which makes it easier for many people to access cultural heritage without any time or space restrictions. However, this study only produced a basic curriculum. In the near future, a detailed education plan must be developed by adding specific details and recommendations, and online and offline pilot operation of the education program is needed. In the long run, authoring tools suitable for virtual museums that go beyond ARTSTEPS should be produced.

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	Children's Museum of the National Museum of Korea
	(https://www.museum.go.kr/site/child/home/)
	Oegyujanggak Uigwe of National Museum of Korea – Virtual experience of Banchado
	(https://www.museum.go.kr/uigwe/)
	National Folk Museum of Korea (https://www.nfm.go.kr/)
	Children's Museum National Folk Museum of Korea
	(https://www.kidsnfm.go.kr/nfmkid/index.do/)
	Seoul Museum of History(https://museum.seoul.go.kr/)
	Website of Seoul Museum of History for children (https://museum.seoul.go.kr/ chd/index.do/)
	Gwangju National Museum(https://gwangju.museum.go.kr/cyber)
	National Museum of Denmark (http://denmark.nfm.go.kr/)
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	Sites in Southeast Asia」
	Park Min-seo. Choi Yeon-hwa, Lim Soon-beom, 2008 <sup>r</sup> Use Cases of Digital
	Heritage Projects at Home and abroad」
	Park Jin-ho, 2008 <sup>r</sup> Cambodia Angkor Wat Digital Restoration」
	Lee Ji-hyung, Kang Kyung-kyu, Kim Jae-woo, 2014 <sup>r</sup> Experience system for
	assembling digital architectural cultural assets using absent miniatures」
	Jo Jung-hoon, Woo Yoon-taek, 2016 <sup>r</sup> Designing an Outdoor Environment
	Augmented Reality Authoring Tool for Cultural Heritage Experience」
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	the Writing of Virtual Museum」
	Lee Myung-jin, Won Do-yeon, 2017 <sup>r</sup> A Study on the Utilization of Digital
	Contents of Iksan Baekje Cultural Heritage」
## International Journal of Asian Heritage

# Pacific Studies:

## Sustainable Conservation of Cultural Heritage

## 아시아 문화유산 연구:

## 문화유산의 지속가능한 보전

태평양

## 2. Survey Research Papers on UNESCO Chair Research Grant

Bridging Asian Communities with New Academic Partnerships and the Exchange of Ideas: Capacity Building in Architectural Heritage Conservation Nikhil Joshi

> Decoding Authenticity: Post 2015 Earthquake Reconstruction in Kathmandu Valley Heritage Sites Monalisa Maharjan

Formulationg "Local HUL" Instrument for Community Based Cultural Heritage Management in the Histori Urban Core of a Medium City – with Semarang and Solo in Indonesia as Case Study Eko Nursanty

Study on the Integration Mechanism of Heritage Conservation and Sustainable Development of Historical Cities Along the "Maritime Silk Road" – Take the Group sity "Guangzhou–Hong Kong" as an Example Yan Wang Bridging Asian Communities with New Academic Partnerships and the Exchange of Ideas: Capacity Building in Architectural Heritage Conservation

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## Abstract

Given the current lack of awareness and training regarding heritage conservation in Asia, it is inevitable that advanced discourses about cultural heritage management are urgently required at every level from the regional to national and global, and so are skilled historic building professionals. It is believed that the current heritage education situation would get even worse in the future due to the rapid urban development of historic cities and mass tourism in Asia if nothing is planned now. The need to lead a collaborative effort with top Asian university partners to advance conservation pedagogy and research is urgently required. This proposed offering would train skilled professionals in architectural conservation who would subsequently develop the region's heritage conservation capacity.

This paper aims to provide a framework for establishing the Asian heritage education community of five Asian universities, which are already running or intending to offer heritage conservation degree courses soon, to develop architectural conservation pedagogy and research. The collaborative programmes would then be provided for students and professionals in the region through classroombased or online programmes. The universities, which could become a part of this heritage community are Korea National University of Cultural Heritage (Seoul, South Korea), National University of Singapore, Southeast University (Nanjing, China), Tsinghua University (Beijing, China), and University of Hong Kong (Hong Kong SAR).

## 1. Introduction

In today's world, a paradigm shift is witnessed in heritage conservation aims from primarily cultural to mostly economic, and to varying degree political aspects as well. Most less-developed countries in Asia, which are already experiencing rapid growth, face several issues and prospects of their urban and rural areas struggling with unplanned urbanization and migration of people, subsequently adding the pressure on cultural heritage management. The degradation of the historic regions of less-developed Asian cities affects the quality of life of millions of residents and migrant workers who have been living and working in historic cities for a long time.

With the exponential growth of several Asian economies in recent decades and the subsequent increase in an average individual's disposable income, heritage tourism in Asia has been transformed into a multi-billion-dollar industry. The consumption of selected (mostly 'monumental' as designated by authorities) heritage sites for profit, in turn, transforms heritage into a commodity for the consumption of mainly foreign tourists. The 'everyday' heritage, which has been a significant aspect of the local identity, mostly struggles to find funding and interest from professionals and authorities. These situations force us to reconsider many issues. What should be an all-inclusive definition of 'heritage' in the context of varied and 'living' Asian culture? Why is a place significant? What type of heritage categorization framework should be used for heritage assessment? What is the role of local narratives and identity in the designation and management of heritage? What is the difference between the Western and Eastern approach to heritage conservation? What is the role of Asia's shared past in shaping its collective future?

Significant monuments, sites, and landscapes are being threatened increasingly by rapid and uncontrolled developments of the built environment. This raises the question: Is our architectural heritage becoming marginalized or even irrelevant to give way to the production of our contemporary built environment? The answer is indeed no, if we manage to convince the stakeholders and policymakers of the power of heritage places; and integrate them into the overall built environment. This asks for a radical integration of heritage preservation policies and practices into the overall urban development and environmental planning practices and procedures, necessitating a multidisciplinary, interdisciplinary training of future heritage professionals who could well understand the nuances and uniqueness of diverse Asian cultures.

The World Heritage Capacity Building Strategy (WHC-11/35. COM/9B) was adopted at the 35th session of the UNESCO World Heritage Committee, held in Paris during June 19-29, 2011 (UNESCO 2011). It stressed the importance of developing regional capacitybuilding strategies and addressed the lack of training components to protect World Heritage and heritage in general. The severe lack of formal higher education programmes in heritage conservation in Asia-Pacific and the influential role of universities in providing capacity building for cultural heritage conservation was highlighted in the 'UNESCO Expert Meeting on Developing a Competence Framework for Management of Cultural Heritage Sites in Southeast Asia' held in Bangkok, on June 4-6, 2018. Given an increased awareness regarding heritage as a significant resource to a nation's economy and the lives of its citizens, it is inevitable that advanced discourses about sustainable heritage management will soon be required at every level from the local to regional and to a global scale, and so will be the skilled historic building professionals. On March 25–26, 2019, sixteen Asian universities met at the National University of Singapore (NUS) to discuss this issue and promote cooperation and strengthen cultural heritage education. This meeting was organized by UNESCO and the Department of Architecture, NUS.

Although most Asian universities and heritage conservation related agencies are aware of the shortage of training and education programmes based in the region for young and mid-career professionals, very little has been done in recent years to resolve this issue in the long run. Most less-developed Asian countries still very much rely on western experts for advice and consultation to manage their heritage sites, including UNESCO World Heritage sites, as they have very little or no heritage conservation capacity building of their own. Hence, it is more urgent than ever to locally train skilled professionals in the conservation field who, with their in-depth knowledge and practical skills, would make informed decisions to preserve their heritage for the present and future generations.

In Singapore, traditional building materials and skilled craftspersons vanished probably during the mid-twentieth century. In Singapore, it is almost impossible to find a working craftsperson or traditional building materials such a lime, clay roof tiles, etc. It is important to note that Singapore has over 7,200 designated historic buildings in more than 100 conservation areas, 73 gazetted national monuments and a UNESCO World Heritage Site. Since the traditional building craft skills have entirely disappeared from Singapore, it has a significant effect on the quality of built heritage structures in Singapore, both the materials and craftsperson are generally imported from other countries, which increases the project cost significantly. The imported materials may or may not be entirely suitable for the local context.

Singapore does not have any specialized built heritage training or education programme at present to train its homegrown professionals and develop their heritage capacity building. Students and professionals interested in learning about heritage conservation have to study overseas (mostly in European countries) to gain heritage conservation training, which is undoubtedly costly compared to studying in Asia. The high cost of studying abroad is the main deterrent for many interested individuals interested in learning cultural heritage management. Since 2016, the Department of Architecture (NUS) has successfully conducted a few architectural conservation-related hands-on workshops and training programmes for local and regional students and professionals to tackle the lack of conservation education opportunities. It will offer a new Graduate Diploma, Graduate Certificate, and Master of Arts in Architectural Conservation programme, commencing in January 2021. This advanced programme aims to provide a unique perspective on diverse Asian cultures, to provide students with comprehensive knowledge and essential hands-on training and experience to develop skills for a range of careers in historic building conservation and related fields. It would offer the students diverse opportunities to enhance their existing skills or build new competencies to advance their careers. This programme, through its balanced approach towards architectural conservation theory and practice with Asia as its central focus, endeavours to train the future policymakers, architects, craftspersons, academics, real estate entrepreneurs, engineers, and surveyors to excel in their careers for sustainable management of the historic environment of Singapore and the region. However, with the current lack of support ecology for heritage conservation professionals, mainly in Singapore and generally in Asia, it is unlikely that heritage conservation education and training programmes would attract a high enrollment, making it costly to run. Thus, new academic partnerships and the exchange of ideas are urgently required to bridge Asian educational communities and build their national and regional capacity in heritage conservation.

## 2. Bridging the gap: Conservation education in Asia

## 2.1. Aims and objectives

This paper aims to propose an online or other innovative pedagogy for heritage conservation courses by creating a network of resources and synergy with five Asian universities currently offering or intending to offer heritage conservation postgraduate-level courses. The universities, which are a part of this study, are the following:

- 1. Korea National University of Cultural Heritage (Seoul, South Korea)
- 2. National University of Singapore (Singapore)
- 3. Southeast University (Nanjing, China)
- 4. Tsinghua University (Beijing, China)
- 5. University of Hong Kong (Hong Kong SAR)

The focus of this paper is to examine curricula of five Asian universities currently offering/ planning to offer postgraduate studies in conservation to:

- Investigate similarities and differences in conservation modules.
- Examine the conservation teaching and learning in the present curricula of schools/ departments.
- Synthesize collected information to establish if advanced conservation joint courses could be developed between schools/ departments to meet on-the-ground cultural heritage management needs in the region. Moreover, to further develop an education plan to address future demands in the heritage sector.

## 2.2. Teaching conservation: Issues and the way forward

## 2.2.1. Developing heritage ecology in Asia

Several universities in Western countries have been offering postgraduate courses in conservation/ restoration of historic buildings, and most of them are well established, such as the University of York (UK), Katholieke Universiteit Leuven (Belgium), University of Columbia (USA), and Carleton University (Canada) to name a few. While most Western universities are aware of the significance of heritage conservation education and treat it as a part of architectural education, in Asia, it is unfortunately still not considered a primary programme. It is rather mostly regarded as a secondary subject to architectural teaching. It is beyond doubt that Asian countries have a great wealth of rich and diverse cultural heritage. However, it would not be wrong to say that in the current education and practice scenario, architecture and conservation often appear to be as poor neighbours in most Asian architecture schools, with no or little communication even in the times of deep transformations which would instead demand their profound and meditated integration. It is vital to ask "what" and "how much" architectural education can offer to conservation education and "what" and "how much" conservation education can provide to architectural education.

The COVID-19 global pandemic has posed daunting challenges for communities and extraordinary opportunities to rethink socioeconomic policies and educational ecosystems. Consequently, much has been at stake for educators and students who engage with the various communities that are the custodians of heritage as the pandemic brought on constraints and obstacles for physical interaction and communication. Hence, exploring and harnessing the "new normal" of learning via alternative ways and initiating community engagement through various digital platforms should be the impetus for a long-overdue overhaul of our architecture education system, and the way conservation training is imparted in institutes of higher learning. The digital revolution impacts all aspects of our lives, particularly access to information and knowledge. Consequently, conservation education must engage with how this change affects our sense of time and history and with ideas concerning heritage conservation in developing Asia.

