Thai Environmental Engineering Journal Vol. 36 No. 3 (2022) : 65-71
www.eeat.or.th

Variation of Moisture Accumulation of Ancient Remains in the Early Ayutthaya Period, The Residence of the Patriarch of Wat Bhudthaisawan, Pranakorn Sri Ayutthaya Province, Thailand

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Abstract

This study measured moisture accumulation variation in the walls of ancient remains and compared it to results from the same measurement site over the last 13 years. It has the potential to reveal significant changes in moisture accumulation. Important murals inside buildings can deteriorate over time if they are not properly cared for. The purpose of this research is to determine the accumulated moisture content on the surface of an ancient wall from the Late Ayutthaya Period. The study was conducted in the patriarch's residence at Wat Bhudthaisawan, Pranakorn Sri Ayutthaya, by measuring the accumulated moisture contents on the surface of the wall at systematically selected locations with a Moisture Meter. The analysis discovered a statistically significant difference between measuring accumulated moisture in the wall at different heights. Moisture accumulation in the wall at the highest level adjacent to the roof had the highest value in all directions and the moisture accumulation in the walls was statistically significantly higher when compared to the results of the study 13 years ago.

Keywords : Moisture; Ancient remains

Introduction

Thailand is in a tropical zone, with relatively high air temperatures and relative humidity all year. High humidity is a leading cause of damage to priceless national art. Moisture in the air, moisture from rain, moisture from the soil, groundwater quantity, and building material are all factors that contribute to moisture accumulation in buildings [1].

Previous research on the relationship between the volume of human activity in buildings and air temperature and relative humidity discovered that they were significantly low within the various styles of buildings and their ventilation. They demonstrated that the air temperature and relative humidity changed over time, with a significant difference each day [1]. The variation of moisture content data in the walls will be an important factor in the materials used in the building's moisture restoration. Measuring the variation of humidity accumulation in the walls of ancient remains and comparing it to results obtained at the same measurement site over the previous 13 years may allow us to detect significant changes in moisture accumulation. Important murals inside buildings can deteriorate over time if not properly cared for. This study may point to the primary causes of the mural's destruction and may also be used as a guide to the restoration of this ancient site using environmental science principles as a guide.

Study area

The study area is located in the ancient remains of the early Ayutthaya Period, the residence of the patriarch of Wat Bhudthaisawan one of the so call temples in the province of Phra Nakhon Si Ayutthaya on the south side of the Chao Phraya River, it is situated across from the city island (Figure 1). This structure was erected where King Ramathibodi I tabernacle once stood

before he moved his capital from Ayutthaya to Ayutthaya. Wat Bhutthaisawan was built as a royal monument during the founding of Ayutthaya in 1353 AD. by decree of King Ramathibodi I. The Important historical structures, including the main pagoda and the residence of Somdej Phra Buddhakosachan, can be found inside the temple.

A historical illustration of Somdej Phra Buddhakosachan's journey to Lanka can be found on the wall. The paintings that decorate the residence are dated to the late Ayutthaya period (1788–2245 B.E.), which corresponds to the rule of Somdet Phra Pet Raja. The painting is made with powdered paint. The way the image is put together tells a tale by placing photographs of various events on each wall [2].

The residence of the patriarch of Somdej Phra Buddhakosachan is an ancient site of great religious and historical value (Figure 2). Currently, it has deteriorated over time. Due to being located on the banks of the Chao Phraya River, it is affected by flooding in the flooding season, causing the walls of the building to have a high level of humidity. This results in the deterioration of the murals over time.

Data collection

In this study, data was collected from July - December 2021 by monthly measurement of the variation of moisture inside the wall. The accumulated moisture contents on the wall's surface were measured at the systematically selected locations using a Moisture Meter. Each point is separated by a distance of about one meter but excludes door and window regions. The east and west walls have a height of about 6 meters and a length of about 5 meters, so the humidity measurement positions can be set to 6 positions in a row, a total of 30 (5Row-6column) (Figures 3). The north and south walls have 4 meters high and about 18 meters long, so there can be 4 humidity measurement positions in each row, a total of 60 positions (4Row-15column) (Figure 4).

