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# Thermal and Environmental Design for Human Comfort in Japanese-Designed Architecture in Thailand

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**Abstract**
These multiple case studies investigate thermal and environmental architectural details unique to the Japanese-designed educational facilities in Thailand, namely [1] King Mongkut Institute of Technology Ladkrabang 's Auditorium and Memorial Hall, [2] Lecture Halls, [3] Kasetsart University's Central Laboratory, [4] Thammasat University's Institute of Japanese Studies, and [5] Ministry of Natural Resources and Environment's Research Center. Data sources include archival records, site surveys, and interviews. The findings reveal various design strategies, such as double-layer walls, complex roofing design, specific orientation, and water features that contemporary sustainable building designs may adopt to increase thermal comfort while reducing energy consumption.

Keywords: human comfort; Japanese Modernism; tropical architecture


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## 1.0 Introduction

Between the 1960s to the early 1990s, Thailand received financial and technical support from Japan through Japan International Cooperation Agency (JICA). This was part of the international assistance to develop human resources to supply the growing agricultural and industrial sectors in response to the country's National Socio-Economic Development Plan 1 (NSEDP 1). Customarily, JICA would commission leading Japanese architectural and construction firms, such as Nikke Sekei, Junzo Sakakura & Associates, and Kisho Kurokawa Architect & Associates, to design and build these facilities.

Although these JICA-funded buildings are aesthetically pleasing and have been recognized by the Association of Siamese Architecture (ASA) for their design quality, the research investigations on these architectures could be more extensive. Since 2016, there have been only a handful of research with the primary focus on conceptual design and historical aspects of these buildings (Apichartworapan, 2016; Sawaki et al., 2018; Pienroj et al., 2019; Chiangsai & Nanta, 2021; Chanta, 2023). However, after being involved in a series of JICA-funded building studies, the author found that the thermal and environmental design of these buildings differed from the conventional styles used by the local Thai architects, which led to further speculation that these features might be useful in contemporary building design for the tropical area. Thus, this qualitative study aims to explore and compile architectural details from five case studies of Japanese-designed research and education facilities, particularly on the aspect of thermal and environmental, and analyze commonalities or differences among these design attributes. This study is the first part of the 2-phase study, where the design attributes collected from this study will be further objectively tested for thermal and environmental efficiency by computer simulation in the following study.

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## 2.0 Literature Review

While three decades of JICA financial and technical support had spawned over fifty Japanese Modernism Architectures in Thailand (Charoensupakul, 1988), the current review shows minimal systematic research studies related to this topic. The main emphasis of Japanese Modernism Architecture study in Thailand, thus far, is the combination of two main approaches; the historical and conceptual design (Apichartworapan, 2016; Sawaki et al., 2018; Pienroj et al., 2019; Chiangsai & Nanta, 2021; Chanta, 2023).

### *2.1 Japanese Modernism in Thailand*

The studies of Junzo Sakakura and Kisho Kurokawa's works in Thailand are of interest for conservation purposes and for deciphering how the exemplary architects adapted their designs in the different cultural and geographical milieus. Junzo Sakakura (1901-1969) was a modernist architect who significantly developed Japanese architecture during the 20th century. He worked closely with Le Corbusier in Paris before returning to Japan and designed several influential buildings that combined traditional Japanese elements with modernist design principles. In the early 1960s, against competition from several international design firms from Denmark, USA, and Netherlands, Sakakura's proposal was selected by the World Bank Committee to design vocational schools in 25 locations around Thailand.

Apichartworapan (2016) investigated Junzo Sakakura's design of the 1966 International Bank for Reconstruction and Development (IBD) loan project for the construction of 25 vocational schools around Thailand and indicated that Sakakura acquired the design of prefabrication and standardization system used in this project during the time he apprenticed at Le Corbusier's atelier during 1931-1939.

Kisho Kurokawa (1934-2007) was one of the founders of the Metabolist movement in the 1960s. He designed many influential buildings in Japan and globally and was known for his innovative use of technology and his incorporation of organic forms and principles into his designs. Chanta's (2023) study of the Thammasat University's Institute of Japanese Studies (1984), presently known as the Institute of East Asian Studies, focuses on the design signature that the Institute characteristically shares with other works of Kurokawa. The results indicate standard design features, with Kurokawa's other work from the same period including the Museum of Modern Art, Saitama (1982) and the Nagoya City Art Museum, Aichi (1987).

