

**FROM TEMPERATE TO TROPICAL :
THE DESIGN METHOD OF JUNZO SAKAKURA
IN THE THAILAND VOCATIONAL SCHOOL PROJECT**



**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF ARCHITECTURE PROGRAM INTERIOR ARCHITECTURE
FACULTY OF ARCHITECTURE
KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG
2019
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Thesis	From Temperate to Tropical: The design method of Junzo Sakakura in the 1966 - 1970 Vocational School Project in Thailand
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ABSTRACT

Junzo Sakakura (1901-1969) was one of the most recognized architects from the Modern Movement period in Japan. He worked for Le Corbusier design firm during 1931-1936, and adopted some of Le Corbusier design signature such as the use of pilotis and golden ratio proportion. In 1961, Thailand was the recipient for the International Bank for Reconstruction and Development (IBRD) to improve 25 vocational schools in the country. However, the aid came under the condition that international architecture firm, instead of the local one, must be commissioned for this project. Among several international firms from Denmark, USA, Netherlands, and etc., the IBRD committee selected the Sakakura Architects and Engineers Associates to carry out this project (1966-1970). Thus, this study aims to investigate the ingenious adaptation of techniques by Sakakura, who specialized in the Temperate climate of Japan. And how he adapted those techniques in the standardized building design in the Tropical zone of Thailand. The analyses are based on the archival research, and field survey comparing the design of Thai vocational education project and Hannan Senior High School, designed earlier in 1960 by Sakakura. The study showed that Sakakura modified elements in his design to fit Thai climate including, classroom size, Golden ratio, deep of cantilever. He also introduced features, never been used in his previous educational building design in Japan, such as south side corridor, corrugated asbestos roofing and louver glass window to alleviate heat, but allowing the indirect sunlight into the classroom.

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JUNICHI SAWAKI

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CHAPTER 1

INTRODUCTION

1.1 Background

Thailand started its National Socio-Economic Development Plan 1 (NSED Plan 1) in 1961 that aimed at improving the country's infrastructure, rural development along with agricultural, and industry support. Two years later, in 1963 the Thai Ministry of Education managed to secure the World Bank loan, to develop human resources for the country's growing agricultural and industrial sectors, and initiated a large-scale project to improve 25 vocational schools including agriculture schools, technical schools as well as teacher training college for the entire country.

However, the World Bank aid came under the condition that international architecture firm, instead of the local one, must be commissioned for this project. Among several international firms from Denmark, USA, Netherlands, and so forth, the IBRD committee selected the Sakakura Architects and Engineers Associates to carry out this project, which was later realized during the period between 1966 to 1970.

Junzo Sakakura (1901-1969) was the one of the most prominent Modern movement¹, in Japan (Fig. 1). He was one of the three Japanese disciples: Maekawa, Sakakura and Takamasa Yoshizaka Of the iconic Swiss-French architect of the Modern Movement, Charles-Édouard Jeanneret or as known as Le Corbusier (1887-1965).

Sakakura certainly received the design influenced from Le Corbusier's during the year 1931-1936 that he worked and studied under the great architect.

¹ Modern Movement is also known as "International Style." Although it was developed in Europe during the 1920s, and become widely accepted in the western hemisphere in the 19 during 1930s, and later spread to Japan after World War II around the later part of the 1940s, after Japan's Colonial Architecture period, as exemplified in Kenzo Tange's winning competition for the Hiroshima Peace Memorial Museum in 1949.

Strong Le Corbusier influence in Sakakura's work could be distinctively revealed in the cleverly mixed of traditional Japanese design with modernism in one of Sakakura's masterpieces design of the Japanese pavilion for the 1937 World Exposition in Paris (Fig. 2)

After Sakakura Associates was formally commissioned from IBRD for the Thai Vocational School Project in 1966, Sakakura and his staffs started designing 25 vocational schools in several provinces throughout Thailand, and finally completed the project in 1970. It is worth noting that, the entire master plan, basic design and final design was done at the Sakakura Associates in Tokyo.

Sakakura cleverly used standardization system to satisfy the needs of the Thai Ministry of Education and to build 25 vocational schools that spread all over the country both in town and rural area in a short period of time. This standardization permitted variability of sizing and configuration suitable for the tropical climate, create unique characteristics of each school, while making it easy to build with local construction techniques that were available in Thailand during that time.



Fig. 1 Junzo Sakakura with Le Corbusier (Source: Isamu, K (1971) 現代日本建築家全集 11 [Contemporary Japanese Architects Collection 11] San-Ichi Shobo, pp.11-106)

No matter how experience Sakakura might be, he was mostly familiar with the architectural design for the Temperate² zone of Japan or other Continental area. It would require some ingenuity and proficiency, on his part, to execute a large-scale project that spread out in a Tropical country such as Thailand. Thus, the objective of this study is to investigate how Junzo Sakakura adapted and implement his architectural designed the Thai vocational school project in the Thai tropical climate.



Fig. 2 Japanese pavilion of the Paris World Exposition (Source: Isamu, K (1971) 現代日本建築家全集 11 [Contemporary Japanese Architects Collection 11] San-Ichi Shobo, pp.11-106)

There is a large difference about temperature, precipitation and humidity between Japan and Thailand climate. High temperature and humidity are the characteristic of the Thai climate. The season is divided into rainy season and dry season. The rainy season in Thailand ranges from June to October and heavy rain falls about an hour every day and there is frequently flooded after rain. Amount of rainfall in Thailand in June - August is about twice as large as that in Japan, exceeding 300 mm per month (Fig. 3).

² Based on *The Köppen climate classification*, Japan is in the ‘*Humid Subtropical*’ Climates that usually in the high 20-30 latitudes, but is within a subset of the *Temperate* or *Mesothermal* climate where Thailand is considered a *Tropical* wet and dry or *Savanna* climate.

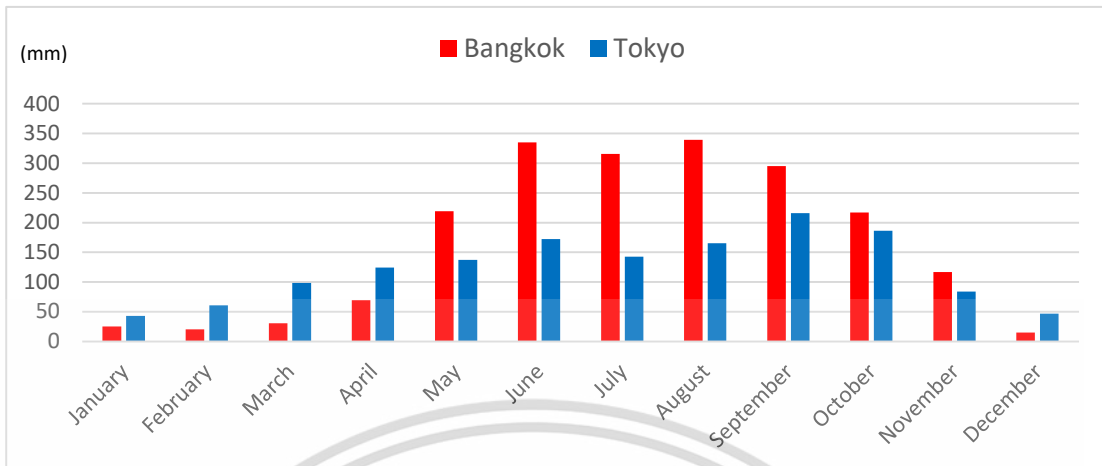


Fig. 3 Average monthly rainfall for Bangkok and Japan from 1901-2015

(Source: <http://www.cru.uea.ac.uk/>)

There are 4 seasons in Japan and temperature difference in summer and winter is about 22 degrees (Fig. 4).