Data analysis

This study will analyze the data in different ways by using descriptive statistical analysis, and two-sample tests, and statistical significance was determined with the Pearson correlation coefficient ($p < 0.05$).

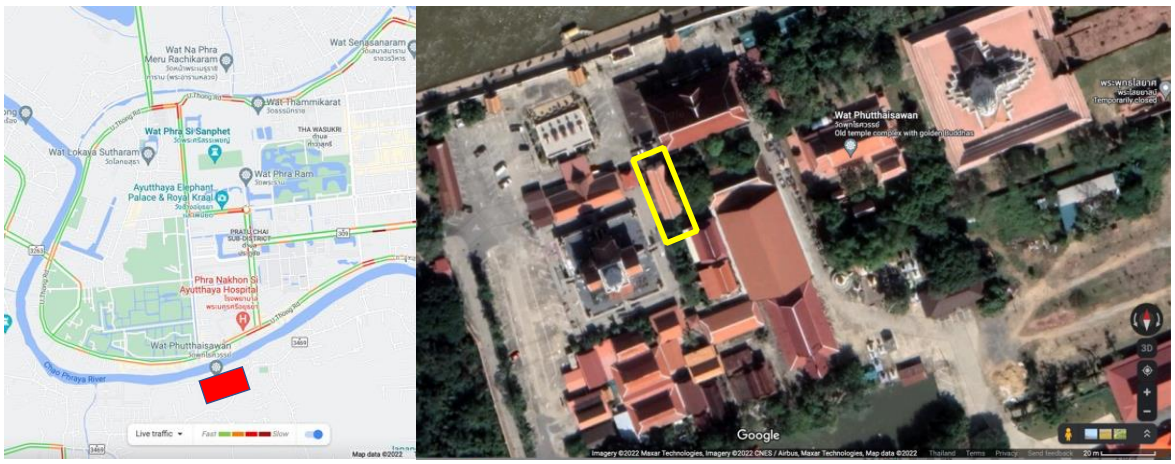

Figure 1 Map of Phra Nakhon Si Ayutthaya (upper) and the area of Wat Bhudthaisawan which locate on the south side of the Chao Phraya River (yellow mark)
Source: www.google.com/maps, 2022