The current lack of support ecology for heritage conservation professionals in most Asian countries calls for an urgent and readily available local or regional opportunity for training and research in this field. However, after university education, a lack of appropriate job opportunities is the main deterrent for many interested students to join conservation courses. This makes several currently running conservation programmes in Asian universities less attractive to students, making them financially unsustainable. Besides, specialized programmes offered in Western countries,

mainly Europe, are expensive and not very suitable for the Asian conservation context. It is necessary to provide a choice to our regional students to earn a conservation degree in their home country by facilitating cooperation in the delivery of conservation courses by various Asian universities, using technology to enhance exchanges, and promoting the study of Asian-centric conservation issues. Interuniversity collaboration, enhanced by technology, will undoubtedly make it more cost-effective to sustain a conservation course. Besides, online education would also attract several midcareer professionals and craftspersons from many developing Asian countries who may not be able to leave their current jobs to attend university for the entire duration (generally one to two years) of the course. The online classes would also provide greater flexibility, as demonstrated by the present coronavirus pandemic crisis when most of the universities, including Asia's premier university, National University of Singapore, has been using various e-platforms to deliver classes. In addition, online courses are also better valued in terms of the financial cost to a university. By building a community of universities offering heritage conservation education and research, it would create a network of resources and synergy among partners to support classroom and online or other innovative pedagogy for conversation education and training. This collaboration of Asian universities would benefit the design of various training programmes and curricula to meet on-the-ground critical needs in cultural heritage management and conservation by producing locally/ regionally trained conservation professionals ready to serve their nation's rich cultural resources.

## 2.2.2. Competence framework for cultural heritage management

In 2018, UNESCO launched an initiative to develop a competence framework to assist cultural heritage site management agencies in strengthening their staff capacities, to ensure improved effectiveness and quality of site conservation and management. This initiative also aimed to help universities and training institutions in designing appropriate courses, curricula, and qualification standards to meet on-the-ground training needs in the fields of cultural heritage management and conservation. The outcome of this effort is the Competence Framework for Cultural Heritage Management (UNESCO 2020) (see figure 1).

The Competence Framework identifies areas of competence (i.e., skills and knowledge) for the various practitioners, at both the institutional and individual levels, involved in managing cultural heritage, including government staff, professionals, and local stewards. The Framework covers four levels of personnel: i) skilled worker, ii) middle manager/ technical specialist, iii) senior manager, and iv) executive. In this way, it spans all types of personnel, from vocational workers to decision-makers, involved in the various aspects of managing cultural heritage.



Figure 1. Overview of the Competence Framework. Source: UNESCO 2020, p 31

It is hoped that the Framework can also be used to stimulate international and intraregional cooperation in the exchange of professional skills and their transmission. While most professionals in the Asia-Pacific region acquire much of their skill and knowledge in the heritage field through work-based learning and personal experience, an increasing number of professionals in the region are gaining skills and knowledge from education programmes in cultural heritage management, which are becoming more numerous and accessible. Based on the core competencies and managerial competencies in the Competence Framework (see figure 1), UNESCO developed a set of academic learning outcomes for postgraduate education in cultural heritage management. The learning outcomes are designed to help higher education institutions in this field to prepare their graduates better and ensure that the graduates' skills, knowledge, and attitudes meet industry needs and expectations, thus enhancing graduates' career prospects and performance, as well as contributing to improving the management of cultural heritage. One of the Competence Framework's primary purposes is "to facilitate the design of appropriate education and training for cultural heritage professionals" (UNESCO 2020, p 19).

## 2.2.3. Sustainable heritage management foundation course jointly run by five Asia-Pacific universities

In November 2020, UNESCO launched the inaugural 'Sustainable Heritage Management Foundation Course' for heritage practitioners in the Asia-Pacific region to upskill and reskill core competencies (see figure 2). Pressures on cities such as the current pandemic, climate change, economic slowdown, and conflicts mean that heritage management approaches need to be reinvented. It has been argued that the conservation-related objectives should go beyond the built heritage conservation, and heritage managers must also mobilize heritage for the local development, as defined by the Sustainable Development Goals. Conducted by UNESCO Bangkok in cooperation with the Think City Institute and the Asian Academy for Heritage Management, the Sustainable Heritage Management Foundation Course course was designed to upskill and reskill professionals working on heritage management, focusing on South-East Asia, to meet these new demands. It covers five core areas of practice defined under UNESCO's new 'Competence Framework for Cultural Heritage Management' and is developed and run by five Asia-Pacific universities (three of them, which are in bold below, are also part of this study):

- 1. University of Hong Kong offering a module on the topic of "Sustainable development."
- 2. National University of Singapore offering a module on the topic of "Heritage policies, principles, processes and ethics."
- 3. Southeast University offering a module on the topic of "Applying laws and regulations."
- Deakin University offering a module on the topic of "Community, rights and knowledge."
- 5. Ahmedabad University offering a module on the topic of "Heritage education and interpretation."

It offers a combination of self-paced online learning and interactive webinars, followed by a capstone project and finale event. The duration of the course is six months, from November 2020 to April 2021. More details about the programme can be found here: https://thinkcity.com.my/sustainable-heritage-managementcourse/



## **SUSTAINABLE**

The current pandemic and other pressures such as climate change, economic slowdown, and conflicts require rethinking approaches to heritage management. Beyond conservation-related objectives, heritage managers must also mobilize heritage for local development, as defined by the Sustainable Development Goals

The Course will upskill and reskill professionals working on heritage management, with a focus on Southeast Asia, to meet these new demands. It will cover five core areas of practice defined under UNESCO's new Competence Framework for Cultural Heritage Management as follows:

Sustainable Development \_ (led by University of Hong Kong)

- Heritage Policies, Principles, Processes and Ethics (led by National University of Singapore)
  - Applying Laws and Regulations \_ (led by Southeast University) \_
  - Community, Rights and Knowledge (led by Deakin University)
  - Heritage Education and Interpretation (led by Ahmedabad University) -

The Course is conducted by UNESCO Bangkok in cooperation with the Think City Institute and the Asian Academy for Heritage Management.

It offers a combination of self-paced online learning and interactive webinars, followed by a capstone project and finale event





## NOVEMBER 2020 - APRIL 2021 APPLICATION DEADLINE: 26 OCTOBER 2020

Visit https://thinkcity.com.my/ sustainable-heritage-management-course/ For More

Figure 2. Call for Applications: Sustainable Heritage Management Foundation Course. Source: https://bangkok.unesco.org/content/call-applications-sustainableheritage-management-foundation-course

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## 3. Heritage conservation education: Status in selected five Asian universities, and observation for development of joint courses

Between May-June 2020, the programme director/ coordinator of conservation programmes of those mentioned above selected five Asian universities were contacted via emails to gather information about their existing/ planned heritage conservation courses at postgraduate-level, taught in English. Four out of the six universities contacted shared their detailed course outline, including topics covered and programme schedule. While the University of Hong Kong offers a two-year full-time MSc (Conservation)<sup>1</sup> and Postgraduate Diploma (Conservation), the National University of Singapore offers Graduate Certificate, Graduate Diploma, and MA in Architectural Conservation (one-year, full-time) commencing in January 2021

(https://www.sde.nus.edu.sg/arch/programmes/master-of-artsin-architectural-conservation/),

the Southeast University mainly offers a short and intensive course "Advanced theory in urban and architectural heritage conservation," and Tsinghua University offers the "Conservation Resources for Architectural Interior and Furniture Training (CRAFT)" programme, taught in four semesters spread over two years. It has a unique profile in that it offers multidisciplinary education and training on cultural studies, material science and conservation skills by using Palace Museum-World Monuments Fund's Qianlong Garden Conservation Project as a laboratory.

As I write this report, MSc (Conservation) admission in 2020 was the latest admission for the part-time programme, and the 2021 admission will be the latest one for the full-time programme at the University of Hong Kong.

Start date	
No. of hours	
Module #	
Module title	

Jan	39hrs	AC5001	Architectural History of Singapore		
Jan	39hrs	AC5002	Conservation Approaches and Philosophies		
Aug	39hrs	AC5003	Urban Conservation and Regeneration		
Jan	39hrs	AC5004	Architectural Heritage Management		
Jan	39hrs	AC5005	Conservation Policy Methodology for Sustainable Development		
Jan	51hrs	AC5008	Design for Conservation		
Jan	39hrs	AC5010	Historic Buildings Survey and Recording		
Jan	39hrs	AC5012	Practical Building Conservation Skills I		
Jul	39hrs	AC5011	Conservation of C20th Buildings		
Aug	39hrs	AC5006	Disaster Risk Management of Cultural Heritage		
Aug	13hrs	AC5007	Dissertation		
Aug	51hrs	AC5009	Design for Adaptive Reuse		
Aug	39hrs	AC5013	Practical Building Conservation Skills II		
Aug	39hrs	AR5xxx	Elective		
Dec	45hrs	AC5014	Internship		
Start date	No. of hours	Module #	Module title		
National University of Singapore MA in Architectural Conservation (MAArC)					

Table 1. Summary of a survey of postgraduate-level conservation courses in selected universities in Asia

Tsinghua University Conservation Resource for Architectural interior and Furniture Training (CRAFT)								
Sep	Oct/Nov							
32hrs	16hrs	32hrs	16hrs	32hrs	16hrs			
80000502	80000722	NA	80000722	NA	80000722			
Ethics	Art and Building Material and Techniques	Wood Science	Optical Microscopy I	Instrumental Analyses	Optical Microscopy II			

Start date			
No. of hours			
Module #			
Module title			

National University of Singapore						
Start date	No. of hours	Module #	Module title			
Dec	45hrs	AC5014	Internship			
Aug	39hrs	AR5xxx	Elective			
Aug	39hrs	AC5013	Practical Building Conservation Skills II			
Aug	51hrs	AC5009	Design for Adaptive Reuse			
Aug	13hrs	AC5007	Dissertation			
Aug	39hrs	AC5006	Disaster Risk Management of Cultural Heritage			
Jul	39hrs	AC5011	Conservation of C20th Buildings			
Jan	39hrs	AC5012	Practical Building Conservation Skills I			
Jan	39hrs	AC5010	Historic Buildings Survey and Recording			
Jan	51hrs	AC5008	Design for Conservation			
Jan	39hrs	AC5005	Conservation Policy Methodology for Sustainable Development			
Jan	39hrs	AC5004	Architectural Heritage Management			
Aug	39hrs	AC5003	Urban Conservation and Regeneration			
Jan	39hrs	AC5002	Conservation Approaches and Philosophies			
Jan	39hrs	AC5001	Architectural History of Singapore			

MA in Architectural Conservation (MAArC)

Southeast University Advanced Theory in Urban and Architectural Heritage Preservation/ MArch*								
Jun	Jun	Jun	Jun	Jun	Jun	Jun		
2hrs	2.5hrs	2hrs	2hrs	2hrs	2hrs	2hrs	54hrs	
C1	C2	C3	C4	C5	C6	С7	S001324	
Conservation, Sustainable Development, and Urban Resilience	The World Heritage Conservation Process	Integrating the Tangible with the Intangible	Engaging Community in the Conservation Process	Under- standing Best Conservation Practice in an Asian Context	Urban Heritage Resilience Across Time and Space	The Heritage Manager's Dilemma: Conservation or Re- development	*Architectural Design	

Start date	
No. of hours	
Module #	
Module title	

National U	National University of Singapore					
Start date	No. of hours	Module #	Module title			
Dec	45hrs	AC5014	Internship			
Aug	39hrs	AR5xxx	Elective			
Aug	39hrs	AC5013	Practical Building Conservation Skills II			
Aug	51hrs	AC5009	Design for Adaptive Reuse			
Aug	13hrs	AC5007	Dissertation			
Aug	39hrs	AC5006	Disaster Risk Management of Cultural Heritage			
Jul	39hrs	AC5011	Conservation of C20th Buildings			
Jan	39hrs	AC5012	Practical Building Conservation Skills I			
Jan	39hrs	AC5010	Historic Buildings Survey and Recording			
Jan	51hrs	AC5008	Design for Conservation			
Jan	39hrs	AC5005	Conservation Policy Methodology for Sustainable Development			
Jan	39hrs	AC5004	Architectural Heritage Management			
Aug	39hrs	AC5003	Urban Conservation and Regeneration			
Jan	39hrs	AC5002	Conservation Approaches and Philosophies			
Jan	39hrs	AC5001	Architectural History of Singapore			