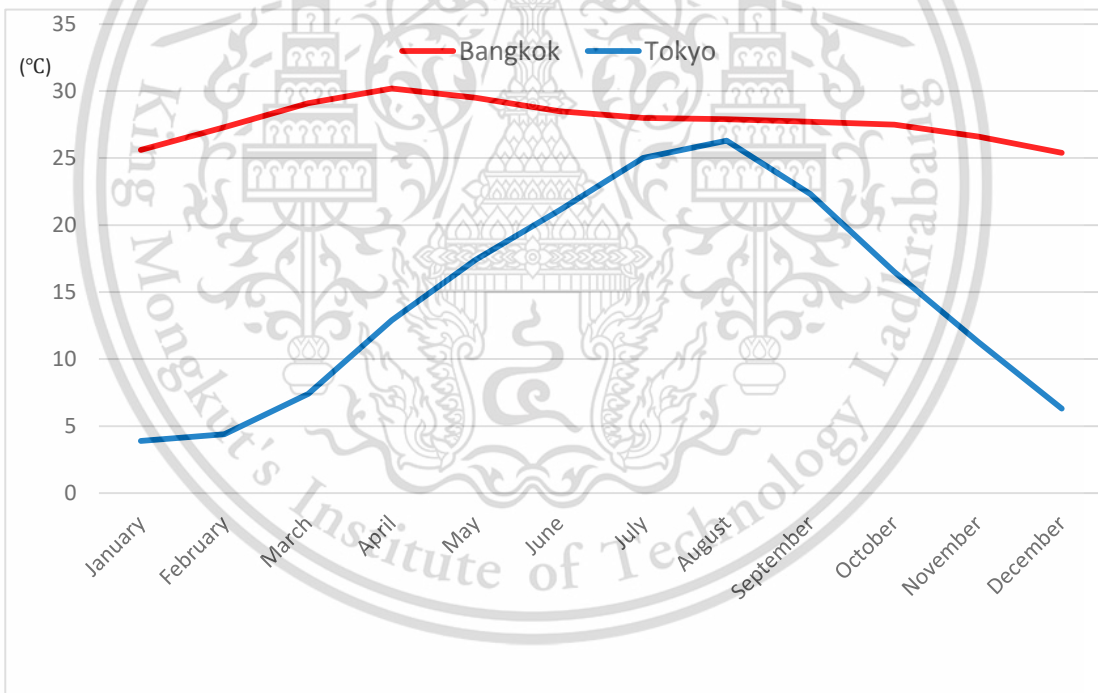


Fig. 4 Average monthly temperature for Bangkok and Japan from 1901-2015

(Source: <http://www.cru.uea.ac.uk/>)

The climate of Japan greatly different between Hokkaido in the north to Okinawa in the south because Japan is long in the North - South. Hokkaido and Tohoku regions are subarctic climate and Southwest Islands are subtropical climate.

1.2 Rationale

Since Frank Lloyd Wright brought Japanese architectural design and styles to the world after he was commissioned to design the Tokyo's Imperial Hotel in 1905, Japanese Design was well received by the general public. Japanese architecture and architects then had opportunities to make their mark in different parts of the world. To date, Thailand has been among one of their playgrounds, and it is undeniable that designers deemed Japanese style impressive and fashionable as evident contemporary design projects.

Junzo Sakakura and his fellow Japanese architects had designed and built several architectural settings in Thailand, but very little is known of them or their design processes. As such, this research will be one of the early attempts to document and broaden the understanding of Japanese Architectural history and influence in the modern day Thailand. Specifically, this study will focus on how Junzo Sakakura transferred and adapted his design technique that was previously used in the Temperate zone of Japan to the Tropical climate of Thailand as well as exploring new techniques that Sakakura introduced or used in the Thai Vocational School project for the first time, and examine the commonalities of the features with typical Thai architectural designs.

1.3 Research questions

1. What were the design techniques that Junzo Sakakura implemented in the Thai Vocational School project that were previously in Japan?
2. What were the design techniques that Junzo Sakakura used in Thailand that had not previously been used in Japan?
3. Following-up from question 2, if any, were there commonalities or differences between the newly implemented designs and traditional tropical architectural design solution typically used in Thailand?

CHAPTER 2

LITERATURE REVIEW

This chapter consists of review of the literature relating to the studies of 1) Junzo Sakakura, 2) the approaches to study design methods, and the appropriate research techniques.

2.1 Previous studies related to Junzo Sakakura

This section reviews previous studies which are related to Sakakura (Table 1). The first two studies, conducted by Abhichartvorapan and Watanabe (2016, 2017), that focus on the conservation of the buildings that are part of Sakakura's Vocational setting, while the remaining 3 studies emphasize on the ingenuity as well as the design process of Sakakura's design in his reknown works such as the Museum of modern art Kamakura (Fig. 5) (or as known as the Kamakura Museum) and Namako Wall (Wada, 2005; 2006), and the 1937 Japanese Pavillion at the World Exposition in Paris (Fujiki,1998). (Fig. 6).

2.2 Framework

It should be noted that the Sakakura relevant research availbale for the review (Abhichartvorapan and Watanabe, 2016; 2017; Fujiki,1998; Wada, 2005; 2006), though have common focus on the work of Junzo Sakakura, but the analysis were performed on ranges of building types. There are some inconsistency of the design elements on which each research paper deems importance. Differing building types coupled with variation of research focus have made it relatively complicate to analyze and compare the architect's design signature.



Fig. 5 The Japanese Pavilion in Paris World Expo 1937

(Source: <https://cakes.mu/posts/8176>)

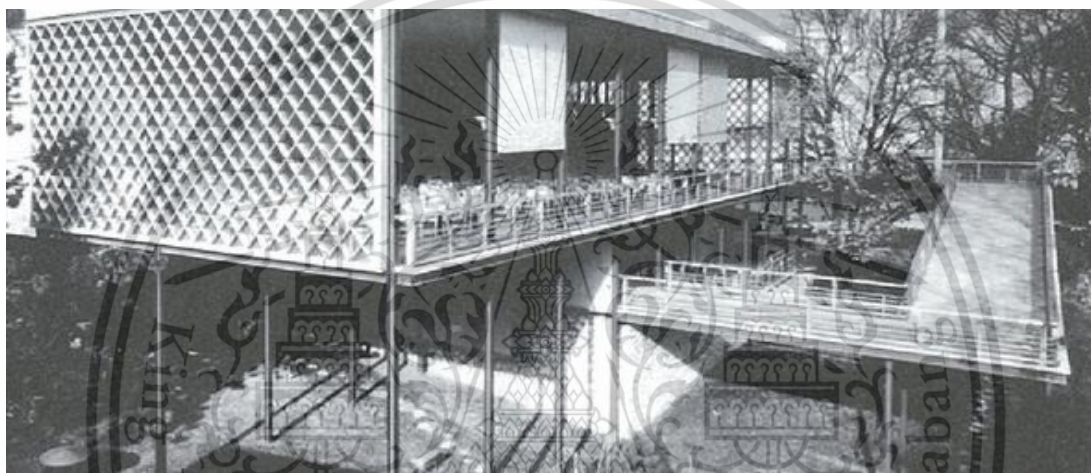


Fig. 6 The Museum of modern art, Kamakura (1951)

(Source: <http://www.moma.pref.kanagawa.jp/kamakura/architecture.html>)

However, for the purpose of understanding Sakakura's design, the following review use the elements within the list of drawings available in the architectural construction drawing (or blueprint) as a structure to efficiently organize and analyze the literatures on the previous work of Junzo Sakakura. These elements can be grouped as 1) Building Layout, 2) Elevation and Section, 3) Roof Design and Structure, and finally 4) Detail Design.

	Article's title	Year	Authors	Source	pp.	Findings [Summary of Findings]
Previous studies related to Junzo Sakakura	THE FUTURE FOR THAILAND VOCATIONAL EDUCATION PROJECT 1965-70 BY JUNZO SAKAKURA	2016	Waeovichian ABHICHARTVORAP AN Kenji WATANABE	Proceedings of the 11th ISAIA	834- 839	This paper describes changes of architectural components that is impacted by weather.
	CULTURAL SIGNIFICANCE IDENTIFICATION OF MODERN ARCHITECTURAL HERITAGE	2017	Waeovichian ABHICHARTVORAP AN Kenji WATANABE	J. Archit. Plann., AIJ, Vol.82 No.735	1377 -138 7	This paper proposes that these Vocational schools structures are of architectural importance, and should be preserved. Also, the paper compare Junzo Sakakura works with Le Corbusier works.
	ANALYSIS ON THE GEOMETRY AND GOLDEN RATIO OF PLANE FIGURE BASED ON THE DESIGN PROCESS A CONSIDERATION ON THE PROPORTION OF “MUSEUM OF MODERN ART, KAMAKURA” DESIGNED BY JUNZO SAKAKURA (Part 1)	2005	Nahoko WADA	J. Archit. Plann., AIJ, No.597	205- 209	Junzo Sakakura used western interpretation of golden ratio learned from Le Corbusier when he adapt western modernism to Japan.

	Article's title	Year	Authors	Source	pp.	Findings [Summary of Findings]
	ANALYSIS ON THE GEOMETRY AND GOLDEN RATIO OF PLANE FIGURE BASED ON THE DESIGN PROCESS A CONSIDERATION ON THE PROPORTION OF “MUSEUM OF MODERN ART, KAMAKURA” DESIGNED BY JUNZO SAKAKURA (Part 2)	2006	Nahoko WADA	J. Archit. Plann., AIJ, No.606	207-214	Junzo Sakakura designed museum which adopt surrounding nature as part of the project. This designing is based on the space composition of the traditional Japanese Katsura Imperial Villa.
	DESIGN PROCESS OF JAPANESE PAVILION, PARIS INTERNATIONAL EXPOSITION 1937	1998	Takuo FUJIKI Kentaro TOYODA	J. Archit. Plann. Environ. Eng., AIJ, No.514	217-223	The design of Japanese pavilion, by Junzo Sakakura combined the characteristics of the site, the modernist spirit received from Corbusier and Japanese expression.

Table 1 Previous studies related to Junzo Sakakura

2. 2. 1 Building layout

This section focuses on the examination of the layout and site orientation of the buildings across 5 previous Sakakura studies.