Figure 2 The area of residence of the patriarch of Somdej Phra Buddhakosachan

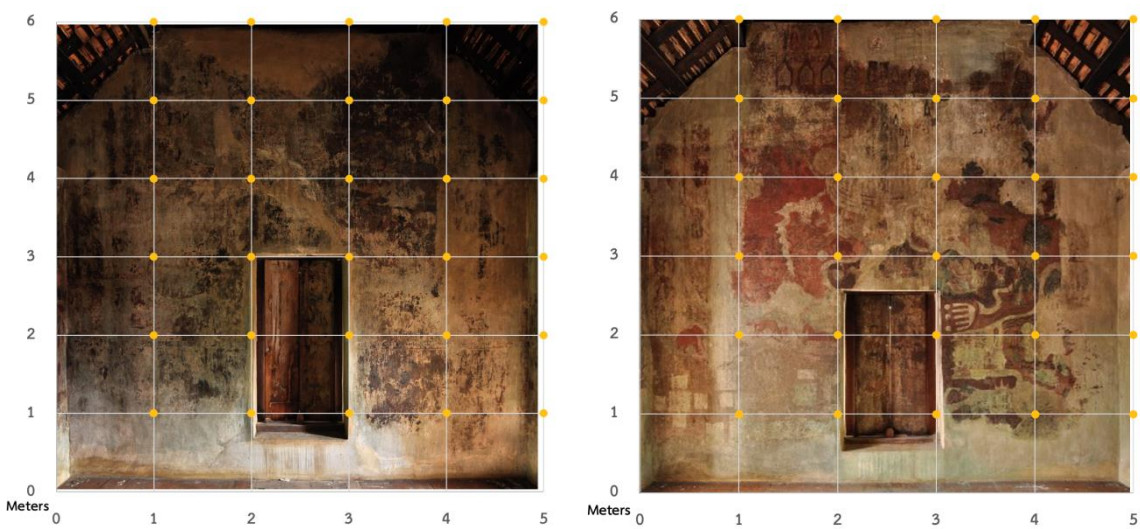

Figure 3 Positions of moisture accumulation measurement in the east wall (left) and the west wall (right)

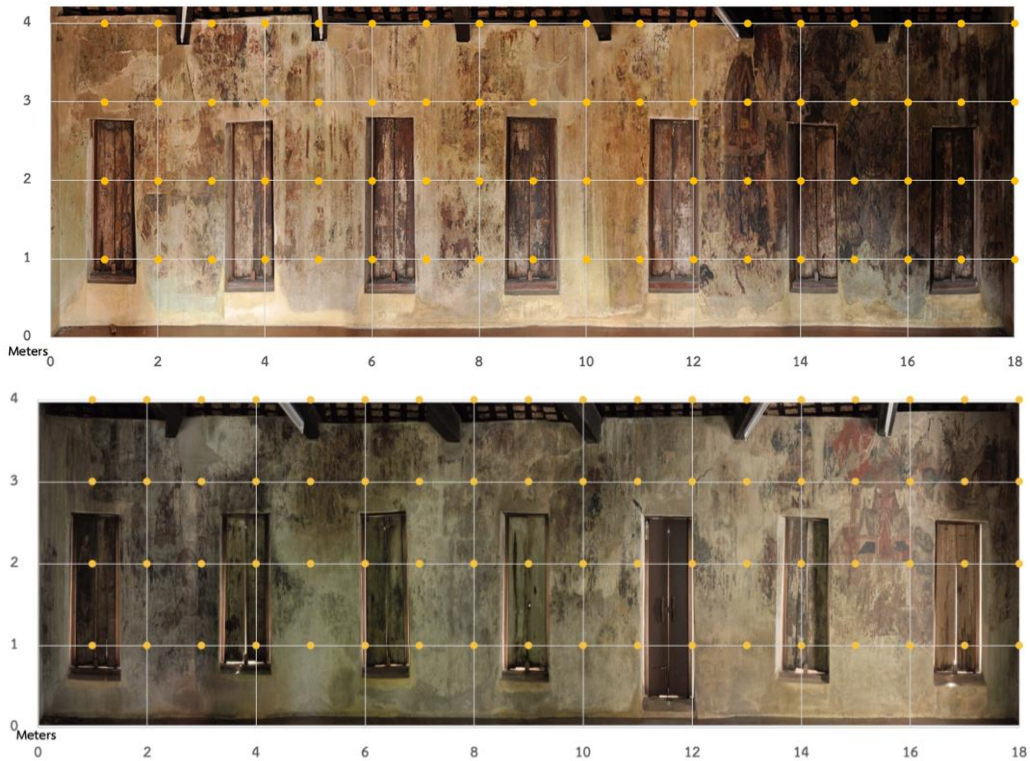

Figure 4 Positions of moisture accumulation measurement in the north wall (upper) and the south (lower)

Results

The variation of moisture accumulation (MC) in the wall

The analysis of variance for moisture accumulation in the walls on all four sides of the line (from the ground) is the main factor, and the order of the set as a factor in segmenting (Blocking factor) revealed that the variation between the rows is significantly ($p < 0.05$) different in three directions of the building, except for the west wall (Table 1), while the variation between columns is not significantly different. Furthermore, upon examining the relationship between MC and an average elevation above ground, a relationship between MC 2021 and height off the ground has been found: It should be noted that moisture at the highest level adjacent to the roof had the highest value in all directions, while moisture at the middle level had the lowest value. This is why the mural in the middle of the wall is still relatively intact. It's worth noting that the most intact part of the mural is located 2-3 meters above the ground level. The MC in this area is relatively low. Because this is a two-story structure, the influx of groundwater effects, as well as the pores of the walls, which can penetrate approximately one meter upwards and then evaporate from the wall, have less influence than rainwater [3].