Chanta (2023) reports typical architectural design features, including the use of modular form to create flexible and Human-Scale designs, organic shapes, and forms which he believed better reflected the natural world and would help create a more harmonious relationship between humans and the built environment, regionalism by incorporating local cultural and historical elements into his designs, as well as sustainable design which reflects Kurokawa concept of "metabolism," an architectural philosophy that emphasized flexibility, adaptability, and sustainability in urban and architectural design. First, however, the study needs to provide detailed information on the elements Kurokawa used to create sustainable and comfortable environmental conditions in his architectural design.

### *2.2 Environmental Design for Human Comfort in Japanese-Design Architectures in Thailand*

Human comfort is about the physical environment in its totality. Human generally feels comfortable between temperatures of 22 – 27°c and relative humidity of 40 – 60 % (Olgyay & Lyndon, 2015). Although people from a tropical zone tend to be more tolerant to heat and humidity than those in cooler climate zones, solar radiation, rainfall, and natural ventilation still strongly affect tropical architectural design. Moreover, these concerns have been emphasized throughout several preliminary reports for constructing JICA-funded projects (Japan International Cooperation, 1974,1983, 1983, 1986).

The techniques Japanese architects used to handle heat and humidity in architectural design in Thailand received interest from architectural researchers (Sawaki et al., 2018; Pienroj et al., 2019; Chiangsai & Nanta, 2021) in the past five years. Sawaki and colleagues (2018) compare Sakakura's 1966 IBD vocational school project with his earlier design of Hannan High School (1958-1962) in Osaka, the warmer climate zone of Japan. The study reveals Sakakura's common problem-solving patterns in handling Thailand's tropical climate, such as various ventilation designs, extensive shading elements, and arrangement of building orientation to place the transversal elevation on the East-West axis. Pienroj and colleagues (2019) investigate King Mongkut's Institute of Technology Ladkrabang Auditorium and Memorial Hall, while Chiangsai & Nanta (2021) examine KMITL Lecture Hall Complex designed by Kume Architect-Engineer. Both studies find the records reveal major concerns for flooding that resulted in the raised ground floor level and the need to use local materials for ease of maintenance and replacement.

The review of previous research not only confirms the attention to detail in Japanese architectural design to cope with the thermal and environmental constraints of the tropical climate but also reveals that all the studies were based on a single case study, which did not lend to the systematic analysis of the design attributes across cases. Therefore, a multiple case studies approach to study the thermal and environmental design attributes of five JICA-funded buildings will provide an in-depth understanding of the design attributes through a comparison of similarities and differences of the individual buildings.

## 3.0 Methodology

This qualitative study aims to explore and compile information on Japanese architects' designs for hot and humid climates by systematically collecting and analyzing archival records and architectural drawings. Data from field research, including direct observation and artifactual measurement, with a supplementary interview with facility managers and executives of the facilities from the case studies, have been used for data triangulation to establish credibility for the study. Informants participating in the unstructured interviews between April 2019 – August 2022 included: 2 faculty members, five facilities managers, and four executive administrators.

Though this investigation provides a wealth of information on the thermal and environmental design attributes of the JICA-funded building, the efficiency of these design attributes is yet to be objectively verified. Furthermore, the selection and classification of the

design attributes are subjectively interpreted based solely on the experience and expertise of the authors. Thus, further objective testing of the design features through computer simulation and comparison of efficiency, energy consumption, and users' satisfaction toward thermal comfort are needed for the next phase of the study.

Five JICA-funded research and educational projects in this study consist of the King Mongkut's Institute of Technology Ladkrabang (KMITL)'s Auditorium and Memorial Hall (1974), KMITL Lecture Room Building Complex (1983), Central Laboratory Facilities at Kasetsart University's Kampangsaen Campus (1978), Thammasat University's Institute of Japanese Studies (1984), and Ministry of Natural Resources Environmental Research and Training Center (1989) is selected to be used as case studies for determining tropical architectural design features unique to these buildings.

*3.1 Case Studies Background*

The cases in this study consist of five Modern Japanese-designed educational and research facilities, which are part of JICA-funded projects built between 1974 – 1989. All but one building were designed by Kume Architect-Engineer Company, while the Thammasat University's Institute of Japanese Studies was designed by Kisho Kurokawa, architect & associate. The usage area of these concrete structured facilities ranges from 1,762 to 18,560 $m^2$ and houses similar functional programming, namely, administration offices, classrooms, laboratories, library, auditorium, canteen or cafeteria, and dormitory for researchers. A brief description of each facility is as follows.