2. 2. 1. 1) Building Lay-out Axis:

In the Vocational School Project, Abhichartvorapan and Watanabe (2016, 2017) find that Sakakura attempts to reduce heat absorbance and emission of heat from the sunlight by using the orientation of the buildings. Just like the Thai vernacular architecture, Sakakura carefully places the narrow side of the structure of the rectangular building on east-west axis to minimize area exposure to the strong tropical sun.

2. 2. 1. 2) Grid, Modulor and Golden Ratio:

The use of grid and modulor system, as influenced by Le Corbusier, are evident Sakakura's work. Sakakura utilizes grid system for effective design adjustment and implementations in at least two projects—the Thailand Vocational School, and the Kamakura Museum. In both projects, he designs a 4-meter span structure within a standardization system of 4-meter grid layout. However, the size column span and grid structure would vary according to scale of the buildings in the certain sites.

Another use of grid and modulor system is repeatedly mentioned by Wada (2005). In the investigation of Kamakura Museum, Wada (2005) points out that Sakakura employs a 4-meter module and golden ratio in his design and create cluster type building lay-out for the grand floor, and the migratory type for the 2nd floor. Golden ratio is one of the most beautiful ratios which is consist by ratio of 1: 1.618. In addition, Le Corbusier made the standard size of the building called Modulor from the dimensions of the human body and the golden ratio, and it is used in his past works. But this Modulor was not made when Sakakura worked in Le Corbusier office. Therefore, there are no Modulor in Sakakura's work but it is used golden ratio and Fibonacci number.

2. 2. 1. 3) Assimilation of the surrounding elements

The assimilation of the surrounding elements into the site design may be viewed as an extension of the traditional Japanese design approach of “borrowing the scene.” This has been the technique the Japanese designers use to supplement a small project site with limited scenery with a vista of a beautiful natural meliue surrounding the place.

The Ladkrabang's Vocational School Project is located near the Chao Phraya River estuary. The area is full of wetland, swamps, and canal both natural and manmade. The construction site of the Cafetorium of Ladkrabang's Vocational School

is right next to the canal, but did not connect to other water sources. However, Abhichartvorapan and Watanabe (2017) indicates that Sakakura use design and excavate small pond, and place the cafetorium structure in the middle of that pond (Fig. 7).

By creating a small pond, Sakakura also cleverly made microclimate for the site. The users of the cafetorium, thus benefit from the reduced temperature that result from the evaporation of the water from the pond. However, it is unclear whether Sakakura create such landscape mainly for aesthetic or for the comfort of the building occupants.



Fig. 7 Cafetorium in Thai vocational school in a former Vocational School in Ladkrabang district, Bangkok, Thailand. (Photo by the author)

2. 2. 1. 4) Amalgamation of Traditional Japanese and Modernism

The work of Junzo Sakakura has been known as the design combination of traditional Japanese and the Modernism architecture, and the Katsura Imperial Villa is among one of them. The Katsura Imperial Villa is a compound made of buildings and gardens established as a separate house of the 17th century royal family. (Fig. 8)

When comparing Kamakura Museum and the Katsura Imperial Villa, Wada (2005) reveals that not only the layout of stepping stone in the garden of Kamakura Museum, but terrace, and the details around the pillar bear the resemblance with those in Katsura Imperial Villa in Kyoto (Fig.8)



Fig. 8 Katsura Imperial Villa in Kyoto
(Photo by the author)



Fig. 9 Left : Stepping stones of the garden in Katsura Imperial Villa (Photo by the author)

Right : Garden layout of the Museum of Modern Art Kamakura

(Reference : J. Archit. AIJ, No.606, pp.212, Aug.,2006)

2. 2. 2 Elevation and Section

The analysis of elevation and section allow us to understand the façade design which is the mediator of the exterior and interior, and the skin that shield the building from the outside environment.

2. 2. 2. 1) Environmental Design:

Abhichartvorapan and Watanabe (2016, 2017) use the section drawing with shade to explain Sakakura's use of deep cantilevers design coupled with south-side corridor to protect the classroom from a strong sun (Fig. 10) in the tropical zone of Thailand.

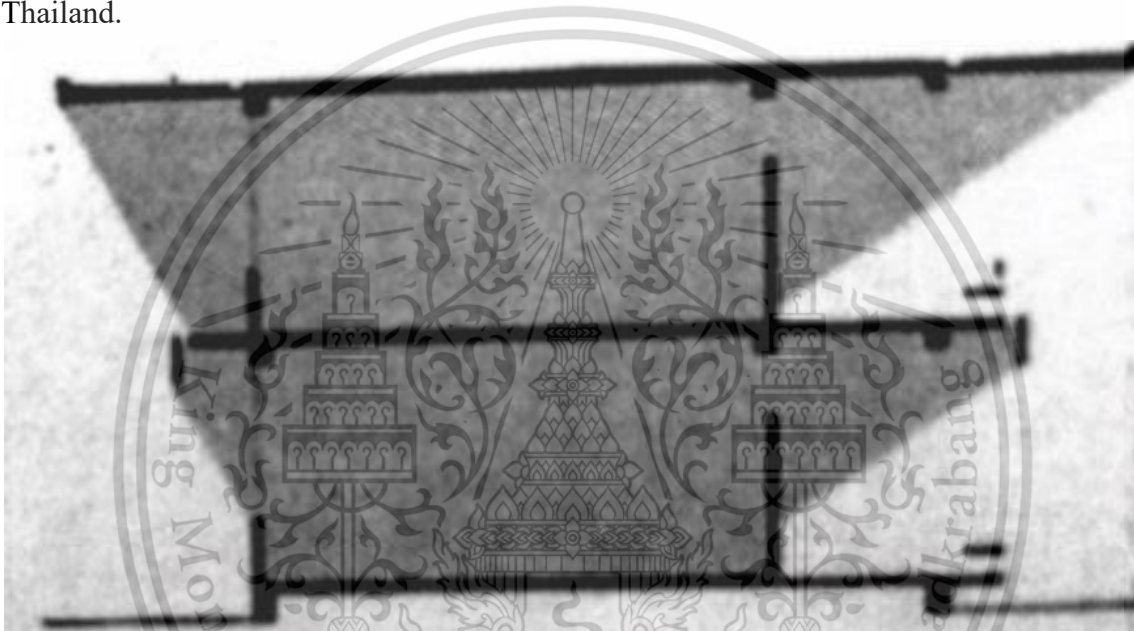


Fig. 10 Deep cantilever design for sun protection

(Source: Toh, T. Shinken-chiku, No.4, pp.184, 1971)

2. 2. 2. 2) Le Corbusier's Influence:

The use of double height void entrance, deep splayed window, board formed concrete finish, slope, and piloti system, which are strongly influenced by Le Corbusier, have been used in previous Sakakura's work and in the studies reviewed. Junzo Sakakura consistently uses horizontal window, piloti, and slope walkway in his work such as that of the Kamakura Museum (Wada, 2006) and the Japanese Pavillion (Hujiki, 1998). The 'Golden Ratio,' which is known as Le Corbusier's legacy, has been applied on the design of window and asbestos board proportion (Fig. 12) of the Kamakura Museum as well as the World Expo's Japanese Pavillion. The Fibonacci number is also found in the design of the height of the Kamakura Museum (Fig. 11)

The studies in this review do not find the influence of Le Corbusier's Modulor system in Sakakura's work. This might be due to the fact that Le Corbusier had not implemented Modulor design in his work during the time Sakakura was apprenticing in his office between the years 1931-1936.

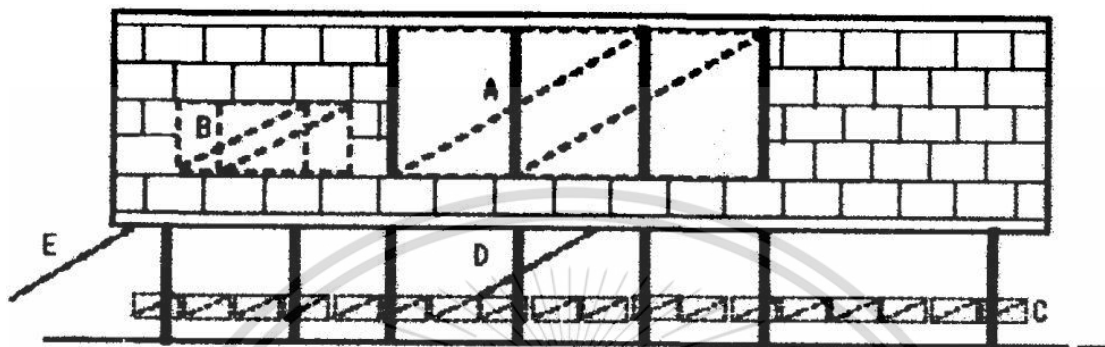


Fig. 12 The application of Golden Ratio in the elevation of Museum of modern art.
(Source: J.Archit. Plann, AIJ, No. 606, pp208, Aug., 2006)