Table 1 The p-value from the analysis of variance of the moisture accumulation in the walls in the row and column of each wall

Wall Direction	p-value	
	Row	Column
East	0.01	0.44
West	0.08	0.70
North	0.05	0.64
South	0.00	0.87

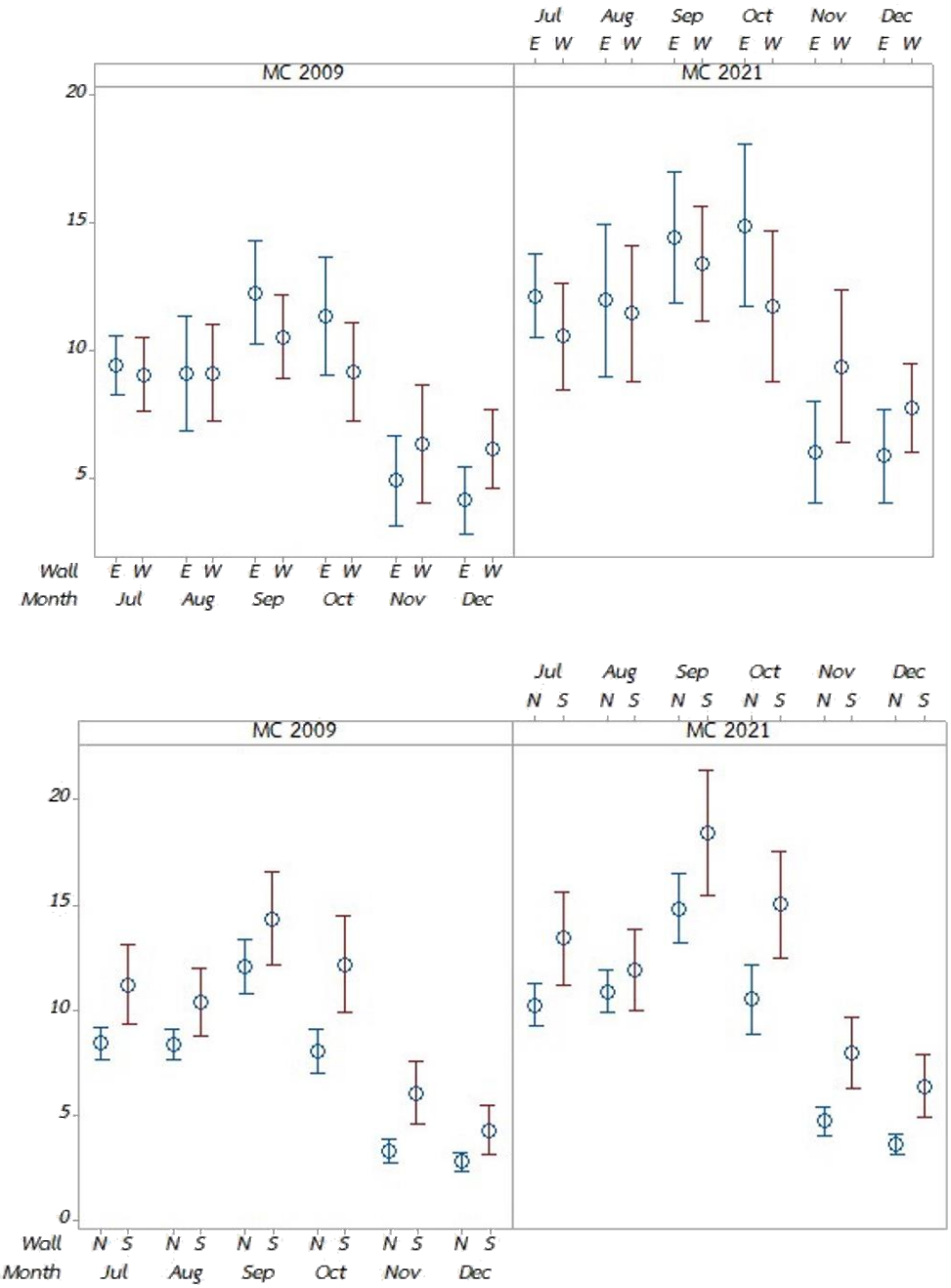

Figure 5 The interval graph compares MC2009 and MC 2021 over a 6-month period (Jul-Dec). Comparisons of building wall sizes are shown in pairs

A comparison study of moisture accumulation in walls between 2009 and 2022 using the T-Value of Paired-samples T-test. MC 2021 was discovered to have increased statistically significantly (Table 2 and Figure 5). The maximum increase trend may be influenced by rain, which is influenced by the southwest monsoon in Thailand during the rainy season.

Table 2 T-Value of Paired-samples T-test between moisture accumulation in the walls of 2009 and 2022

	East 2021	West 2021	North 2021	South 2021
East 2009	-12.88**			
West 2009		-12.48**		
North 2009			-15.63**	
South 2009				-16.68**

(**P<0.01, *P<0.05)

Conclusion

Due to rain, the humidity in the walls of this building varies significantly and peaks at about 1.00 meters below the roof. When the amount of moisture accumulated in the wall is compared to the previous 13-year study, it is discovered that the amount of moisture accumulated in the walls of this ancient building has increased. This could be because the material has deteriorated. A single-story building built close to the ground is distinguished by this phenomenon. The amount of groundwater absorbed by capillaries action is effective at 1 - 2 m above ground level [4]. Moisture is one of the most important factors influencing building performance and durability, particularly in humid climates. Moisture-related problems in the building include chemical deterioration and dissolution of materials such as gypsum sheathing and glued wood products [5].

The MC problem must be addressed at its source. The primary causes are water leaks and moisture condensation. The initial cause must pinpoint the location of the leak. It could be a perforated ceiling or a wall-to-roof joint. These joints are being repaired. Walls exposed to direct rain and moisture seeping through old plaster Care must be taken, especially during storms, to avoid splashing rain and to allow the building to dry completely before closing [6].