The first and the second cases comprise the 1600-seat Auditorium and Memorial Hall (1974) and the Lecture Hall Complex (1983) at the King Mongkut Institute of Technology campus. These two facilities are located on the wetlands on the eastern border of Bangkok and are prone to flooding risks. Kume Architect-Engineers designed both buildings and were part of the first grant aid from the Official Development Assistant (ODA) for KMITL. The total functional area of the Auditorium is 1,762 $m^2$, while the Lecture Hall is 18,560 $m^2$.

Fig. 1. The KMITL Auditorium and memorial hall (1974)
*(Source): Courtesy of Pienroj (2019)*

Fig. 2. The KMITL Memorial Hall (1974)
*(Source): KMITL Archive*

The third case is the Central Laboratory Facilities at Kasetsart University's Kampangsaen Campus (1978), Nakhon Pathom province, designed by Kume Architect-Engineers. This single-story building complex is home to various laboratories and supporting facilities,

including a library, seminar hall, and administration offices, to serve the need of agricultural studies and related fields with a total area of 9,738 m2.

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Fig. 3: Kasetsart University's Central Laboratory at Kampangsaen Campus (1978
*(Source): Authors,2023*

Fourthly, the Thammasat University's Institute of Japanese Studies (1984) was designed by the renowned Japanese architect Kisho Kurokawa architect & associates. How Kurokawa got involved in this project is still being determined, but it was probably around the 1980s when he actively worked in Southeast Asia. Located in Pathum Thani province north of Bangkok, the two-stories structure offers 4,723.6 $m^2$ of usage area consisting of offices, meeting rooms, a printing room, storage, a ballroom, a restaurant, 120 seats, a 20-seat library, and references room, publication shops, various size classrooms, laboratories, and a dormitory for researchers.

Fg. 4: Thammasat University's Institute of Japanese Studies (1984).
*(Source:) Authors,2023*

The last case study is the Ministry of Natural Resources Environmental Research and Training Center (1989) in Pathum Thani province, located 47 km north of Bangkok. This 8,156 $m^2$ facility aims to be a pollution prevention center, conduct research and training activities, and foster a workforce in environmental conservation. The three-story buildings complex comprises research, training, monitoring, dormitory, and administrative blocks.

Fig. 5: Ministry of Natural Resources Environmental Research and Training Center (1989)
*(Source:) Authors,2023*

## 4.0 Findings

The content analysis of interview results indicates that the building occupants are satisfied with the thermal and humidity level within these facilities. In addition, the building occupants and facilities managers of all cases reported minimal reliance on additional air-conditioning since the building provides adequate air ventilation and comfortable temperature within the general area of the buildings.

Although one of the facilities was designed by different firms, the exploratory study reveals some common environmental design characteristics. Table 1 compares distinctive design features that help reduce heat transfer and humidity across five buildings, including a double concrete roof, walls and stairwells, water features, and other design elements. Table 1 compares thermals and environmental design across five case studies.

Table 1. Environmental Design Elements from 5 Case Studies *(Source:) Authors (Source:) A*

| | Architectural Design Firm | Roof | Walls & Stairs Well | Water Features | Other Design Elements |
|---|---|---|---|---|---|
| KMITL's Auditorium (1974) |  (Kume Architect-Engineers) |  |  | | |
| KMITL's Lecture Halls (1983) |  (Kume Architect-Engineers) |  |  |  |  |
| Kasetsart University's Central Laboratory, Kampangsaen Campus (1978) |  (Kume Architect-Engineers) |   | | |  |
| Thammasat University's Institute of East Asian Studies (1984) |  (Kisho Kurokawa) |  |  |  |  |
| Ministry of Natural Resources Environmental Research and Training Center (1989) |  (Kume Architect-Engineers) | |   |  | |

### *4.1 Roofing*

All roof structure from the case studies is made of concrete slab, which impedes both heat gain and loss from the environment. In addition, the informants note that a concrete roof is generally good for the cool weather during the winter and morning time because it retains the temperature and warms up the building comfortably.

The KMITL auditorium uses a double-layer roofing system by laying over the concrete slab with corrugate tile to prevent direct solar radiation. The corrugated asbestos cement covering on the roof slab is the general and rational way to protect interior space from radiating heat and use the air gap between the cover and concrete slab as insulating layers.

KMITL lecture halls have distinctive techniques to create an s-curved roof form, which helps diffuse natural light from the north side (reduce energy consumption from artificial lighting). In addition, Kasetsart University's Central Laboratory and Thammasat University's Institute of East Asian Studies have heat outlets on the roof to release hotter temperatures from the air pocket within the plenum, which is uncommon in Thai architectural design.