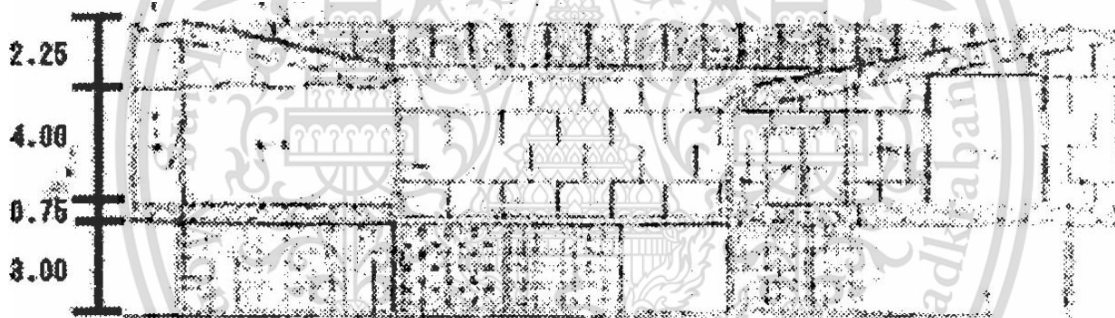


Fig. 11 Section of the Museum of modern art, Kamakura by using Fibonacci number
(Source: J.Archit. Plann, AIJ, No. 606, pp209, Aug., 2006)

2. 2. 2. 3) Traditional Japanese Design Influence

Analysis of elevations and sections allows the researcher to trace the influence of traditional Japanese design, including the use of Oya-ishi (Fig. 14) and Namako Wall (Fig. 13) design, in Junzo Sakakura's work.

Namako wall is one of the Japanese traditional style wall using for many purposes. It is a strong and durable construction method that creates a big plump plaster grout between the gaps of the tiles. The study of elevation of the Japanese Pavillion in Paris shows that Junzo Sakakura uses of this famous Namako wall in his design to display and emphasize Japanese characteristics to the viewer.

In summary the studies of elevation and section shows a combination of influence of Le Corbusier including the use of dry construction, golden ratio and Fibonacci number and traditional Japanese design techniques such as the adoption of Namako Wall and the use of Oya-ishi in his design of the Modernism architectural style.



Fig. 14 — Oya-ishi

(Reference: <https://ja.wikipedia.org/wiki/%E5%A4%A7%E8%B0%B7%E7%9F%B3>)



Fig. 13 — Namako wall

(Source: http://izufull.com/shop_print.php?sid=N23HZXqMF8)

2. 2. 3 Roof Design and Structure

A roof is an important part of a building envelope. It is the framing or structure that supports the covering on the uppermost part of a building or shelter which provides protection weather including rain, snow, heat, wind and sunlight. The analysis of roof characteristics allows the researcher to understand concepts of architectural design, the purpose of the building that it covers, and the availability and limitation of roofing materials, and the design technique within the locale.

Roof design and structure drawings are only used in study by Abhichartvorapan and Watanabe (2016, 2017) and Wada (2006). The first study finds that corrugated asbestos sheet is used in Thai vocational school, which might due to the availability of the material and the unawareness of asbestos toxicity during the time of design (late 1960s).

Though never been used by Le Corbusier, both studies also indicate the use of truss design for the roofing structure. The close examination of the upper part of Kamakura Museum envelope leads Wada (2006) to conclude Sakakura install glass panels as a part of truss structure of the roof to permit natural lighting from the roof through the interior space pf the museum (Fig. 15).

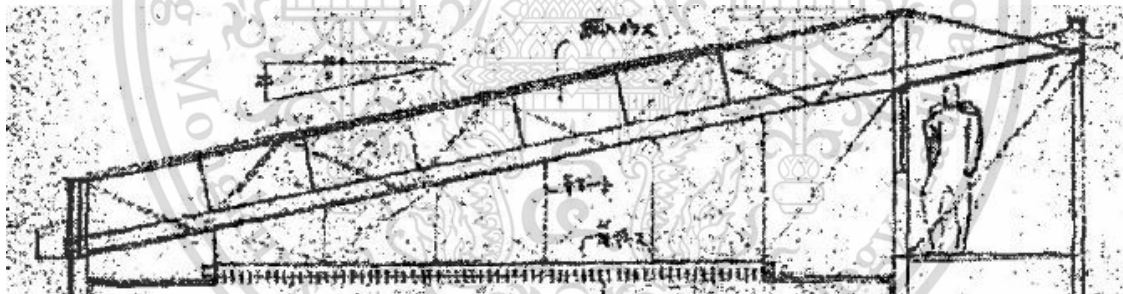


Fig. 15 The roof of the Museum Kamakura

(Reference: J.Archit. Plann., AIJ, No. 606, pp. 210, Aug., 2006)

2.2.4 Architectonic Detail

Architectonics detail in this sense refers to detail study of an architectural structure. The study of architectonic detail permit the understanding of availability of materials, and construction technique as well as the symbolic, cultural, and economical aspects of the building design. However, the related literatures have not examined this aspect in Sakakura's design.

Summary

Sakakura's design may be viewed as a combination of influence from Le Corbusier and the traditional Japanese design. The Le Corbusier influences are consisting of the Golden Ratio, Fibonacci number, piloti, dry construction, and slope design. The traditional Japanese influence may be seen in the adoption of the proportion from Katsura Imperial Villa as well as the use of Namako Wall design and Oya-ishi stone. Furthermore, both of Thai vocational school and Museum of modern art, Kamakura are mainly used 4m long span. A summary of the categorical analysis by using the framework is tabulated below (Table 2).

Project	Thai vocational project		Museum of modern art, Kamakura		Japanese pavilion
Previous study	Abhichartvorapan (2016)	Abhichartvorapan (2017)	Wada (2005)	Wada (2006)	Fujiki (1998)
1. Layout & Axis	East-west axis orientation	East-west axis orientation		Symmetrical East-West and North-South axis orientation	
	South corridor	South corridor		Stepping stones layout is similar to Katsura Imperial Villa	
		4-meter module	4-meter module		
		Grid system	Golden ratio		
		Walkway enclosed outdoor	Circuit vs. Cluster style		
		Corridor as transitional space			
		Use landscape to microclimate			
	Building landmark				
2. Elevation & Section	Deep cantilever	Deep cantilever		Horizontal window	Namako wall
		Thai vernacular shelter characterize the Cafetorium		Piloti	Piloti
		Double-height void entran		Golden ratio	Slope
3. Roof design & Structure	Slabbing roof	Slabbing roof		Fibonacci number	
		Steel space truss		Triangular truss	
4. Architectonic Detail		Deep splayed windows	Dry construction	Steel pillar surrounded by mortar	
		Board formed concrete finish	Cantilever		

Table 2 Previous studies of Sakakura as categorized by the research framework

2.3 Review of Research Methodology

The aims of this section are to review relevant research methodology previously used in the studies on Junzo Sakakura and Design Method (See: Table 4). The review topics range from 1) Research Paradigm, 2) Research Design, 3) Data Collection and Analysis, and 4) Informants and Recruitment Techniques. The purpose of this review is to critically assess the research design and techniques appropriate for investigating architectural elements within the research frameworks for this study.

2.3.1 Research Paradigm

The studies of Design Method and particularly of the iconic architect is normally conducted retrospectively. In most case, the research will attempt to understand multiple factors that influence background, inspiration, thought process, work pattern of the architect of interests. The paradigm that lend it self to the exploration of such pluralistic world view is of the Naturalistic stance.

Most of the research studies in this review are based on the Naturalistic paradigm or Naturalistic combined with Quantitative techniques (Qu et al., 2010; Yamada, 1998) with stronger emphasis on the first stance. This due to the flexibility in the research design, and the depth of information gaining through the iterative process of the Naturalistic paradigm.

2.3.2 Research Design

The research design, of all of research studies reviewed (Ohno, 2012; Qu et al, 2010; Takatori, 2011; Yamada, 1998; Ogura, 1986), can be categorized as Historical Research as they investigate and compile past occurrence. Case Study research is also found to be useful for studying the work of an iconic person as evident in the studies by Abhichartvorapan and Watanabe (2016, 2017) and Takatori (2011).

2.3.3 Data Collection and Analysis

Data of a of Historical Research is generally comprised of multiple sources such as archival records, interviews, observations, field survey, and site measurement. Similarly, the previous studies reviewed rely on architectural drawings as the main information source. In addition to the architectural drawings, the articles and pictures from architecture magazine can be very useful as they provide an insight of how the architect and her work are regarded by the contemporary peers and public.

Relevant data collection techniques and analysis from the related literatures is reviewed and presented based on the aforementioned analytical framework as follows. The summary of data collection and analysis is shown in Table 4.

An examination of building layout is a useful approach to understand the

design method of the architect, and it is an indispensable tool for Design Method studying. All of the studies reviewed (Ohno, 2012; Qu et al, 2010; Takatori, 2011; Yamada, 1998; Ogura, 1986) use the building layout to read into a spatial organization within the project, and how this organization is related to the physical and socio-cultural context of the site.