MA in Architectural Conservation (MAArC)

## University of Hong Kong MSc in Conservation

 Sep	Oct	Mar	Apr	Nov-Dec	Nov		
23hrs	30hrs	54hrs	26hrs	49hrs	29hrs		72hrs
CONS8110	CONS8103	CONS8104	CONS8109	CONS8112	CONS8027	CONS8205	CONS8203
Architectural Heritage and its Significance	Charters and Legislation of Conservation	Management and Practice in Conservation	Cultural Landscapes	Repair and Restoration of Heritage Buildings	Heritage Inter- pretation in Conservation	Dissertation	Practical Training in Conservation

Start date			
No. of hours			
Module #			
Module title			

National Ur	National University of Singapore						
Start date	No. of hours	Module #	Module title				
Dec	45hrs	AC5014	Internship				
Aug	39hrs	AR5xxx	Elective				
Aug	39hrs	AC5013	Practical Building Conservation Skills II				
Aug	51hrs	AC5009	Design for Adaptive Reuse				
Aug	13hrs	AC5007	Dissertation				
Aug	39hrs	AC5006	Disaster Risk Management of Cultural Heritage				
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Jan	39hrs	AC5012	Practical Building Conservation Skills I				
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Jan	39hrs	AC5004	Architectural Heritage Management				
Aug	39hrs	AC5003	Urban Conservation and Regeneration				
Jan	39hrs	AC5002	Conservation Approaches and Philosophies				
Jan	39hrs	AC5001	Architectural History of Singapore				

MA in Architectural Conservation (MAArC)

## Korean National University of Cultural Heritage Graduate Degree Course

Interpretation and Criticism in World Heritage	Theories of World Heritage	Conservation Management of World Heritage	Conservation Philosophy of World Heritage	Conservation and Restoration of World Heritage	Repair Technique of Modern Cultural Heritage	Maintenance Theory of Modern Cultural Heritage	Conservation and Use Technique of Modern Cultural Heritage

## continued from p. 8

Start date			
No. of hours			
Module #			
Module title			

National University of Singapore					
Start date	No. of hours	Module #	Module title		
Dec	45hrs	AC5014	Internship		
Aug	39hrs	AR5xxx	Elective		
Aug	39hrs	AC5013	Practical Building Conservation Skills II		
Aug	51hrs	AC5009	Design for Adaptive Reuse		
Aug	13hrs	AC5007	Dissertation		
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Jan	51hrs	AC5008	Design for Conservation		
Jan	39hrs	AC5005	Conservation Policy Methodology for Sustainable Development		
Jan	39hrs	AC5004	Architectural Heritage Management		
Aug	39hrs	AC5003	Urban Conservation and Regeneration		
Jan	39hrs	AC5002	Conservation Approaches and Philosophies		
Jan	39hrs	AC5001	Architectural History of Singapore		

MA in Architectural Conservation (MAArC)

## Korean National University of Cultural Heritage Graduate Degree Course

	-						
Conservation and Application Methods of Historic Cities	Comparative Studies of Modern Urbanism	Urban Morphology and Historic Urban Restoration	Preservation and Management of Historic Urban Landscape	Conservation Philosophy in Architectural Cultural Heritage	Study of Traditional Building Materials	Cultural Heritage and Construction Methods	Engineering Research in Wooden Architecture

## 4. Conclusion

Unlike mainstream architectural design education, which generally follows a hands-off approach, heritage conservation teaching and learning should be hands-on. It is impossible to conserve a building without being involved with the setting because preserving is a creative act using the resources, both physical and cultural, available within that setting and sustaining cultural values in the historic environment. Hence, any heritage conservation academic course in the Asian context must balance theory and technical knowledge. It is evident from the above samples of current offerings in the Asian region that the conservation programmes seem to have some commonalities both in content and the mode of delivery (generally face-to-face teaching). These commonalities could be explored further to develop various joint courses using diverse teaching methods such as face-to-face, online and hybrid that would bring the best of the faculty from various Asian universities, with expertise in multiple aspects of conservation issues relevant to the Asian context. As I conclude this paper, I am pleased to state that both the National University of Singapore and the Korean National University of Cultural Heritage are in discussion to jointly develop at least two modules on sustainable management of historic urban cities in Asia and conservation of World Heritage sites. Both courses will be offered via a digital platform in 2021. Also, the National University of Singapore and Southeast University is planning to provide a joint conservation design studio for architecture/ architectural conservation students in the second half of 2021.

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## Decoding Authenticity: Reconstruction of Rani Pokhari Post 2015 Earthquake in Nepal

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## Abstract

The earthquake of 2015 caused immense damage to the cultural heritage of Kathmandu Valley. It also triggered debates on authenticity. Due to the type of construction materials used, seismic vulnerability, and organic linkages of people with the heritage, the values defining authenticity are quite different in Nepal, compared to the West. Among several sites that were destroyed in the earthquake, Rani Pokhari was chosen as the subject of this study. This site is an interesting case due to several aspects. First, it was the most controversial site under reconstruction and also, it is the first site where the locals, experts, and youth protested against the plan to reconstruct the site in a non-traditional style. Second, it was a white washed dome shaped temple in the centre of the pond before the earthquake, which was reconstructed in sikhara style. Also, from its construction in 1670 to 2015, it had undergone several cycles of restoration, renovation, and even reconstruction.

The study took place during the reconstruction by the National Reconstruction Authority so the on- site observation along with the controversies and issues raised could be included and analyzed. Looking through the lenses of authenticity in heritage reconstruction, this paper explores different values in context of Nepal and discusses the traditional practices and the practices prevalent in heritage conservation post 2015.

Keywords Authenticity, Heritage Conservation, Kathmandu Valley, Earthquake.
## 1. Introduction

On April 25, 2015, an earthquake of 7.8 magnitude hit Nepal. It destroyed numerous monuments, historic buildings, and houses, taking more than 5000 lives. According to the preliminary list from the Department of Archeology survey, only within the Kathmandu Valley, 76 monuments completely collapsed and other 357 were partly damaged or partly collapsed. Among these monuments the chosen site of study - Rani Pokhari was partially damaged. The last devastating earthquake took place in 1934, which was of 8.4 magnitudes and was known as Great Bihar Earthquake (Government of Nepal, 2015). After eighty years, the earthquake of 2015 was a massive threat as the population density of cities had increased massively. Earthquakes are common in Nepal, with devastating earthquakes occurring at the interval of 80–100 years. The earthquakes of 2015 not only prove to be destructive but also prose a challenge in heritage restoration and reconstruction.

As most of the countries in the world Nepal didn't had formal heritage conservation practices in the previous earthquake. Only in 1956, Nepal passed the first formal heritage conservation act—the Ancient Monument Preservation Act. Nepal received international exposure in the field of heritage conservation with the declaration of Kathmandu Valley as a UNESCO World Heritage Site in 1979. Many Nepalese heritage professionals received training from intergovernmental agencies such as UNESCO and UNDP, which had a significant impact on the heritage policies and conservation plans of Nepal (Chapagain, 2008). The daily lives of Nepali people are deeply linked with the nation's tangible and intangible heritage. Communities still take care of the temples, monuments, and courtyards that have been passed on through generations as well as perform rituals, organize festivals, and sometimes restore monuments as well (Maharjan, 2016).

The international heritage conservation practices treat tangible and intangible heritage as separate entities with two different conventions. Even though, intangible heritage got the formal recognition much later with the convention for the Safeguarding of Intangible Cultural Heritage in 2003. The Venice Charter (1964), focused on historic buildings and sites, was insufficient to protect living heritages such as those in Nepal. For archeological heritage and museum objects, which are presented as exhibition pieces, the Venice charter and early operational guidelines are applicable. But the heritages that are still living undergo wear and tear in the process. The communites also restore, replace, remake and reconstruct the monuments as needed. Such activities are happening since the seventh century, the time of Amsuverma, according to Prof. Sudarshan Raj Tiwari<sup>1</sup>. The Nara document highlights the intangible values associated with the monuments and sites. Interestingly the Nara document was born out of the controversy in the reconstruction of a Buddhist monastery by the Japanese cooperation project (Masuda, 2015) which also led to a decade long discussion ultimately leading to the listing of Kathmandu Valley World Heritage Site in the Danger list in 2003 (Kai, 2015).

The earthquake of 2015 was a wakeup call for the management of the dense city and heritage conservation. It also opened a Pandora's box of authenticity issues. Taking the case of reconstruction of Rani Pokhari, a highly controversial project, this paper will analyze the authenticity in context of Nepal and post 2015 earthquake. This paper does not aim to provide a panacea for the authenticity issue of Kathmandu Valley but intends to contribute in the on-going discussion in a scientific way and continue the momentum.

<sup>1.</sup> Interview with Prof Sudarshan Raj Tiwari took place on July 30, 2020. Also conversations in several informal meetings occurred.

## 2. Methodology

Since Kathmandu Metropolitan City (KMC) started the reconstruction of Rani Pokhari, the site has been in controversy. It drew protests and criticism from locals, civil societies, activists, and experts. The author was also involved in organizing events to restore the pond in the traditional way so the information from that period is also included in the paper. Literature review of the relevant national and international documents, research articles, books, reports, translations of the stone inscriptions, and newspaper articles was done. During the research phase the reconstruction of the pond and temple was in process, so direct observation of the site was also possible. Several field visits were made, due to which the process of reconstruction, engagement of the people, and other aspects of the site could be observed. The materials and technology used in the reconstruction, as well the process itself were observed. The author also interacted with the masons, craftsmen, carpenters, and workers on the site. Due to the Covid-19 pandemic, field visits could not be undertaken at the beginning. After the second phase of the lockdown, the reconstruction work continued as the reconstruction came under the pride project<sup>2</sup>. Necessary precautions were taken while field visits and social distancing was maintained during in person interviews.

Interview was another form data collection used for the research. Interviews with experts, artisans, architects, mansions, heritage activists, locals, and heritage professionals were conducted. During the site visits, masons, carpenters/artisans, and site managers were interviewed. Some of the interviews were formal while others were informal talks. Further, interviews were conducted with experts, heritage professionals, and communities involved;

<sup>2.</sup> To speed up the reconstruction of the destroyed monuments, Government of Nepal designated few projects as pride project. The priority was given to such projects with funs and necessary support.

these took place in other locations, not on the site. The interview questions were open-ended. The interviews were recorded with permission of the interviewees. Some respondents chose not to be recorded due to the controversies associated with the site. Also some interviews were done over the phone due to the pandemic.

When the reconstruction was in the final stage, issues related to the water recharging system ignited a fresh controversy. Activists and experts organized online discussion programs such as "Water management in Rani Pokhari: The way forward." Additionally, onsite protests and discussions were held. All these programs and events were intended to pressurize the authorities to reconstruct the pond and temple in the traditional way. This process was also documented and analyzed. The researcher was also coordinating the online discussion on authenticity with the ICOMOS Nepal members. These discussion programs helped gain insights in authenticity in context of Nepal. Analysis of the old pictures of the pond and temple was also done to understand how the site has changed from past to present.

## 3.1 Study Site: Rani Pokhari

Rani Pokhari is one of the most recognizable landmarks of Kathmandu. It consists of a rectangular pond with a temple in the center. The temple is accessible by a bridge from the western side. The pond is surrounded by a promenade with small strip of a garden. This pond was barricaded with a high iron fence making it inaccessible to public. At the four corners of the pond outside the fence stood four smaller dome shaped temples. Within the fence on the southern side lies the statue of the King with his two sons riding a giant elephant. Besides the elephant statue, there is a small temple with Shivalinga. On the northern side on the bank of the pond is the stone statue of God Narayan. King Pratap Malla built the pond and temple in the center of the pond in 1670 A.D. This is documented on the stone inscription placed by the King which is still present at the North-West corner (Clark, 1957). The local legends tell the story of the King building the pond and temple to console the grieving queen after the death of their son as the name Rani Pokhari literally translates to Queen's Pond. However, the local people refer to this pond as *Nhu Pukhu* which means a new pond in Nepal Basha, and the inscription also makes no mention of the Queen. Only King and his son Chakravartendra who died before the completion of the pond are mentioned.