*4.2 Walls and Stair Wells*

The wall of the KMITL auditorium has detail, which does not show in the blueprint of the construction drawings, that releases humidity from the air gap between the double walls. In addition, KMITL Lecture Halls and Ministry of Natural Resources Environmental Research and Training Center stair landings are cleverly designed to keep the continuity of the modular systems on the building envelope while helping create a chimney effect that leads to good ventilation in the otherwise would-be musty stairwell.

The veranda or corridor that constructs around the main facility is found in Kurokawa's Institute of Japanese Studies design and Kume Architect-Engineer's design of the Ministry of Natural Resources Environmental Research and Training Center. This design feature is distinctively different from the Thai architectural design elements. However, the building occupants and facilities manager of these two cases agrees that this feature serves as a buffer zone that protects from the elements while allowing the occupant to have visibility of the outside environment.

*4.3 Water Features*

The survey reveals the use of water features in the landscape of KMITL's Lecture Halls, the Thammasart University's Institute of Japanese Studies, and the Ministry of Natural Resources Environmental Research and Training Center. The water features adjacent to the architecture help reduce outside air temperature before entering the building. The different temperatures between water and ground create air buoyancy, which leads to desirable air movement. The disadvantage is that the humidity with water may create a steamy and uncomfortable condition.

*4.4 Other Design Features*

The design of voids through several floors is found at the KMITL Lecture Halls. It creates an exciting vista and induces the chimney effects that lead to air movement and buoyancy of the hot air to the upper zone and dissipation into the external environment. A single load-covered walkway around an open court filled with green space has been seen in all cases. The court gets shading from the buildings, which lowers the temperature and is partially protected from direct sunlight, allowing the area to be used comfortably throughout the day.

To avoid direct solar radiation from getting into the building, the KMITL Lecture Halls are principally designed with an east-west orientation on their lengthwise, with windows on the south and north side to employ natural ventilation. No openings are installed on the east and west sides, but hollow space in the form of a double wall is provided for insulation. Eaves or sunshades are installed for shading at the south and north side openings.

## 5.0 Discussions

Local meteorological conditions are critical factors in architectural design. Two seasonal winds are the primary consideration for the ventilation of architectural design in Thailand. First, the north-easterly wind between November and March brings cooler temperatures, generally less humidity, and less chance of rainfall. Another is the southwest monsoon between June and September which brings monsoons and humidity from the Indian Ocean. In the feasibility study phase, all JICA reports instruct that efficient shading design and structural elements that promote natural ventilation should be implemented, in the architectural design, to handle the tropical heat and intense sunlight (Sawaki, 2018; Chiangsai & Nanta, 2021).

Speculatively, Modern Japanese architects are familiar with the use of concrete slab roofing design since the structure is strong enough to bear the weight of snow, which is common in Japan, especially for the wide-span structures of the public facility. The concrete roof is more expensive than the traditional Thai roof design, which employs local wood, terracotta, or corrugate roof tile. The advantage is reduced construction time and a readily available industrial construction system. The JICA documents emphasize the need for adequate heat-insulating layers between the roofs and durable waterproofing designed against active solar radiation and heavy rainfalls. Extensive uses of eaves and louvers would also minimize heat and rain's effect (Japan International Corporation, 1978; 1983; 1989)

Exterior walls are also affected by solar radiation. Also, in Thailand, it is possible to obtain the draft by the seasonal south-north winds throughout the year. The best use of this natural benefit is to create large openings to facilitate natural ventilation. High humidity is the main problem in Thailand. The use of a humidity release gap has yet to be previously seen in traditional Thai architecture. However, it has been employed as a restoration technique in several historical temples with humidity problems to preserve the mural painting.

The single corridor and gallery around the courtyard also help provide adequate natural ventilation and lighting with little dependence on additional equipment. This architectural design element is characteristically Japanese. It embeds the Japanese architectural culture and serves as a buffer zone that protects from the elements while allowing the occupant to see the outside environment. This design element is the modern interpretation of *Engawa*, a transition space, a veranda or corridor constructed around the Japanese house (Chiangsai & Nanta, 2021; Chanta, 2023).

## 6.0 Conclusion& Recommendations

The findings reveal various patterns of roofing design, such as double-layer and curved roofs, the buildings' orientation, and the use of water features around and within the building compounds. Other strategies included using double-layer walls to reduce heat transfer from the outside environment, ventilation gaps in the walls, and concrete roofing to reduce the accumulation of heat and humidity that may be used in contemporary building design to create thermal and environmental comfort for the building occupants. Architectural detail collected from this study may be adapted and used in sustainable contemporary building design that would increase human comfort while reducing energy consumption.