Diagrammatic study is an efficient way to analyze the building layout. Through the comparison of changes in the design of building layouts and room arrangement by using diagram (Ohno, 2012; Qu et al, 2010; Takatori, 2011; Yamada, 1998; Ogura, 1986). For example, Ohno (2012) identifies how Le Corbusier gradually adopted indigenous elements into his Chandigarh project. In the same light, Ogura (1986) distinguishes how Modern architecture adapted to the African climate by creating a diagrammatic analysis of building layout.

Aside from the building layout, the other aspects of architectural drawings such as Elevations and Sections, Roof Design and Structure, and Architectonic Details have been sporadically used as supplementary information. Some research studies incorporate the diagrammatic analysis of building's elevations and sections as well as roof design and structure to further elucidate the relationship between architectural design and climate (Ohno 2012; Ogura, 1986; Qu et al., 2010). Architectonic Detail has rarely been a subject of the design methods, available for this review, a single study by Ogura (1986) focuses on details of the louver window as a means to understand the design adaptation.

To triangulate with data derived from the analysis of drawings and archival records, information from field survey (Ogura, 1986), and interviews such as the technique used by Abhichartvorapan and Watanabe (2016, 2017) are very useful.

Former colleagues, staff of individual architect design office, university professor and the editor of architecture magazine, or relatives of an individual architect can provide insightful information for the research. As for the recruitment of the informants for the interview, very little is indicated in the literature.

In summary, both previous studies of Junzo Sakakura and the other Design Method studies adopt the Qualitative or Combine research paradigm. The studies typically take a Historical Research design stance, and rely on the information from drawing, pictures, and archival records. Supplementary information sources, to ensure the confirmability and credibility of the data, including testimonial from the informants such as former co-workers, acquaintance, or direct observation from field surveys and site measurement. Summary of research review matrix is shown in Table 4.

	Article's title	Year	Authors	Source	PP.	Findings [Summary of Findings]
Previous studies related to design method	A STUDY ON LE CORBUSIER'S HOUSING CONCEPT FOR THE URBAN PROJECT IN CHANDIGARH: LE CORBUSIER'S HOUSING DESIGN REFERRING TO VERNACULAR ELEMENTS	2012	Takashi OHNO, Masato KAWAMUKAI	J. Archit. Plann., AIJ, Vol.77 No.606	183-191	Le Corbusier has focused on 9 indigenous factors for the urban project in Chandigarh, which include strip-shaped site, front yard, fence, backyard, bedroom, veranda, orientation, roof shape, joinery.
	A STUDY ON THE DESIGN METHOD OF AXIS USED IN THE TINGBAO YANG'S ARCHITECTURAL WORKS	2010	Yi QU, Tsutomu SHIGEMURA, Tamotsu ASAI	J. Archit. Plann., AIJ, Vol.75 No.651	1111-1116	This paper classifies 5 types of plan arrangement by analyzing 59 works of the architect Tingbao Yang.
	AN INQUIRY INTO THE SPATIAL COMPOSITION OF GEOFFEREY BAWA'S HOTEL WORKS: A STUDY ON GEOFFREY BAWA (2)	2011	Aiko TAKATORI	J. Archit. Plann., AIJ, Vol.76 No.670	2457-2466	This study investigates the connection of each function room and classification by internal, external, intermediate area in the work of Geoffery Bawa, the Sri Lankan architect.
	A STUDY FOR SPACE-MEANING ON THE USING COLUMNS IN VILLA SAVOYE OF LE CORBUSIER	1998	Masami YAMADA	J. Archit. Plann. Environ. Eng., AIJ, No.503	233-238	Le Corbusier using rectangular columns and round columns in villa Savoye. Rectangular columns are used structurally and round columns are used as a design.
	EARLY MODERN ARCHITECTURE IN EAST AFRICA AND ITS ADAPTATION TO THE CLIMATE	1986	Nobuyuki OGURA	Transactions of AIJ. Journal of architecture, planning and environmental engineering. No.367	108-115	The early Modern architecture adapts to the African climate by minor changes of design elements through the use of scientific and design vocabulary.

Table 3 Previous studies related to design method

	Article's title	Year	Authors	Paradigm	Research design	Data analysis	Informants	Data collection				
								Interview	Drawing	Photographing	Archival	Field measurement
Literature review related to Junzo Sakakura	THE FUTURE FOR THAILAND VOCATIONAL EDUCATION PROJECT 1965-70 BY JUNZO SAKAKURA	2016	Waeovichian ABHICHARTVORAPAN, Kenji WATANABE	Qualitative	Historical Case study	Drawing Picture	Tsutom Abe Toh Tadahiro	•	•	•	•	•
	CULTURAL SIGNIFICANCE IDENTIFICATION OF MODERN ARCHITECTURAL HERITAGE	2017	Waeovichian ABHICHARTVORAPAN, Kenji WATANABE	Qualitative	Historical Case study	Drawing Picture	Tsutom Abe Toh Tadahiro	•	•	•	•	•
	ANALYSIS ON THE GEOMETRY AND GOLDEN RATIO OF PLANE FIGURE BASED ON THE DESIGN PROCESS: A CONSIDERATION ON THE PROPORTION OF “MUSEUM OF MODERN ART, KAMAKURA” DESIGNED BY JUNZO SAKAKURA (Part 1)	2005	Nahoko WADA	Qualitative	Historical	Drawing	Tomohiko Komada Shuichi Kitamura Tadayasu Sakai Toshio Yamanashi Yasuto Oota Yuri Sakakura Miho Kida Toshihumi Kitamura Riichi Miyake	•	•		•	

	Article's title	Year	Authors	Paradigm	Research design	Data analysis	Informants	Data collection				
								Interview	Drawing	Photographing	Archival	Field measurement
	ANALYSIS ON THE GEOMETRY AND GOLDEN RATIO OF PLANE FIGURE BASED ON THE DESIGN PROCESS: A CONSIDERATION ON THE PROPORTION OF "MUSEUM OF MODERN ART, KAMAKURA" DESIGNED BY JUNZO SAKAKURA (Part 2)	2006	Nahoko WADA	Qualitative	Historical	Drawing Archival	Tomohiko Komada Shuichi Kitamura Yasuto Oota Sakakura's family Toshihumi Kitamura Riichi Miyake	•	•		•	
	DESIGN PROCESS OF JAPANESE PAVILION, PARIS INTERNATIONAL EXPOSITION 1937	1998	Takuo FUJIKI Kentaro TOYODA	Qualitative	Historical	Drawing Archival	Yuri Sakakura Yasuto Oota Matsusumi Hiroshi Soichi Yagisawa	•	•		•	
methods	A STUDY ON LE CORBUSIER'S HOUSING CONCEPT FOR THE URBAN PROJECT IN CHANDIGARH: LE CORBUSIER'S HOUSING DESIGN REFERRING TO VERNACULAR ELEMENTS	2012	Takashi OHNO Masato KAWAMUKAI	Qualitative	Historical	Drawing			•		•	

Article's title	Year	Authors	Paradigm	Research design	Data analysis	Informants	Data collection				
							Interview	Drawing	Photographing	Archival	Field measurement
A STUDY ON THE DESIGN METHOD OF AXIS USED IN THE TINGBAO YANG'S ARCHITECTURAL WORKS	2010	Yi QU Tsutomu SHIGEMURA Tamotsu ASAI	Combined method	Historical	Drawing	Juichi Yamazaki Yang	•	•	•	•	•
AN INQUIRY INTO THE SPATIAL COMPOSITION OF GEOFFREY BAWA'S HOTEL WORKS: A STUDY ON GEOFFREY BAWA (2)	2011	Aiko TAKATORI	Qualitative	Historical Case study	Drawing Archival			•		•	
A STUDY FOR SPACE-MEANING ON THE USING COLUMNS IN VILLA SAVOYE OF LE CORBUSIER	1998	Masami YAMADA	Combined method	Historical	Drawing Archival			•			
EARLY MODERN ARCHITECTURE IN EAST AFRICA AND ITS ADAPTATION TO THE CLIMATE	1986	Nobuyuki OGURA	Qualitative	Historical	Drawing Picture	Patrick I. Wakely		•	•	•	

Table 4 Review of methodology

CHAPTER 3: RESEARCH METHODOLOGY

Little information about the Japanese architects' legacy in Thailand is documented although numbers of architecture are known to be their work. Thus, this research intend to compile and analyze the Modernism architect, Junzo Sakakura's, work in Thailand during the late 1960s. The following content in chapter present the research design for the investigation of Junzo Sakakura Design Method in his Thailand's Vocational School project.

The investigation seeks to **compare and contrast** the design techniques that Sakakura previously use in the design of an educational setting in the Temperate zone of Japan, and the Tropical zone of Thailand by comparing the educational architectures, the Thailand Vocational School project versus the Hannan High School in Osaka, that were designed in same decade of the 1960s.