Historians believe that the King kept four inscriptions at the four corners of the pond. Only one inscription located at the North-Western corner of the pond is intact. According to epigraphist Kashinath Tamoth, the four inscriptions contain the same text and were kept in four corners to demarcate the area of the pond. King Pratap Malla also constructed temples within the area of the stone inscriptions but the deity is not mentioned (Clark, 1957). The inscription is written in Nepal Basha and Nepali. It mentions that the water was brought from 51 holy places and explains the spiritual importance of the pond. But it does not say anything about the architectural style or materials used in the temple. The king himself was a tantra practitioner, he built the temple in the honor of the tantric goddess *Jhamkeshwori* also known as *Hari Sankarini*.

From the time of King Pratap Malla to pre-2015 earthquake, the temple and surrounding area of the pond underwent many changes with regard to the style, the materials, and even the deity inside the temple. As the inscription does not mention the construction style, many experts have tried to figure out the original style. Domes were added to the temple in 1851 when Jung Bahadur Rana renovated the Newar style temple (Slusser, 1998) and had it white washed with lime mortar. However, it was not mentioned whether it was in the *sikhara* style or tired roof style. As mentioned in the expert committee report, H.N. Olfied, a British resident in 1850 to Nepal, wrote in his book *Sketches*  from *Nipal* that Prime minister Jung Bahadur Rana pulled down the picturesque object in the center of pond and replaced it with an ugly structure made with plaster. Slusser (1998; p. 149) also mentioned, *"Exotic to the Valley are the dome temples, structures of limited artistic metric that are rustic interpretations of Mughal buildings"*.

Dome shaped structures seem to be introduced in the Valley during Rana and Shah period but this style was present in Malla period too. Only during Shah period, Shahs and their prime ministers built several dome shaped monuments, even replacing the older pagoda style to dome shape. If we analyze the old pictures of Rani Pokhari, it is evident that several changes have been made to the temple. In addition to the central dome shaped temple, the four smaller dome shaped chapels around the temple and the other four dome shaped temples outside of the pond were constructed by Jung Bahadur Rana (Slusser, 1998). [see the pictures in the end]

## 3.2 Controversies on Reconstruction

When discussing the reconstruction of Rani Pokhari post 2015 earthquake, the controversies surrounding it should be also addressed. Local people, civil societies, activists, and youth protested against the reconstruction being done by the KMC in 2016. It was the first public protest in Nepal against non-traditional conservation of a heritage site. This phenomenon is interesting in itself, as it showed that people have developed a sense of heritage, which was not present before. Many ancient water sprouts and ponds were demolished to make modern structures in the past. People kept quite and even supported the initiatives. It seems that the devastation caused by the earthquake in 2015 ignited a sense of heritage in citizens and led to more heritage professionals actively engaged in safeguarding Nepali heritage.

The KMC took the responsibility of reconstructing Rani Pokhari after the earthquake. It started to build the temple and pond with cement, bricks, and iron rods. The contractors never had experience of construction of heritage sites. The pond was barricaded with green sheets to prevent passer-bys from seeing what was happening inside. The general public became aware of the KMC's intentions only when a picture from the construction site showing protruding iron pillars in the temple was posted online. However, it was too late as by that time the KMC had already bulldozed the pond walls and built concrete retention walls and also destroyed the temple that could have been just restored on a minimum budget. This sparked a huge public outrage. Big crowds with placards and traditional music gathered on-site and a whole protest campaign was organized. Public delegations met the KMC, Department of Archeology, and even the Mayor of Kathmandu. Events were organized to discuss the reconstruction of ponds and temples in the traditional style as other cities of Kathmandu Valley were restoring ponds in the traditional way, which is economical and sustainable as well.

The public perceived the KMC's plan to modernize Rani Pokhari as insensitive. Along with the KMC, other concerned government organizations and the Department of Archeology (DoA) were blamed. The decision of KMC to construct the temple and pond with concrete and iron would have erased the intrinsic value of the pond. In addition, the construction of water fountains with lights, amphitheater, and cafes would have destroyed the spiritual aura of the place. Later, after several protest campaigns, discussions, and related events, the KMC, DoA and Nepal Reconstruction Authority (NRA) jointly appointed a committee of eleven experts and three advisors to rethink the reconstruction of Rani Pokhari and create a new proposal after studying the site. When KMC demolished the temple of Rani Pokhari, some people suggested that it was an opportunity to rebuild it in the original style chosen by King Pratap Malla. This idea was picked up by the study committee and it was decided that the temple would be reconstructed in the way King Pratap Malla had originally built it, which was the *sikhara* style or *granthakut* style as Prof. Sudarshan Tiwar calls it (who is also in the expert committee).

The report submitted by the expert committee forwarded the plan to rebuild the temple in the style adopted by King Pratap Malla in 1670 A.D. as there was evidence of four doors in the four sides of the temple, a feature of the *Granthakuth* style. It also recommended reconstructing the pond in the traditional way and stressed the need to conduct further study of the pond. The committee proposed a three-phase plan and gave recommendations for long-term maintenance of the pond. In the first phase it was suggested to remove all the concrete development done by KMC and rebuild the temple in the *granthakuth* style. It advised scrapping the KMC's plans and drawing new architectural plans and carrying out the reconstruction under the expert supervision. The bridge to the temple was to be reconstructed in the traditional way and the concrete sprouts in the temple were to be taken out and replaced with the uniform stone ones. Regarding the pond, the natural recharging was to be studied by hydrologists to understand the natural recharging system, the inlets, and the outlets for long-term maintenance. Next, the report also discussed the second and third phases. These subsequent phases dealt with topics like refilling the water by rainwater harvesting and maintenance of statues in the traditional way.

One public interaction was done to consult on reconstruction of Rani Pokhari that was advertised through public notice. At that event organized in the city hall of Kathmandu, people criticized the insensitive decision by KMC but the debate on stylistic decisions regarding the temple, which was the main objective of the event, did not take place. Thus, ultimately there was no input from the public on the architectural style. The report submitted by the experts suggesting granthakut style was based on 25 days of research, which was approved by the parliament of Nepal. The responsibility of reconstruction of Rani Pokhari was given to Nepal Reconstruction Authority. The reconstruction was promoted as the "National Pride Project" and a deadline of nine months was given to complete the construction of pond and temple. To engage the local community in the reconstruction, the responsibility of the pond was given to the user committee group, which was a group of local people. The contract for the construction of pond, bridge, and wall was given to a suitable contractor.

## 4.1 Authenticity in International Context Vs Nepal

The International Charter for the Conservation and Restoration of Monuments and Sites, also known as Venice Charter was formulated in Venice in 1964 and then adopted by ICOMOS in 1965. It proved to be a major international guiding document for conservation and restoration of historic monuments. It also highlighted the word "authenticity" --"It is our duty to hand them on in the full richness of their authenticity." (ICOMOS, 1964). Later it became the fundamental gualifying criteria for the inscription of a cultural site in the World Heritage List. Although the Venice Charter laid the foundation for heritage conservation, it did not take into account the diversity of heritage in the world. It's curatorial approach for the conservation (Arazo, 2013) is not applicable in cultural contexts outside of Europe. The destruction caused by the two world wars, the industrial revolution in the west, and the international campaigns for safeguarding Venice from the floods and for rescuing monuments in Nubia and Philae from the Aswan dam led to the Venice Charter and the UNESCO 1972 Convention and its emphasis on the material importance of continuity of the memory (Gutchow, 2017).

One of the difficulties of the Venice Charter and earlier version of Operation Guidelines was that the cultural heritage is identified as monumental architecture (Jerome, 2008). Countries that did not share similar cultural values as the west have problem accepting the standard set by Venice Charter and early operational guidelines for authenticity. Due to which these documents received constant criticism in heritage conservation approach for being too Eurocentric. The approach of authenticity is different in different cultural contexts that could not be covered by the narrow definition of material authenticity. A long period of discussion led to the Nara document of Authenticity in 1994. The Nara document broadened the authenticity approach on heritage conservation and defined authenticity on the basis of cultural context, but did not set a limited fixed criteria for all judging all heritages as in the case of Venice Charter. It laid equal emphasis on tangible and intangible value of cultural heritage (Jokilehto, 2006).

In 2005, eleven years after the Nara conference, the operational guidelines for the conservation of World Cultural Heritage included an elaborate definition of authenticity (Bortolotto, 2013). Authenticity criteria was no longer limited only to the form and design, materials and substance, but also included use and functions, traditions, techniques, and management systems, location and settings, language and other form of intangible heritage, spirit and feeling; and other internal and external factors (UNESCO, 2019).

Despite the broadening of the criteria for judging authenticity, the western approach to conservation is still prevalent. The modern concept of conservation tries to separate the present from the past, isolating and glorifying the past and completely ignoring the present contributions. As Paulios (2014) mentions, *"freezing time and space allows the landscape or monuments in it to be packaged, presented and turned into museum exhibits"*. There are still many different types of heritage, which are being ignored in conservation practices. Due to the limited scope of understanding of diverse heritage from a limited mindset, there is a greater chance of losing diversity, community's association with the heritage, and traditional know-how. Time to time, there have been clashes concerning reconstruction and restoration of heritage especially in the cases when the monuments and sites are destroyed by natural calamities like earthquake, landslides etc. or manmade calamities like fire or armed conflicts.

Like many languages in the world, Nepal too does not have the exact translation of the word "Authenticity." Nepal entered into the formal heritage conservation after establishment of Department of Archeology and Ancient Monument Preservation Act (AMPA) in 1956 AD. For AMPA, it was too early to understand the complexities of heritage conservation. After several amendments in AMPA it's still not able to address the new emerging concepts in conservation such as authenticity (DoA, 1956).

Even though the formal heritage conservation practice started late in Nepal, there were age-old traditions put in place to take care of tangible and intangible cultural heritage through an indigenous social practice known as Guthi (Maharjan, 2016). It is based on caste, locality, and functions; and even had land and buildings as endowments for the smooth operation of festivals, rituals and maintenance of monuments (Slusser, 1998; Regmi, 1968). People belonging to the Guthi had responsibility of taking care of temples (cleaning, repair, restorations etc.) and also to continue everyday rituals and annual ceremonies as Guthi members. People practiced occupations according to their caste such as masons, carpenters, priests, farmers, painters, and so on. This also helped to transfer the skills and knowledge from father to son, which continued for generations.

"Replacing a carved strut (with or without documentation of its predecessor) of a temple in Nepal was ruled out by the principles of the Venice Charter, because it never occurred to the authors of the charter that replicas of deities would be carved by carpenters whose ancestors had carved the originals." (Gutschow, 2017) P. 45

There is not exact translation of word authenticity in Nepali language or any other languages spoken within Nepal. But many authors mention some words used in the ancient inscriptions such as *karoti navakam varayahah* (given a new cover), *jirnoddhara pratipaditam* (renovation completed), *punah samsthapya vidhivata* (reconstructed according to ordained rules), and so on (Chapagain and Tiwari, 2018). Also *"The Sanskrit term jirnoddhara can mean anything from maintenance and major renewal to total replacement"* (Gutschow, 2017; p. 41). The use of these words signifies that the renovations, reconstruction, repair, or total replacement has been in the Nepali cultural context. This has been still continuing which not only gave continuity to the heritage but also produced heritage of its own.