However, this is only the exploratory phase of the study on Japanese Modernism architecture in Thailand, which will comprise several dimensions. Regarding the building technology study, the information and data collected for this study are based on the users' subjective experience and the researcher's expertise. Therefore, objective examination to gather empirical evidence on the performance of these design using actual measurements or computer simulations are highly recommended. The influence of Japanese Modernism on Thai architecture is another possibility for future research, as there is limited information and the development of Modern Thai architecture. Finally, as many of these buildings are thirty years and older, research studies focus on exploring approaches for building conservation or retrofit to serve the needs of today's occupants while maintaining their design and historical integrity will warrant further investigation.

Understanding this architecture will also fill in the gaps in the developmental factors influencing the development of Thailand's contemporary architecture. Furthermore, studying Japanese-design architecture in Thailand enables the appreciation of the diverse range of cultural expressions that have emerged throughout history and will also inform the historical significance and value of buildings and structures, which can inform preservation efforts. Finally, through this investigation, designers can also learn of different design approaches and techniques used by Japanese architects, which may be applicable for further developing sustainable designs and styles corresponding to tropical architectural design requirements.

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## Paper Contribution to Related Field of Study

Architectural History and Environmental Technology

## References

Abhichartvorapan, W. & Watanabe, K. (2016). "The Future for Thailand Vocational Education Project 1965-70 by Junzo Sakakura" Journal of International Symposium on Architectural Interchange in Asia, 11, pp.834-839.

Abhichartvorapan, W. & Watanabe, K, (2017). "Cultural Significance Identification of Modern Architectural Heritage." Journal of Architecture and Planning, AIJ, Vol. 82 No. 735, pp. 1377-1387.

Araki, M (2017). "A Story of King Mongkut's Institute of Technology Ladkrabang." Mitsuru Suemori, The International Development Journal, pp.55–173, Japan.

Charoensupakul, A. (1988). The Japanese government provided architectural assistance as well as technology transfers to facilitate cultural understanding of the case of Thailand, Academic Journal Faculty of Architecture Silpakorn University vol. 8, 1988, pp. 129-140. )in Thai(.

Chiangsai, N. & Nanta, P. (2021). Spatial Organizations Characteristics of Japanese Architectural Design in Thailand during the 1970s -1989s. The 12th Graduate Integrity Conference, King Mongkut Institute of Technology Ladkrabang, Bangkok, Thailand. )in Thai(.

Farhady, M., & Nam, J. (2009). Comparison of in-between concepts by Aldo van Eyck and Kisho Kurokawa - Through theories of 'twin phenomena' and 'symbiosis,' Journal of Asian Architecture and Building Engineering. pp. 17-23, 8(1).

Japan International Cooperation, (1978). "Preliminary design for Central Laboratory & Greenhouse Complex of Kasetsart University Kampangsaen Campus in The Kingdom of Thailand," Japan International Cooperation Agency Library, pp.18-56.

Japan International Cooperation, (1983). "Basic Design Study on The Construction of The Lecture Room Building King Mongkut's Institute of Technology in The Kingdom of Thailand," Japan International Cooperation Agency Library, pp.50-80.

Japan International Cooperation, (1983). タイ王国 タマサート大学日本研究センター設立計画基本設計調査報告書, 1983, pp.14-34.

Japan International Cooperation, (1989). “Basic Design Study Report on The Establishment of The Environment Research and Training Center in Kingdom Thailand," Japan International Cooperation Agency Library, pp.103-167.

Olgyay V. Olgyay A. & Lyndon D. (2015). Design with climate: a bioclimatic approach to architectural regionalism (New and expanded). Princeton University Press.

Sawaki, J. (2019). "Architectural Design Methods for the Tropical Climate by Junzo Sakakura in Case of a Vocational School Project in Ladkrabang, Thailand," Master Thesis of King Mongkut's Institute of Technology Ladkrabang, pp.1–52.

Sawaki, J., Nanta, P., Kuanprasert, R., Ogura, R. and Irie, T. (2018). From Temperate to Tropical: The Design Method by Junzo Sakakura in Thailand Vocational School Project. 12thISAIAConference, October 23 –26, Pyeongchang, Korea.

Xue, C., Q. L., Xiao, J. (2014). Japanese modernity deviated: Its importation and legacy in the Southeast Asian architecture since the 1970s, Journal of Habitat International, vol. 44, pp.227-236.