Besides the exploration of the transference of Modernism movement between Japan and Southeast Asian country such as Thailand, the it is anticipated that we might find approaches for design adaptation that could be implemented in the contemporary period.

3.1. Research Design

From the previous chapter, Historical research and Case study are often used in previous studies related to design method. Thus, this paper also adopts Qualitative paradigm, through the using of the Historical research design.

The main data sources will be based mainly on archival records such as the architectural drawings, initial photographs taken during the construction, and architectural journals with supplementary data from field research including observation, and artefactual measurement as presented below.

The Thai Vocational School Project in Ladkrabang:

- Original drawings fom the National Archives of Modern Architecture
- Site measurement, and field observation
- Archival Records

:Osaka Prefectural Hannnan Senior High School:

- Original drawings
- Site measurement, and field observation
- Architecture magazines.

Sources of data used for the analysis is shown as follows: In case of getting stuck the research, returned from data anlysis to data ollection.

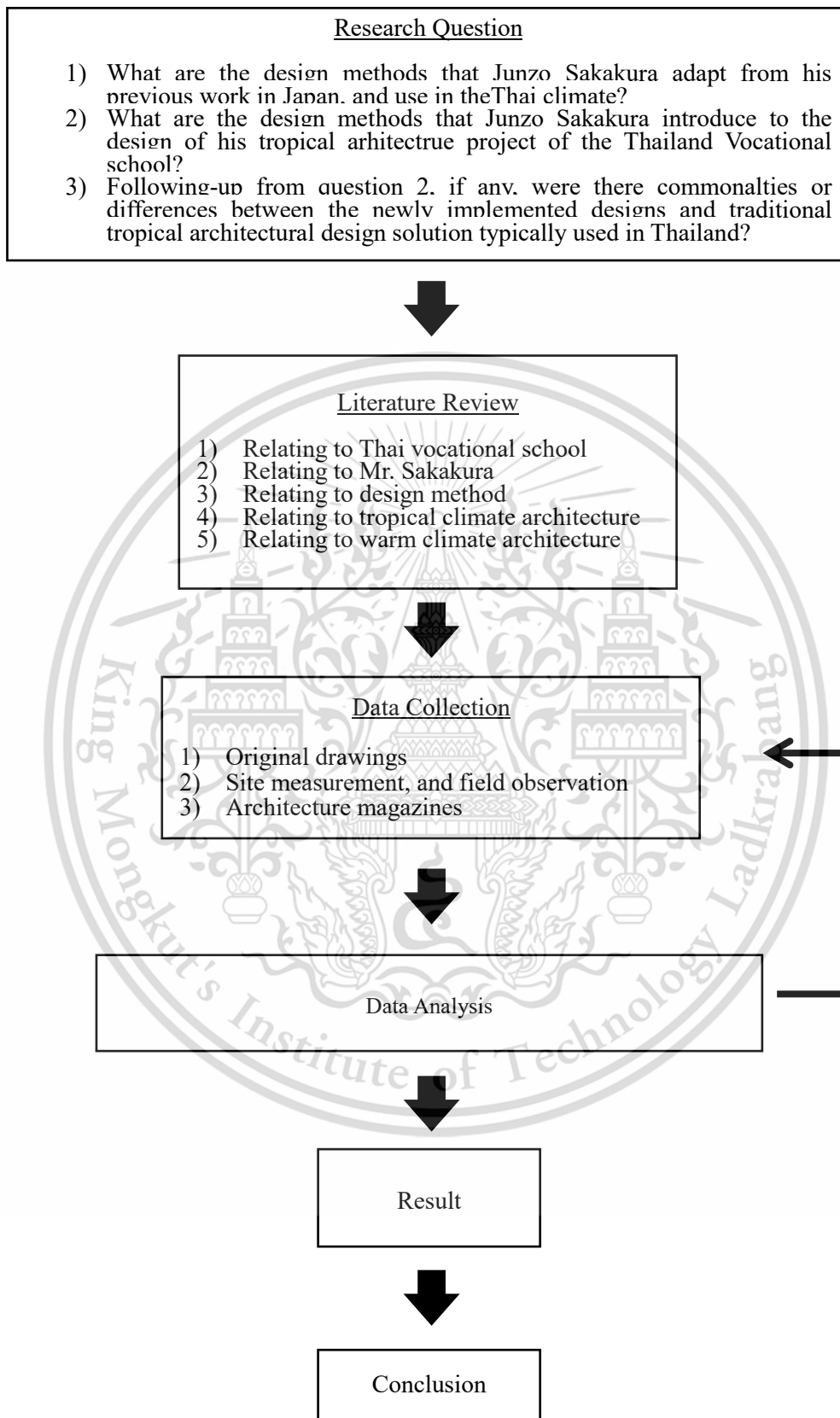


Fig. 16 Diagram of Research Design

CHAPTER 4: RESULTS

In comparison, both projects completion time were around 8 years apart where the Hannan High School completed in the early part of the 1960s, and the Ladkrabang Vocational School project in the late 1960s. The differences of the total site area is around 293,000 sq.m, but the total floor area is only 1,800 sq. m. difference.

This chapter presents the design techniques that Junzo Sakakura use in the Ladkrabang Vocational School, in Ladkrabang, and the Osaka's Hannan High School by using the proposed framework of 1) Building layout, 2) Elevation and Section, 3) Roof design and Structure, 4) Architectonic Details. After individually described and discussed, the techniques of both facilities will finally be juxtaposed and compared.

4.1 Background Information

4.1.1 The Thai Vocational School in Ladkrabang

Junzo Sakakura and his staffs have been commissioned to design 25 vocational schools projects throughout Thailand during the year 1966-1970. The projects spread all over the country in the provincial area of Thailand, where the trained technicians are scarce and vocational schools are needed, such as Chaingmai, Nakhon Phanom, Chonburi, Bangkok, and so forth.

The capacity as well the students body of each facility that Sakakura design were different. To efficiently handle the variation of design requirement, they decide to use standardized design system, which consists of several building types. And each building type can be scaled up or down by varying of column span. Then, they would choose the buildings from ranges of the standard types, and place in each vocational school campus.

The criteria for building selection was based on the each school's conditions such as scale of the students, location, cost and so on. For this reason, form of each facility building at each school are almost same, but perhaps with different combination of scale.

The Ladkrabang Vocational School, which is a used in this comparative study is now a part of the Faculty of Agricultural Technology within the campus of King Mongkut's Institute of Technology Ladkrabang (KMITL). It is located 50km east of central Bangkok, and was built in the 1970 when KMITL started out as a vocational school. To date, some of the buildings have been vacant or partially used as laboratory or faculty members' office.

Since the construction area of the Ladkrabang Vocational school was in a

wetland Sakakaru had to landfill the site. However, since the area was close to the Chao Phraya estuary, it would be difficult to control the water and the diluge in the area during the monsoon season. Instead of reclaiming the whole paddy field, and completely change the original landscape, Sakakura decided to leave the structure in the water by using piloti (Fig. 17). This design is relatively similar to the traditional house-on-stilts that evolves in the geographical location, such as Thailand and other Southeast Asia low land, where flooding is commonplace.

The layout of each Thai vocational school is divided in 4 zones including Practical teaching, Academical teaching, Common and Residential zone (Fig. 18). The Cafetorium is placed in Common zone that is located in center of the vocational school for easy to access from all zone.



Fig. 17 Classroom building in Ladkrabang 1970
(Source: Shinkenchiu, No.4, pp.177, 1971)

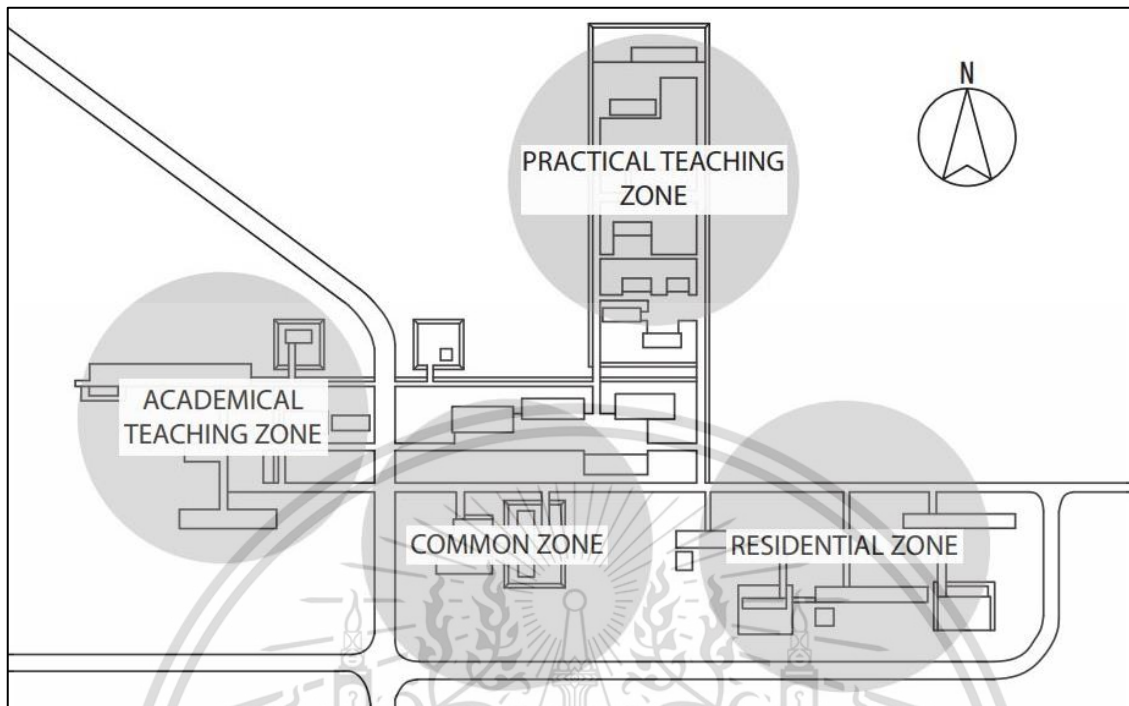


Fig. 18 Layout plan of Vocational School in Ladkrabang
(Retouch of the original drawing)