".. cycles of construction, destruction, renovation and/or reconstruction have not only led to overlapping layers of history, meaning and materials in the heritage but also established its own standards of understanding, knowing and safeguarding it for presentation, preservation and enhancement, thereby informing us how the societies in the Kathmandu Valley have taken action to conserve the heritage passed on by the preceding ones." (Chapagain & Tiwari, 2018; pp.136-137)

These cyclic repair, renewal, renovations or even replacement were born out of necessity. The building material for the monument and traditional houses in Nepal is mainly mud, bricks, and timbers. Due to climatic conditions such as heavy monsoons, coupled with the frequent occurrence of earthquakes of small and large magnitudes due to Nepal being in a seismic zone, made cyclic repair and replacement necessary. In terms of tangible heritage, very few surviving buildings in Nepal are "originals," if the definition of authenticity is restricted to the building material and a building's initial construction (Tiwari, 2017; p. 170). Authenticity was later defined in "Integrated Management Framework" as a cyclic repair and transfer of knowledge with craftsmanship:

"The authenticity of the Kathmandu Valley World Heritage property is retained through the unique form, design, material and substance of the monuments, displaying a highly developed traditional craftsmanship and situated within a traditional urban or natural setting, which have however throughout history gone through the process of cyclical renewal." (Department of Archeology, 2007; pp.5)

The Basic Guidelines for the Preservation and Rebuilding of Monuments Damaged by the Earthquake prepared by the Government of Nepal defined several key terms such as authenticity, restoration, reconstruction, rehabilitation, cyclic renewal, and many more. It defined authenticity as (translated form Nepali):

"Authenticity refers to the fundamental values, beliefs, characteristics, character, attitudes, qualities etc. that have been historically recognized in any object of structure and accepted on social and scientific grounds." (Government of Nepal, 2016; p.7)

Further clarification or detailed guidelines on authenticity are not published which renders the definition ambiguous, leading to varied interpretations.

#### 5. Findings

Rani Pokhari is quite different from the other temples of Kathmandu Valley. Most of the temples have daily visitors and active caretakers performing their duties according to the Guthi system. In case of this temple and pond, the access to the site is restricted except twice a year. Once on the day of Bhai tika people come to worship Balgopaleshwor temple. The celebration of Chaath puja festival for the people of Terai Community is a new addition. The rituals in this festival take place in the water. The pond has two components: pond as a spiritual place and the temple of Bal Gopaleshwor. In the earthquake of 2015, there was a minor damage to the pond and partial damage to the temple. Mr. Kai Weise<sup>3</sup>, President of ICOMOS Nepal, mentioned that there was no need to demolish the pond and temple, as there were several other monuments waiting for restoration and reconstruction. According to him, the pond and temple would have been restored in a budget of less than 10 lakh Nepalese rupees (around 7000 Euros). While KMC demolished the pond embankment, the pond water dried up and ponds bottom was bulldozed without doing any excavation or research. Also the partially damaged temple was demolished leaving four smaller dome shaped chapels surrounding the main temple. Thus, the process of reconstruction did irreversible damage to the temple and pond.

After long controversies mentioned earlier, the Nepal Reconstruction Authority took the responsibility of the reconstruction of pond and temple. The contract of temple, bridge, and embankment wall along with the pavement was given to the contractor. For maintenance of the pond, a user committee was formed with the local people and ward chairman. The timeframe of nine months was provided to finish the work, which was delayed by few months due to Covid-19.

## 5.1 Pond

When King Pratap Malla constructed the pond, it was not to supplement the aesthetic beauty of the temple but to build a

<sup>3.</sup> Meeting with Mr. Kai Weise (ICOMOS Nepal President) took place in 30th September 2020. Besides that many other interactions took place with him

spiritual site (*Tirtha*). He brought water from 51 holy sites from different places. The pond was refilled with the underground channel from the spring. The spiritual value of the pond was much more important than the material value of the temple and the description of the structure of pond (Clark, 1957). The text on the stone inscriptions at the four corners of the pond tells the pond's history. It says that the water was brought from different holy sources but not anything about the temple style or area of the pond. Historians believe that on the eastern side of the pond, the open space was used as the burial site for babies (ibdi.). Around the pond, there were smaller statues of deities and the giant stone elephant with king and his sons riding it. The area of the pond used to be much larger in the past. It was encroached in different time period for construction of college, police building, and roads around it.

The Kathmandu Valley has its own ingenious traditional way of constructing and restoring ponds that is still in practice. It was layered with 2-4 inch of black cotton clay that blocked water form leakage. When the excavation was done in Rani Pokhari by expert committee, up to 90 cm of the bed of the pond it was found that 2-4 inch of black cotton soil and sand in alternating layers. According to the local legends, the bed of the pond had wells that help to recharge the water. But expert Prof. Sudarshan Raj Tiwari mentions it might be sand wells not actual well. They could not find any such things, as the bulldozer already destroyed the bed of pond. The pond was recharged with the water brought through underground ducts and this has been also destroyed. According to Mr. Sushil Shrestha,<sup>4</sup> who has experience of restoring the ponds traditionally, every pond has an inlet and outlet. Inlet to recharge the pond and outlet to discharge overflow as well as to clean the pond. On the southern side, a small volume of water was flowing to the pond via channel structure of the bricks (Karki,

<sup>4.</sup> Interview with Mr. Sushil Shrestha took place in 20th September 2020 in Patan.

2020). The expert committee recommended studying the pond with the help of a hydrologist to understand the pond's natural recharging system and to find out how water used to flow to the pond originally. But this was never done, which was the biggest challenge of pond reconstruction. Regarding recharging the pond, the controversy still continues as NRA built deep boring to refill the pond, which contradicts the suggestion of the expert committee. The expert committee has also advised the government to stop deep tube well within the periphery of 1000 meters of the pond. In contrary NRA itself built deep tube well inside the pond boundary to recharge water artificially.

The expert committee had recommended removing the retention wall and boundary wall around the pond built with stone, cement, and iron by KMC. Only retention wall was removed but the boundary wall was hidden behind the glazed bricks. The water-recharging inlet was found on one side of the pond while other was not found as it was destroyed by the construction (Karki, 2020). The user committee formed for the pond was just a caretaker of the construction material. They did not have any decision-making power nor any say in construction. It seems just a formality to involve the community. Consultation was taken from Bhaktapur (another city in Kathmandu Valley) Municipality where pond restoration had been accomplished in the traditional way. Even women's groups with experience in restoring ponds came to help with the pond restoration in Rani Pokhari initially, but later it stopped. The people working in the pond were the same people working in the temple and bridge.

## 5.2 Temple-Jhamkeshwori to Balgopaleshwor

When the temple was destroyed by earthquake in 2015, it revealed different layers of history and material use. In the inner sanctum, bricks, wood, mud mortar, and lime mortar had been

used. White washing had been done outside. In several places, cement plastering was seen. The bridge was also made from the cement and white washed. Since there are no historical records regarding style and material used in Rani Pokhari, the expert committee depended on the sketch of the Rani Pokhari site that was made when Persian Prince Waldemar visited Kathmandu Valley in 1845 (Kvaerne, 1979). The historical records mentioned that Jung Bahadur Rana replaced the Newar building with the dome shaped temple, which was not common during the Malla period (Slusser, 1998; Study Committee, 2018). Sikhara (literally known as mountain style) of temple constructed in bricks and stone was ubiquitous in Malla period (Korn, 2014; Slusser, 1998; Gutschow, 2011). Granthakut is one of the sikhara style in which portico is attached and the portico can be one or four. This type of style is found only in Nepal according to Prof. Tiwari. In case of Balgopaleshwor temple, there are four porticos.

Detailed documentation of the *sikhara* style of Balgopaleshwor temple was not present neither the word *granthakut* was mentioned anywhere. But still the expert forwarded the plan to reconstruct in *granthakut* style based on three major arguments. First, the sketch during the visit of the Persian prince shows the *sikhara* style. Second, during the time of King Pratap Malla he built several tantric temples in sikhara style. Third, the presence of four door structure on the four sides of the temple. The base of the temple was not changed when it was reconstructed in dome shape and based on that proportion the length and breadth of *granthakut* style was drawn. According to the site engineer Mr. Purna B. Shrestha,<sup>5</sup> who did the detail drawing of the temple, it was copied from the *Pratappur* temple in Swyambhu, which was also built by King Pratap Malla. One point to be noted is that even the *Pratappur* temple has undergone several restorations and

<sup>5.</sup> Interview with site supervisor Mr. Purna Bahadur Shrestha took place in 21st September 2020 in Rani Pokhari. Also other interactions took place during field visit.

even reconstructions. Even in last two decade it was done twice. In 2003, it was destroyed by fire that was rebuilt and again in 2011 lightening damaged it.

Even though the four small dome-shaped chapels on the four corners of the Balgopaleshwor temple were later additions, they were not removed. According to the engineers involved, these smaller domes complemented the new structure, and more importantly, the chapels also had historical value. There are contradictions in the presence of the dome structure. King Pratap Malla built the temple for the tantric goddess Jhamkeshowri also known as Harisankari. Later Shiva linga and Balgopaleshwor (baby Krishna) statue was added to the temple a few generations after King Pratap Malla. Even though all the deities are present, this temple is now known as Balgopaleshwor temple.

#### 5.3 Material Use

In the different cycles of construction, reconstruction, and restoration of the temple and bridge different materials were used. These included; normal bricks, glaze bricks, mud mortar, lime surkhi (grounded brick) mortar; white wash during the addition of the domes; and cement in the later half of 20th century. In the past reconstructions, bricks and other reusable materials had been reused. According to the mason Mr. Dev Ratna Maharjan, in the latest reconstruction by KMC, the old bricks were not reused, and the doors were too worn out to be reused. KMC removed old bricks from the site when it started reconstruction. On the site, still some old bricks of different sizes, forms, and designs were found, which must have been brought from the other temples for reuse in the past. The cement used in the temple and the bridge was taken out and was rebuilt with bricks and lime *surkhi* mortar. It's not just in this temple that lime mortar was used, but post 2015 most of the sites were using lime *surkhi* mortar and glazed bricks

in place of mud mortar and normal bricks (*Maa appa*). The exact year when lime *surkhi* mortars began to be used in Nepal is not known. Guschow (2011) mentions the first white plaster used in Newar architecture was in north wing of Patan Durbar built by Bahabur Shah in between 1785–1795 A.D. Post 2015 earthquake, UNESCO started promoting the lime *surkhi* mortar in heritage sites by providing training to masons and construction workers and it even published a guide for using lime *surkhi* mortar in post 2015 earthquake reconstruction work (UNESCO, 2020).

## 5.4 Technical intervention

KMC tried to rebuild the temple and pond with the modern materials to strengthen it but it drew many controversies and led to waste of time, money, as well as historical value. According to the experts involved in rebuilding the temple, the foundation was not destroyed but was strengthened. The intervention of wooden frame in the foundation was done. In addition to that, the steps in the plinth which rises from the pond was replaced with stones as stones are more durable than bricks and chances of damage by water is less. But the bricks at the lower level of the bridge that are in constant contact with the water were not changed. According to the site engineer Mr. Suman Maharjan, those kinds of bricks are not made anymore and they are still in very good condition. The whole pond is now surrounded with the wall, which is made from glaze bricks and lime *surkhi* mortar. The pond that was white before the 2015 earthquake has now turned red after reconstruction.

#### 6. Discussions

The heritage of Kathmandu Valley has a history of cyclic restoration, renovation, and even reconstruction. The heritages of

the Valley are living heritages and have an organic relationship with the people, monuments, and sites. The geographical location and the material use make them vulnerable and in need of constant repair. Also the wear and tear of monuments and objects with everyday use also leads to constant restoration and renovation. In this process, the same heritage is endowed with layers of history. The diverse tangible and intangible heritage still continued in the Valley is due to the presence of different cultural influences. The original style and detail of Balgopaleshwor temple is not known but old pictures show the changes that occurred over time. During the Rana period, whitewashed dome shaped style architecture became common. After the earthquake of 1934, many tiered temples were converted to dome shaped, which was "ill-advised architectural marriage" (Slusser, 1998; p.). Similarly dome shaped temple of Rani Pokhari had added to the diversity of heritage even though some experts claim that structure did not have any heritage value.

The Rani Pokhari site was the subject of a big controversy and was in the limelight for all the wrong reasons. Before the decision was made to construct it in the Granthakut style, a public discussion on building style was not conducted nor any consultation from the public was sought. Newar heritage became a hot topic during the restoration and reconstruction, but it is necessary to understand what Newar heritage actually means. The replacement of other mortars with lime *surkhi* mortar and glazed bricks (dachhi appa) is understood as Kathmandu Valley heritage. But there is a need to go beyond that and understand the traditional construction technologies and materials such as mud mortar and different types of bricks. Even though the layman seems to have awareness of heritage that is limited to the aesthetics. The parts of Nepalese heritage that are intangible or that are valuable due to their functionality and sustainability have not been explored.

Community plays a major role in the continuity of heritage. There

has been a great emphasis in community involvement in heritage conservation but in case of construction of Rani Pokhari, just a user group is formed for the sake of formality. When engaging the community, the locals must play an active role, and not passively agree with every decision that is made by the authorities. While engaging the community, there should be transparency from the very beginning.