Moisture is a major factor in the degradation of porous masonry materials such as stones, bricks, mortar, and plaster. The open pores in the plaster and brick/stone masonry supports, as well as their contact with the microclimate and external factors, cause problems for wall paintings in particular [7]. Salt solutions that easily transfer to the plaster beneath the painting may find their way through the porous mortar backing and onto the wall. The volumetric expansion caused by the crystallization of these salts may have a negative impact on the adhesion of the pictorial film to the plaster as well as the adhesion between the plaster layers, resulting in the surface disintegrating [8]. The study of theology for the preservation of ancient sites is still limited at the moment. For these reasons, the pursuit of appropriate methods for preserving valuable ancient sites should be given careful consideration [9].

Because the monthly and annual rainfall in central Thailand is expected to be higher than average in 2022. In order to preserve cultural heritage, relevant authorities must take this damage into account. As a result, ancient buildings with roof leaks or that are exposed to rain may accumulate more moisture (1991-2020). In order to preserve cultural heritage, relevant authorities must consider this damage. The paintings inside this historic structure are very old and susceptible to moisture damage. The traditional short roof style is vulnerable to the effects of rainwater. During the rainy season, opening the building for ventilation and using fans to help ventilate may be an option.

The findings of this study can be viewed as a case study on the impact of moisture on buildings in general and historical sites in particular, implicating future construction and restoration considerations. Moisture level measurement and management in historical sites should be viewed as an ongoing process that will guide future cultural heritage conservation planning.

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