4. 1. 2 The Osaka Prefectural Hannan Senior High School

The Osaka Prefectural Hannan Senior High School (Hannan High School) was designed by Sakakura in the early part of the 1960 (Fig. 19), and has been used for the same purpose until today. The buildings of this highschool is situated on the land reclaiming the Yosami pond—the oldest pond in Japan.

The core axis of the school structure is may be determined by a wide corridor passing through the north and south of each building. All of the classrooms can be directly access from the stairs via the landings. Staircase room provides the main open-well or a vertical connection that to the 2nd floor corridor. This staircase room can be easily observed in the 2nd floor classrooms plan.

The 2nd floor corridor of Hannan Highschool is also arranged along the north-south direction, is the core connection for the three school buildings (Fig. 20). The staff room and principal office are located on the center of 2nd floor. The special classrooms are also located in the central building, and with similar distance from each classroom.

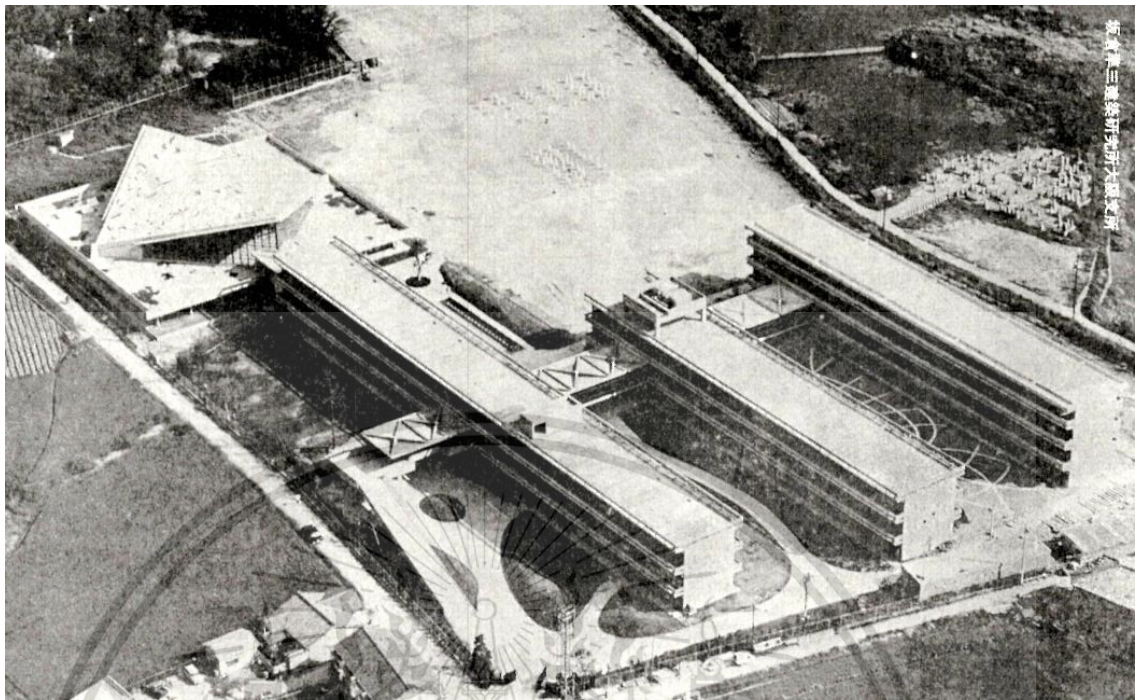


Fig. 19 Osaka Prefectural Hannan Senior High School

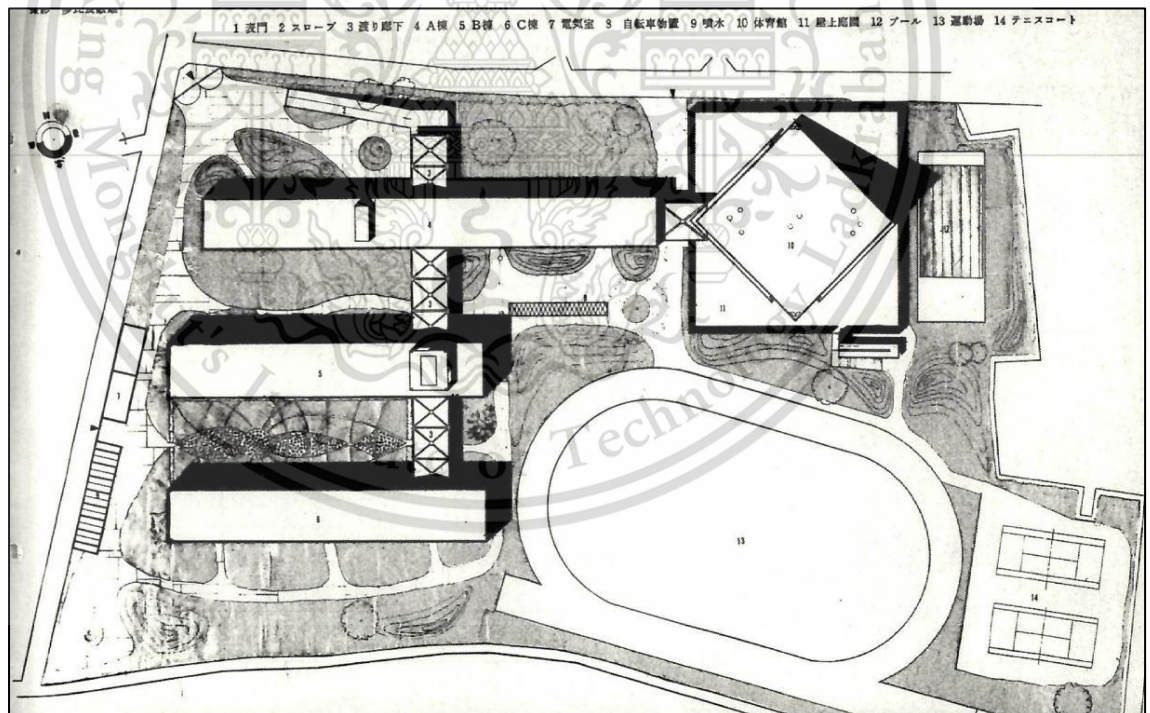


Fig. 20 Layout plan of the Hannan High School
 (Source: Shinkenchiku, Vol39, No.2, pp.126-133, 1964)

4.2 The Classrooms and Dormitory Buildings

The information from the construction document indicates that form of the dormitory building were similar to that of the classrooms. The main different was the classroom building being 2.5 m longer than Dormitory. Thus, dormitory is buidng can be used interchangeably as a classroom. Exept there is no bench lined up infront of the main corridor opposite to the rooms in the dormitory building.

4.2.1 The Building Layout and Axis

The Differences:

This dormitory is designed as a under the consideration that it should be connected to the cafetorium since the architect assumes that student's free time and various activities would be revolved around the cafetorium. The design of sleeping quarter could accommodate 12 people, and attached to it was one study room to serve the occupants within the cluster.

Sakakura placed the classroom building to face the south side while having the corridor faces north side. This design was distinctively opposite to the general Japanese school design to embrace the sunlight to brighten classroom. The Ladkrabang vocational school was arranged to have the corridor on the south side of the classroom to get better ventilation from the Southwest wind, but still get some light from the south during the dry season. Similar to the design of the dormitory corridor, a row of bench is established along the main corridor in front of Classroom as a place for students to relax.

For the Hannan High School, there is only short width balcony and no corridor in both north and south side of the classroom (Fig. 21). This balcony is not used main flow line. Access to the classrooms is connected directly from the stairs via the landings. Therefore, windows can be provided on both sides of the classroom, and more light can be gathered.