After the completion of the reconstruction, the Government of Nepal and National Reconstruction Authority are promoting this site as the best example in the reconstruction. But Rani Pokhari has failed in several stages. The destruction to the pond and temple, which wiped out centuries of history, is never talked about. KMC wasted of taxpayers' money on the wrong reconstruction and no one was held accountable, not even a public apology was sought. By presenting the aesthetically pleasing structure and calling it a traditional monument is not fair as most of the values has been lost in Rani Pokhari. Following the example of Rani Pokhari there are several other sites, which are advocating to revert back to the Malla style demolishing the standing monument. This site can be an example for do's and don'ts in heritage reconstruction but can never be the best case study.

## 7. Conclusion

The continuity of heritage in Nepal is through cyclic renovation, restoration, and even rebuilding. The construction materials, the climate, and the natural calamities do not allow Nepal to follow the international conservation model. The heritages of Nepal are living heritages, and so they have a dynamic relationship with people, past and present. With the Nara document, the values of authenticity can be understood in different ways such as spirit of place, use and functions, location and setting, traditions and techniques, spirit and feelings, and other internal and external factors. In case of Rani Pokhari the traditional techniques, spirit of place, traditional functions should be explored which has not been not. Despite lacking at several places, reconstruction of this site is being promoted as a model reconstruction, which should not be the case. This will set the wrong example for the future heritage reconstruction projects.



Figure 1. Original area of Rani Pokhari. Length 180 meter and breadth 140 meter. © Report of the Study Committee



Figure 2. Original Plan of Rani Pokhari Prepared by Er. Suman Maharjan. Source: Bishnu Karki



Figure 3. Stone inscription present in the North-Western corner of Rani Pokhari. This inscription is mostly covered by the roadside shopkeeper. © Monalisa MaharjanCommittee



Figure 4. Bulldozer removing the concrete structure constructed by Kathmandu Metropolitan City. © Save Heritage



Figure 5. Concrete embankment built by Kathmandu Metropolitan City © Save Heritage



Figure 6. Reconstruction of Pond. © Monalisa Maharjan



Figure 7. Sketch of Rani Pokhari during the visit of Persian Prince to Kathmandu Valley in 1845.



Figure 8. Rani Pokhari before 1934 Earthquake



Figure 9. Rani Pokhari post-earthquake of 1934.



Figure 10. Rani Pokhari before 2015 Earthquake



Figure 11. In the process of construction of Balgopaleshwor in center of Rani Pokhari



Figure 12. Pratappur temple built by Pratap Malla. The details of Balgopaleshwor temple was copied from it.



Figure 13. Rani Pokhari after completion of Reconstruction. © Monalisa Maharjan



Figure 14. Night View of Rani Pokhari ©NRA

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Formulating "Local HUL" Instrument for Community Based Cultural Heritage Management in the Historic Urban Core of Historic City – with Semarang and Solo in Indonesia as Case Study

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#### Abstract

The UNESCO World Heritage listing is often misunderstood by the government and the community in Asia, including Indonesia, as tourism promotion or branding. This tendency has led to unwanted consequences, such as gentrification, the commodification of heritage, loss of physical integrity, etc. Small and medium cities in the Asia Pacific region have been facing rapid social and physical transformations due to decentralization and expansion of economy and infrastructures from the metropolitan areas into hinterlands. These developments have threatened the historic urban core due to the weak planning and lack of conservation policy.

This paper aims to formulate a more coherent and comprehensive heritage management instrument for a medium city (e.g., provincial and regional capitals, or smaller towns), based on the Historic Urban Landscape (HUL) recommendation by UNESCO. Cases in two cities will be used in this study: Semarang, and Surakarta, in Central Java, Indonesia.

The study will focus on three components: (1) Comprehensive mapping of tangible and intangible cultural heritage assets to find the "DNA" of the community and place; (2) Capacity building and empowerment of the local community to protect its heritage and to develop the economics of heritage; and (3) Protection and continuation of the authenticity of local living heritage (the "DNA" of the community identity and place personality).

It is expected that the outcomes of this research will contribute to: (1) the formulation of comprehensive local HUL mapping of tangible and intangible heritage as the basis for a more scientific and democratic process in managing conservation and urban development; (2) the provision of Heritage Management Recommendations for Local Community and Local Government; and (3) the production of new knowledge and contribution to the literature on the topic of urban planning and heritage conservation.

KeywordsHUL; Community; heritage management; DNA of the city; city<br/>competitive advantage

## 1. Introduction

The management of places and heritage buildings has a considerable influence on all aspects of a city's life and development. The restoration of a place that has unique values and plays a vital role for humans is able to make a very positive contribution to the life of the community. Preservation of cultural heritage buildings is a vital component of the city's revitalization efforts. Various ways have been attempted to produce many effective methods of conservation of cultural heritage buildings. Heritage tourism is often rooted in historic buildings. Cultural heritage buildings are also increasingly being accepted as important places that connect the new generation with older generations, thus being used for education and civic awareness (Purwanto 2005).

Revitalizing the historic environment and landscape is important to ensure that our quality of life is improved and community cohesion is maintained. Voluntary activities are often used to maintain and promote historic buildings, including walking tours, environmental activities, and other things that are also recognized as valuable ways to keep people, especially seniors, active and involved in their communities. Historic Urban Landscape (HUL) is an approach for managing heritage resources in a dynamic and continuously changing environment. It is based on recognizing and identifying layering and interconnection of natural and cultural, real and intangible, international, and local values that exist in each city. According to the HUL approach, these values must be taken as starting points in overall city management and development (Bandarin and Oers 2013).

According to UNESCO's recommendations, HUL is defined as a mapping of an urban area, a result of the historical layering of cultural and natural values and attributes, beyond the concept of a "historical center" or "ensemble" to include a broader urban context and geographical arrangement. This broader context includes the topography, geomorphology, and natural features of the site, the artificial environment (both historical and contemporary), open spaces, land use patterns and spatial organization, as well as all other elements of urban structures, in addition to social and cultural practices and values, economic processes and dimensions of intangible inheritance. All of this contributes to the city's distinctiveness, the spirit of place ("genius loci"), and the uniqueness of urban experience, which must guide any decisions regarding the planning and design of interventions (Albert, Bernecker, and Rudolff 2013). Various studies show that the loss of heritage areas is caused by changes in the economic conditions of the population, an increase in land value, and a lack of cooperation and knowledge between the stakeholders involved (Tucunan, Sulistyandari, and Perkasa 2018). However, this is also caused by urban development pressures that prioritize modern and futuristic concepts and a weak sense of belonging in the people and government (Ichwan 2004).

This research used two case studies in Central Java, Indonesia: Surakarta (Solo) and Semarang, as shown in Figure 1 below. Both cities were chosen for the quality and quantity of the historical layers they have. The city of Surakarta, founded in 1745, is a legacy of the Islamic Mataram Kingdom, the largest Islamic kingdom that has ever existed on the island of Java. After the demise of the last king of Surakarta, Hadiningrat, the Mataram kingdom and the royal palace was passed on to his elder son Kanjeng Gusti Pangeran Haryo (KGPH). On his crowning in 2004, he was bestowed with the formal title of Pakubuwana XIII as per tradition (Alkaff 2016). Figure 1 below describes the location of Semarang and Surakarta in Central Java Province, Indonesia.

Semarang's history begins around the sixth century CE, on the coastal area called Pragota (now Bergota), part of the ancient Hindu Mataram Kingdom. It was a port, protected by a group of small islands. Due to ongoing sedimentation, the islands were interconnected into a land (Purwanto 2005, Buchori et al. 2018).



Figure 1. Surakarta (A1) and Semarang (A2) as the case studies

Since its beginning until now, Semarang's port city has thrived as a part of the international trading network, especially since the establishment of the shipbuilder's settlement of the followers of the great Ming Dynasty Admiral Zheng He in 1435. The place is now known as the Sam Po Kong temple complex in the Gedung Batu area. Both cities have been growing into a relatively large city, with a population of 499,337 in Surakarta (2010) and 1,556 million in Semarang (2010). Semarang developed into a cosmopolitan city, while Surakarta remains a royal city.

HUL method, which was intended initially as a heritage management instrument for cities with World Heritage sites, was implemented in the analysis for both Semarang and Surakarta. Neither city has World Heritage sites, but they have significant historical areas that may potentially be recognized as World Heritage sites in the future. The analytical steps were carried out in the following steps, as summarized in Figure 2 below.



Figure 2. The potentials of Semarang and Surakarta in developing the city's competitive advantage (Nursanty, 2020)

## 2. Material and Method

This study uses a qualitative method where the data obtained is interpreted according to the existing context. This qualitative research was conducted to examine the condition of natural objects in two cities, where the researcher was the key instrument (Silverman 2016). Qualitative research is research that intends to understand the phenomena experienced by research subjects such as behavior, perception, motivation, action, etc. in a holistic manner, and by means of descriptions in the form of words and language, in a special natural context and by utilizing various natural methods (Schroeder 1991). The purpose of qualitative research is to explain a phenomenon thoroughly by way of collecting data in as much detail as possible, resulting in the obtainment of deeply insightful data. (Hall 2009). The distinctive feature of quantitative research is that it departs from data, utilizes existing theories as explanatory material, and ends with a theory.
Data collection in this study involved mapping of cultural heritage objects that have been registered with the Education and Culture Office in each local government, both Surakarta and Semarang. Data were collected using snowball lines, according to the mapping pattern in the first stage, where trends were directed according to interrelated information (Yin 2009). Collecting data about the community and their perceptions of using heritage spaces to find local value is done using big data in the form of a combination of structured, semi-structured, and unstructured data collected through social media to obtain information and to use in this research project for modeling, predictive hierarchy, and analytic applications at a later stage (Mills 2019). The process of finding City DNA uses the "Butterfly Mamoli" method discovered by researchers by connecting each object physically with the community's emotional values . (Nursanty 2019).

## 3. Analyzing the Royal City of Surakarta

The city of Surakarta (Solo) is an autonomous region city in Central Java province, Indonesia, with an area of 44.04 km2, a population of 519,587, and a density of 11,798.06/km2 (2019). It is the third-largest city in Java after Bandung and Malang by population. The river on the east side of the city was made famous worldwide by the song *Bengawan Solo*. Together with another royal city of Yogyakarta, Surakarta was the successor to the Mataram Sultanate. The Sultanate was divided into the two cities by the Giyanti Agreement in 1755 (Kota Surakarta 2020).

The total population of Surakarta in 2010 was 503,421, consisting of 270,721 men and 281,821 women, spread over five sub-districts covering 51 villages with an area of 44.1 km2. The sex ratio is 96.06%, which means that for every 100 women, there are 96 men. Compared to other cities in Indonesia, Surakarta is the most populous city in Central Java and the 8th most populous city in Indonesia (Kota Surakarta 2020). The position and area are described in figure 3b below.

The Batik industry is one of the common industries in Surakarta. Klewer Market and several other traditional batik markets and centers, like in Laweyan and Kauman, have become leading Batik trade centers in Indonesia. In addition to Klewer Market, Surakarta also has many traditional markets, including Pasar Gedhe (Pasar Besar), Kembang Market, Pon Market, Legi Market, Kliwon Market (now known as Sangkrah Market). Besides, there is also an antique market called Triwindu Market (or Windu Jenar) which has become a tourist destination; every Saturday night its name becomes Ngarsopuro Market. The Keris and Souvenir Market North Surakarta Palace are other famous markets. Surakarta's business center is located along the main road, Jalan Slamet Riyadi. Several banks, hotels, shopping centers, international restaurants, tourist and entertainment destinations are located along this protocol road, including Graha Soloraya, Loji Gandrung (the mayor's official residence).



Figure 3. Surakarta city gate, \Lambda in 1936. Source: unknown; 🕒 in 2018. Source: Gogenius, 2018

Figure 3 above depicts the change in the city's appearance in an important location, namely the entrance gate to the Kasunanan Surakarta palace, the authenticity of which is maintained in the comparison between 1936 and 2018. As the largest royal heritage city on the island of Java, Surakarta City, namely Mataram, has Focusing area (A) Focusing area

successfully maintained its royal identity, like a child who grows up but still uses the same heart and continues to live as long as it beats.

Figure 4. Position and extent of Surakarta (Nursanty, 2020 [on Google map])

Figure 4 above depicts the area of the city of Surakarta which is part of the province of Central Java and details about the natural attributes that have been recorded in the list of cultural heritages in Surakarta are depicted in Figure 5 below.



Figure 5. Map of Surakarta Natural Attributes. Source: Nursanty, 2020. Notes: The image notation is in the attachment section.

#### 3.1. Place History of the Royal City of Surakarta (Solo)

Figure 6 shows the chronological development of the historic core of Surakarta. Laweyan village, which has existed at the DI location since 1546 (Kusumandari 2011), has been developing as a center for batik trade. The cotton plantation and rivers provided natural resources and played an essential role in economic development there. C1 is the palace's location where the first king, Pakubuwana II, settled down in 1745 after the kingdom center was transferred from Kartasura in 1745. The area was also occupied by the courtesans and both administrative and religious advisors. Between locations B1 and C1, there is location D1, which functioned as a supportive space for the royal court's activities, such as the artists' residences and recreation centers and urban cultural spaces.



Figure 6. Hierarchy of Surakarta's heritage area, based on the place timeline. By Nursanty, 2020, on Google map

In its development, the Cl area, since the birth of the city of Surakarta, was occupied by the natives (N) with community activities supporting work. It was divided into two sub-areas. Cl-N (native) consisted of the Royal Palace, Kauman Village (Royal scholars settlement), and Kampung Baluwarti. During the colonial era, sub-area Cl-D was occupied by the Dutch community, who played a role in the founding of this new palace. Within this subarea stood the Vastenberg Fortress, which was directly opposite the Surakarta palace area. In Figure 7 below, the development of sub-areas B1, C1, and D1 from the eighteenth century until now is shown. The communities in sub-areas B1 and C1 have maintained the tangible and intangible heritage for centuries and continue to do so in the present.



Figure 7. Elements and the strengths of the city of Surakarta. By Nursanty, 2020, on Google map

#### 3.2. People and Culture in the Royal City of Surakarta

Place attachments are emotional bonds between people and places and are the main concepts in environmental psychology. This condition is greatly influenced by a person and his personal experience (Florek 2011). Several studies have tried to define what makes a place meaningful and gives a sense of attachment that grows between a person and his place. It was found that there is a fundamental difference between "meaning" and preference—"in a place to define meaning as a process of thought, feeling, memory and interpretation caused by a landscape, while what is meant by preference is the level of preference in a landscape compared to others." (Schroeder 1991). Figure 8 is the analytical diagram of the elements of the local HUL. The community's historical places on the left side are used for various functions, as shown in the right part of the diagram (B1-Cu; B2-Cu; B3-Cu).



Figure 8. The role of people and culture in the development of Surakarta. By Nursanty, 2020

## 4. Analyzing the Cosmopolitan City of Semarang

Semarang's history began in the eighth century CE on the northern coastal area called Pragota (now Bergota) as part of the ancient Hindu Mataram kingdom. It is now the capital of Central Java Province. Semarang is a large city with a population of around 2 million. The city is geographically divided into two areas: the upper hilly areas on the south and the lower flat land on the north part, between 4 to 10 km from the coastline. The lower town, where most businesses, trading, and high-density settlements are situated, is prone to flooding (Franke et al. 2012). The upper town was initially planned as a low-density location designated for the upper social class during the late colonial period. Figure 9 below illustrates the change in Semarang from 1770 to 2020.



Figure 9. A Painting of Semarang in 1770. Source: Johannes Rach, 1770; B Semarang in 2020. Source: Pemerintah Kota Semarang, 2020

#### 4.1. Place and History of the Cosmopolitan City of Semarang

Figure 10 below illustrates the position of Semarang and the extent of urban development. The growth of Semarang city is due to the port, one of the most important harbors in Indonesia since the colonial period.



Figure 10. Location of Semarang and extent of development. By Nursanty, 2020, on Google map

Figure 11 below shows the distribution of natural and cultural heritage in Semarang obtained through the comprehensive cultural mapping process



Figure 11. Map of Semarang Cultural and Natural Attributes. Source: Nursanty, 2020. Notes: The image notation is in the attachment section.

Figure 12 below illustrates the result of the historical place developments from past to present. The core area A2 developed

into several places: 1. Bergota (the place of origin of Semarang); 2. Kauman (Javanese settlement); 3. Pecinan (Chinese settlement); 4. Kampung Melayu (multi-ethnic mixed settlement of the Yemenis, Madurese, Malay, Sundanese, Kalimantan, etc.); 5. Dutch Town (former Dutch town).



Figure 12. The historic core area of Semarang. By Nursanty, 2020 on Google map



Figure 13. Development of the city areas based on the historical timeline. By Nursanty, 2020, on Google map

Figure 13 above describes the hierarchy and chronology of Semarang. B2, called Bergota, is the origin place of the settlement in Semarang in the fifteenth century. It was a former Chinese shipyard and settlement, next to a native settlement, when the area was still on the coastline before the progressive sedimentation took place. Area C2 developed during the next stage of urban development when B2 moved closer towards C2, and the new agglomeration occurred in the form of three settlements: Kampung Kauman, Kampung Melayu, Pecinan, and Dutch Town.



Figure 14. The hierarchy of the Semarang City heritage area is based on the place timeline. By Nursanty, 2020 on Google map

Figure 14 above illustrates in more detail the development of C2. In the next stage, it is divided into C2-N, namely native settlements consisting of: Kp Kauman (2), the area of residence of the Javanese who succeeded the Pesantren Kiai Pandanaran (the native founder of Semarang); Kampung Melayu (4), which was occupied by Arab Yemeni migrants and the Indonesian archipelago communities such as Bugis, Madurese, Banjar etc.; Pecinan (3), the ethnic Chinese settlement; and Dutch town (5), the former European town. Area D2 (6 in the note) is the current CBD area of Semarang, called Simpang Lima, which is increasingly outgrowing the old historic core, as shown in figure 11 above.



Figure 15. The element and strength of the Semarang city DNA. By, Nursanty, 2020 on Google map

Figure 15 above illustrates Semarang city's development, which shows the D1 area's role as the new business center. It has been growing bigger and has finally outgrown the historic core area of C1. E1 is the current extent of the city and provides all the amenities of a modern city.

#### 4.2. People and Culture of the Cosmopolitan City of Semarang

Among many people currently living in Semarang, there is a wide diversity of cultures and their respective peculiarities, such as Javanese, Chinese, Arabs, and many more, making it a truly cosmopolitan city.



Figure 16. The role of people and culture in the development of the Semarang Cosmopolitan city. By Nursanty, 2020

Referring to the historical buildings and names of places in Semarang, there were four dominant: Islam, Chinese, European, and Javanese, that developing and mingling since the formation of the city. These cultures and their materialization are persisting within the historic core area of the city until now.

In contemporary cities, the weakening of a city's identity is often caused by uniformity, aggravated with places' commodification, which has led to the loss of local identity. The identity of a place is related to the meanings and perceptions people have about their environment. The loss of identity weakens the depth of meaning, attachment, and diversity of place experiences (Ujang 2012).

The analytical diagram shown in Figure 16 above describes the relationship between the place and the local community's influence. It shows the ability to influence the strength of the place's meaning: (i) the area in place B1 is a place that starts with the existence of a community of people who use natural products as a source of trade. This trade can work well due to rivers' potential as the most straightforward means of transportation in the past and gave birth to agricultural culture and trade in B2-Cu agricultural products; (ii) C2 area is occupied by native people, divided into four settlements. It gave birth to ethnic culture according to their community groups in C2-Cu; D2 is a place where initially it was a supportive space but eventually developed beyond all elements and became a new form as a modern contemporary cosmopolitan city of E2.

## 5. Result and Discussion

Based on research in the two case studies on the Royal City of Surakarta and Cosmopolitan City of Semarang, a clear relationship is found to answer research questions about the role of local HUL on a city's growth's competitive ability.



Figure 17. The Twin Hexagonal diagram to find the elements of Local HUL. By Nursanty, 2020

Three stages in the formation of a place, in general, is explained in the diagram in Figure 17 above. (i) Place with notation B, where the initial establishment of a city is initiated by a group of local people who occupy a natural resource that can provide a sustainable source of life for the community (B1 and B2). During this period, people could increase their expertise in improving the quality of natural resources and made their environment able to compete with other places around them. In Surakarta, it was the batik merchant community who were the catalysts of B1, and in Semarang, it was the traders of spices and natural products, which were the catalysts of B2. (ii) Growth in places B to C generally occurs when there is interaction with migrants, both other tribes and other nations. City activities are becoming increasingly complex, and communities are becoming groups according to their ethnicity and livelihood based on their innate expertise.

Native communities occupied both C1 (Surakarta) and C2 (Semarang) with their cultures. In the next historical period, the natives grew together with European settlements as part of the city's development, during the Dutch colonial period. (iii) In D are spaces that initially functioned as supporting spaces, currently able to change their roles as supporters of modern cities' growth. The need for city services in a modern city is easily placed in these supporting spaces in D. D1 in Surakarta, and Semarang is a row of offices and shops

## 6. Conclusion

The study found that HUL, which is based on tangible elements that can be recognized through changes and developments in urban space, strongly influences the local community's culture as the main actor in making decisions about the use and change of city space. As the primary role holder for the change of living place, the community is the giver of meaning for the strength of a place and gives strength to the city to be able to compete with other cities around it.

The Twin Hexagonal diagram (figure 14) illustrates the stability of the three stages of city development that will always be sustainable. Firstly, the birth and growth of a place are strongly influenced by the natural potential that humans can develop to enhance their ability to manage natural resources to win the competition. Secondly, the growth of places with a particular character in a city is strongly influenced by the ethnic groups that enrich it and provide specificity according to the inherited values inherited by each ethnic group (C). Thirdly, the development of a place that can make room for the development of a modern city is strongly influenced by the availability of a place that can change flexibly and be accepted by space users, local people, and migrant communities (E).

Cities in Asia are undergoing rapid transformation due to dynamic changes in the economy (trade, tourism, consumption, social disparity, etc.). It has caused advantages or disadvantages to economic competitiveness, cultural authenticity, social harmony, historical continuity, environmental sustainability, and physical integrity. Conservation is a management of change and permanence, and the HUL instrument is intended to balance the preservation of the historical significance of tangible and intangible urban heritage with the agenda for economic development and urban regeneration.

HUL methodology and policy instrument, which is initially mandated for cities with UNESCO World Heritage sites, is also useful for the heritage management for cities with significant heritage places in the context of changes. The basis for HUL formulation is the comprehensive mapping through empirical/ grounded research, documentation, and stakeholders' engagement.

The HUL mapping process follows a systematic chronological synchronic layering of maps with significant places identified, selected, classified, and agreed upon through all stakeholders' consensus and deliberation process. During the prolonged lockdowns and limitations during the COVID-19 pandemic, data and information harvesting and interpretation from the internet (such as big data, social media, digital maps, etc.) are necessary and useful. The study and mapping exercise conducted in two medium-sized cities in Indonesia (Surakarta and Semarang) during the pandemic period has demonstrated the possibilities of implementing the HUL methodology, as stated above. The mapping focuses on identifying the community's and place's essential elements (or the "DNA") that persists, thrives, and keeps future growth potentials. These potentials are fundamental in ensuring the city's competitive advantage at national and international levels.

The city's DNA elements' strength determines the local community's capacity to protect its heritage and develop heritage economics. In order to ensure the cultural authenticity and social continuity, capacity building, and empowerment of the local community are essential steps to be adopted and integrated into the local government's urban planning and policies.

"Local HUL" is based on the mapping of the DNA of the local community and place. Through this research, the strength of the mapping and analysis methodology is applied and tested effective for showing the significant "Outstanding Local Value" ("OLV") related to the tangible and intangible attributes of the people and place.

As has been discovered from this study, the historic urban area has a stable "core" (attribute) that anchored the Outstanding Local Value, which remains stable for a long time. The "core" is surrounded by peripheral areas or related elements that change over time. The dynamic relationship between the stable core and the changing peripherals is the key factor in the identity strength of a place belong to a community. This dynamism is the genesis for the city's competitive advantages.

Further study through pilot-project is necessary to create a policy for the effective community based cultural heritage management instrument in the historic urban core in the future.

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Study on the Integration Mechanism of Heritage Conservation and Sustainable Development of Historical Cities along the "Maritime Silk Road" — Take the group city "Guangzhou–Hong Kong" as an example

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#### Abstract

According to reports from international agencies such as the United Nations, the World Bank, the Asian Development Bank and the African Development Bank, by 2050, more than 90 percent of urbanization in the world will be concentrated in Asia and Africa, with about 2.5 billion people entering cities from rural areas. This will have a fundamental impact on the global urban structure. Asian countries are experiencing unprecedented rapid urbanization, and the sustainable development of cities in the future exists in the constantly updated historical environment. How to sum up the historical experience reasonably, and then push the countermeasures and path for the future development?

This research focuses on Guangzhou-Hong Kong as the core node and a typical specimen of the Chinese section of the Maritime Silk Road. The group city is not only interdependent in spatial geography, but also a combination of trade, culture, and history. The research studies the historical patterns of interactive development between Guangzhou and Hong Kong under the influence of "Sea-River." It analyzes the characteristics of urbanization mode determined by natural geography, and the types of secondary city clusters driven by the trade and economy. It explores the internal logic and motivation, and deeply explores the interaction between the region's history and culture, economy and trade, natural environment, national policy, and urban structure. It explores the new development mode of historical culture and local resources conservation and utilization, and puts forward the integration mechanism of historical urban heritage conservation and sustainable development in the future.

## 1. Introduction

China is an ancient civilization with long-standing traditions. It occupies an important position in the history of human civilization, having contributed outstanding planned heritages to the world. Following the mid-19th century, Chinese cities and their urban planning initiated the country's modern transformation. Since China's reform and opening-up in the 1980s, China has experienced the largest scale of rapid urbanization in world history, during which China accumulated many unique experiences. According to the United Nation research report on world urban development, more than 85% of the world's urbanization will be concentrated in Asian and African countries in the next 30 years. Undoubtedly, China's experience will provide a reference for the urbanization process in Asia, Africa, and other countries.

In October 2013, when Chinese President Xi Jinping visited ASEAN, he put forward the strategic concept of the 21st century Maritime Silk Road. By studying the evolution and interaction process of historical cities along "Belt and Road" and constructing the international cooperation mechanism, it is an important step to seek historical consensus, promote cultural interconnection, and realize the goal of building "human destiny community. (President Xi Jinping)"

The "Maritime Silk Road" is not only the route of trade, but also the route of culture. Considering this background, the sustainable and resilient development of urban social culture is particularly significant. Asian cities are experiencing unprecedented rapid urbanization, and the resulting urban development must occur in a sustainable manner. It is considered that the whole concept of conservation-development should be shaped by the perspective of social and economic development and urbanization, which is also an important reason to focus on the study of historical cities. Focusing on the deep cooperation and exchange between cities along the "Belt and Road," this study examines the historical pattern of a city against the background of the contemporary "Maritime Silk Road," summarizes the historical experience, and promotes the establishment of an integration mechanism of heritage conservation and sustainable development of historical cities along the route.

The research not only focuses on the historical development of "Guangzhou" and "Hong Kong" cities, but puts the historical pattern of these two cities in the deep cooperation and exchange of cities along "Belt and Road." It focuses on the history of integrated development of Guangdong and Hong Kong, especially the close connections of social economy and culture and the interaction between the two cities since modern times. The study of the historical origins of the relationship between the two cities is based on the continuity and superposition characteristics of history, an understanding of the laws and regulations of urban development, and the mechanism of generation and power, so as to better guide the future practice and highlight the importance of history.

## 2. The research of Group City

Patrick Geddes introduced the concept of combined city in his book *Cities In Evolution: Conurbation*. A combined city is a region encompassing many cities, large towns, and other urban areas. Due to the growth of population and the expansion of trade and commerce, these places come together to form a constant city community or an industrial developed zone. There are two main categories of combined cities (or group cities): 1) a combined city with a central metropolis (where the population gathers) surrounded by satellite cities or commuter towns, as seen in London and Tokyo. This category represents exactly what "conurbation" means. 2) a combined city that is composed of two or more main cities with no metropolis, such as Ruhr in Germany. In most cases, the group city is a multi-center urbanized area. That's what most contemporary studies refer to.

One of the most outstanding professors in the research field is Prof. Hu Gang from Jinan University. In his article A study in building a giant group city surrounding Hangzhou Bay《构建环杭 *州湾巨型组合城市研究》)*, Prof. Hu Gang stated that cities with similar terrain and economic conditions, close proximity to each other, and similar cultures tend to complement each other in urban functions; due to the close links between such cities they can be integrated into a group city (Hu Gang & Yao Shimou, 2002). In From City Group To Group City (《从城市群走向组合城市》), Prof. Hu Gang revised the definition of group city: group city is an aggregate of two or more cities which in certain historical and realistic conditions are close to or next to each other, are similar in natural conditions and cultural background, provided with developed transport and communication network, are mutually complementary in function, are linked closely in industrial structure, appear to have the multiple-center pattern, and are independent in public administration. He regarded a group city as the metropolitan interlocking region in the inner city group, and it included dual-core-pattern group city and multiple-centerpattern group city (Hu Gang, 2006). Some other scholars view a group city as the composition of outer node cities surrounding the core city with administrative level, population size and GDP at the same level. This same-level-pattern group city is composed of a few cities close to each other. Since there is no radial effect from a higher ranking core city, they combine together and help each other improve, and that is a practical way for cities to become a region (Ge Chunhui, Zhu Yuyu, Liu Peirui, 2013). Some other scholars consider a group city to be the combination of inner functional zone in a city, which divides a whole city into many cell cities (Wu Weiwei, 2019). While Prof. ZhouFuduo regarded a group city as a city on a larger scale composed of two or more cities in his article A study on the development of a group city: Discussion on the combination of KunYang and AoJiang (《组合型城市发展研究一兼论

尼阳镇与鳌江镇的组合》).(Zhou Fuduo,1993) As the world changes, the definition of group city improves, and it is mostly considered to be an outcome of regional integration nowadays. Recent studies suggest that the formation of a group city is primarily based on physical proximity, and is further encouraged by the integrated development of economy and infrastructure. The concept of Urban League is similar to it.

Group city is not only the relationship between the lips and teeth at the geographical level, but also the connection between economy and culture. It is to study the linkage development between cities from the perspective of correlation, including space, culture, belief, economy and other multi-dimensional connections, not only limited to the spatial form level. Quanzhou-Shishi-Huizhou is the combination of parallel coastal cities, Xiangshan-Zhoushan-Ningbo is the combination of coastal towns and inland rivers (Hong Kong-Guangzhou also has had this relationship historically), the "Yangtze River Delta" Shanghai-Nanjing-Hangzhou is a megacity cluster structure centered on Shanghai, forming the Yangtze River urban belt and economic belt with a long history. There was no Shanghai in history. Since the Yuan and Ming dynasties, Nanjing-Suzhou-Hangzhou had been the three parallel economic centers. The coastal defense, and later the colonies, promoted the development of Shanghai from the Qing Dynasty.

## 3. The Historical Pattern of Guangzhou-Hong Kong Linkage Development

The research on the historical pattern of Guangzhou-Hong Kong linkage development will be carried out from three aspects: the interactive development of "water and city," the interaction between cities, and then the linkage development between cities and the changes of the structure of the surrounding secondary urban agglomeration.

#### 3.1 The Interaction of Water and City

Guangzhou-Hong Kong is a typical specimen of a "river-sea" group city, with Zhongshan, Dongguan and other secondary urban agglomerations as the hinterlands. The project takes the interaction between "water" (river basin, ocean) and town in the living environment of regional historical cities and the linkage development between cities as the breakthrough point. This approach fully shows the natural environment of the generation and development of this group city, as well as the cultural characteristics and urban types. Hong Kong is a typical private capital priority model, so the city is a spatial form formed by the combination of high-volume rate and high-density small plot construction, and most of the plots are controlled by large families or large capital, and high quality plots are located close to the water.

#### 3.2 Interactions between Cities

The interaction between the inland river and the ocean brings the interaction of cities and the influence of water system (inland river and sea) on the development of the group city in different periods. Guangzhou-Hong Kong was a "semi-colonial-colonial" dual-city model in modern times. After the founding of New China, the "inland city-concession" city relationship governed respectively by China and Britain was formed, which continued the "officialcivil" dual-mode linkage since the late Qing Dynasty. After the reform and opening up, based on the combination of historical accumulation of interaction and good policies, it jointly promotes the development of secondary urban agglomeration between the two cities, and accelerates its integrated development.

#### 3.3 Inter-city linkages brought changes in urban structure

Inter-city linkage development (including economic hinterland

development) brings about changes in urban structure. Guangzhou was the urban node on the sea route. With the British colonists encroaching on Hong Kong, it gradually evolved from the former "tomatoes on sticks" structure to the "dumbbell" structure, that is, the importance of Hong Kong transcended Dongguan, Zhongshan, and other cities on the route. This "dumbbell" structure further promoted the development of other cities along the route, strengthened the influence of Guangzhou-Hong Kong poles, and then evolved into today's pattern.

The study of the historical pattern of Guangzhou-Hong Kong linkage development includes three levels, that is, it analyzes the relationship between urban landscape environment and urban development, and explores the changing process of "combined city" linkage development, as well as the relationship with the secondary urban agglomeration and the regional urban structure.



Figure 1. The Historical Pattern of Guangzhou-Hong Kong Linkage Development

# 4. Heritage Conservation and Sustainable Development of Historic Cities

Guangzhou has been one of the most important trading seaports in Southern China since ancient times; it was the place where the local administrative centers were always located under different dynasties. Even during the sea ban period of the Ming and Qing dynasties, it was designated as the only legal trade port by the government. Since Guangzhou was a city full of external opportunities, there are many traces of cultural blending within the city, including food culture, religious culture, some foreign cultural and religious sites, and so on. In the early days, Hong Kong was a small unknown fishing village, a part of one of Guangzhou's administrative divisions under most of the dynasties. It began to gain a foothold in Guangzhou's foreign trade from Song and Yuan dynasties. It is said that the name of Hongkong (Xianggang in Chinese, which means spice harbor) was derived from its function as a trading port for spices. In modern times, Hong Kong developed rapidly during British colonization, and became the most developed city of maritime trade on the South China sea because of the Victoria harbour.

It can be seen that the two cities have formed a good cooperative relationship in the process of dealing with global trade since ancient times, which is determined by their geographical advantages and cultural factors. In addition, the two cities in the history of trade cooperation model and Guangdong and Hong Kong today's "front shop and back factory" in contemporary age have something in common as well. Guangzhou has the advantage of deep and broad hinterlands and has been an administrative center for many years, while Hong Kong has the advantage of coastal location and Victoria harbour. One is the economic center of ancient China and the latter is the economic center of modern China. Geographical and historical factors have cemented their cooperation.

Guangzhou-Hong Kong's existing historical ties can also serve as an opportunity to develop the tertiary industry. We can build the basic layout of public transport facilities in the Guangdong-Hong Kong-Macao Greater Bay, and then carry out Guangzhou-Hong Kong integration of tourist route, postal services, and information industry connection. Like the concept of the Silk Road, the original historical tie between Hon Kong and Guangzhou can be utilized to enhance the interconnection with each other.

Asian countries are experiencing unprecedented rapid urbanization, and the sustainable development of cities in the future is bound to become an important topic as historical environments undergo changes. The project proposes to pay attention to the study of historical cities, sum up laws and experiences in historical development, and classify urban types and their development models from the perspective of social economy and history and culture, forming a holistic concept of conservation-development in urbanization process. The countermeasures and paths for the conservation of historical urban heritage based on sustainable development are related to future development in the urban historical environment and the integration of historical culture and environment into the elements of urban economic development.

Therefore, we should explore the combination of urban history and future development, integrate historical culture with economic development, and integrate historical and cultural urban network with economic and industrial network. The current study proposes to summarize the laws and experiences of historical development, and form a holistic concept of conservation-development from the perspective of socio-economic development and urbanization. It aims to link historical urban heritage conservation with sustainable development and carve an integrated path of urban heritage conservation and sustainable development in the historical environment.

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