Fig. 21 Narrow balcony in Hannan High School

(Photo by the author)

The Commonalties

Both classroom building of Thai vocational school and Hannan High School are similar in form. The shape is rectangular with the long in the east-west axis direction to minimize solar radiation.

The classroom size in both projects are of the same size—8.0 m. × 8.0 m. However, the Thai vocational school beam span is 4m long, which is half the size of the 8.0 m. of its Osaka counterpart.

The analysis indicates that the classroom plan components of Thai vocational school might be based on the 'Golden Ratio' of 1:1.618 just the same as the Kamakura Museum design (Fig.22). The detail proportion of the building may be illustrated as

1). Stair case 4.0 m. : 6.5 m. = 1 : 1.625, only 0.007 differences from the Golden Ratio Proportion.

2) .Class room include corridor and bench size proportion is 8.0 m. : 13.0 m. = 1: 1.625, almost the Golden Ratio.

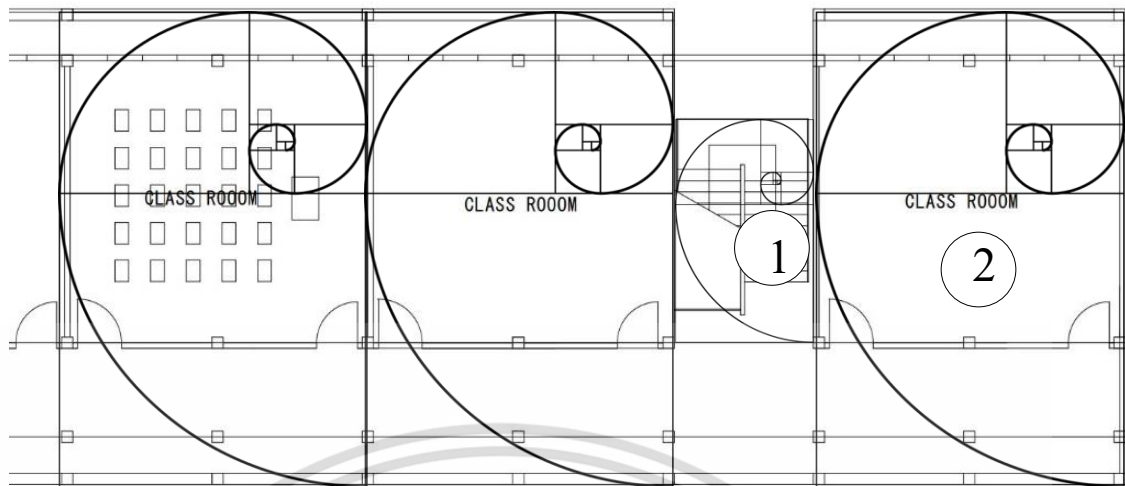


Fig. 22 Drawing of classroom with golden ratio
(Retouch of the original drawing)

4. 2. 2 The Elevation and Section

The Differences

The features that we can distinguish of the building from the two projects are the depth of building cantilever or the cantilever. The Hannan High School cantilever is 1.8 - 2.3 m. in depth where the northside cantilever of the Thai vocational school of is 3.0 m, and the south side is 5.5 m. (including corridor's depth) (Fig. 23). This might due to the fact that Sakakura placed the corridor of the Thai vocational schools in south outside, and the cantilever must have enough depth to protect the classroom from the sunlight's glare.

This deep cantilever also works well to prevent intense rain of the Southeast Asian Monsoon into the room. During the Monsoon season in Thailand, heavy rain falls may be expected daily. As a result, sunlight and heavy rain falls can be protected by deep cantilevers but the classroom in the Thai vocational school is darker than Hannan High School and does not intake much natural light.

Also, the size of pillars and beams are different. The size of beam of the Hannan High School is 800 mm × 250 mm but the vocational school is 650 mm × 250 mm. And size of the pillars is 700 mm × 700mm in Hannan High School, whereas it is 300mm × 300mm in vocational school. It is less than half of Hannan High School. However, the span of the pillar is 8.0 m in Hannan High School, which is the twice 4.0 m in vocational school. These differences are thought to be due to frequent occurrence earthquake in Japan, although there are not many earthquakes in Thailand.



Fig. 23 Deep cantilever in Thai vocational school in Ladkrabang (Photo by the author)

The Commonalties

The ceiling height of both Thai vocational school and Hannan High School is 3.5 m. (Fig. 24) (**Error! Reference source not found.**). Unlike the design of the Kamakura Museum, the author could not find a trace of Fibonacci number in the proportion of either project.

4. 2. 3 Roof Design and Structure

The roof design and structure of the Thai vocational school and the Hannan Highschool are different in both the design and the material selection. Sakakura uses corrugated asbestos sheet on the roof for against heat in the Thai vocational

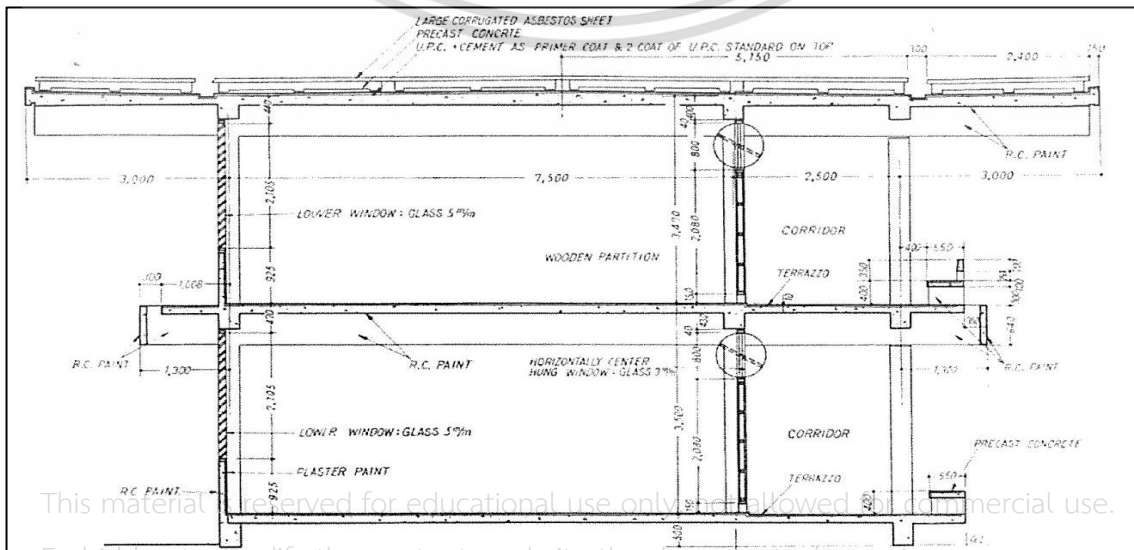


Fig. 24 Section drawing of classroom in Thai vocational school

(Source: The Kenchiku, Vol.4, No. 127, pp.54, 1971)

school building (Fig. 25). This corrugated asbestos sheet was widely available in Thailand during the 1960s. The availability of this material may be one its attractive quality especially for the maintenance and repaired. Conversely, there is only a 24 mm. thick cemented excelsior board beneath the roof slab in the Hannan High School (Fig. 26)

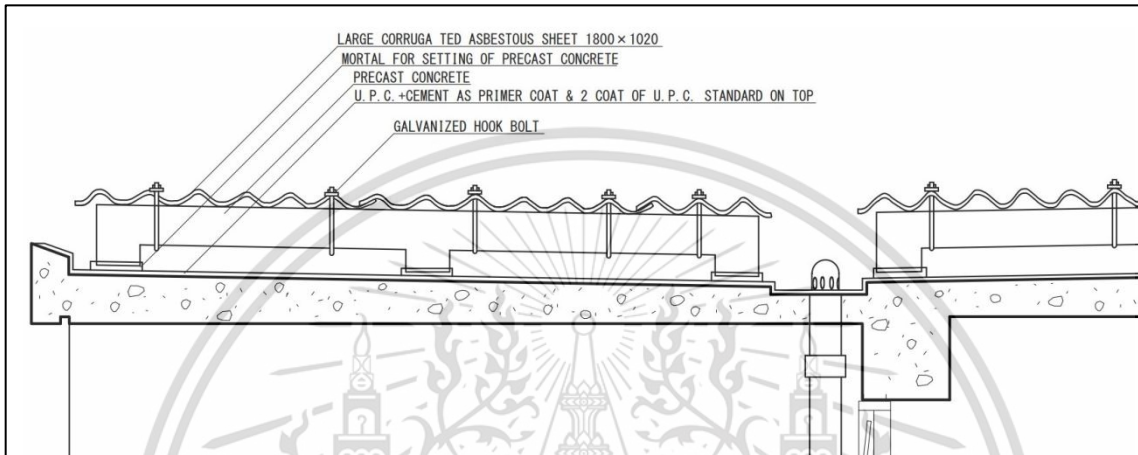


Fig. 25 Corrugated asbestos sheet on the roof
(Retouch of the original drawing)

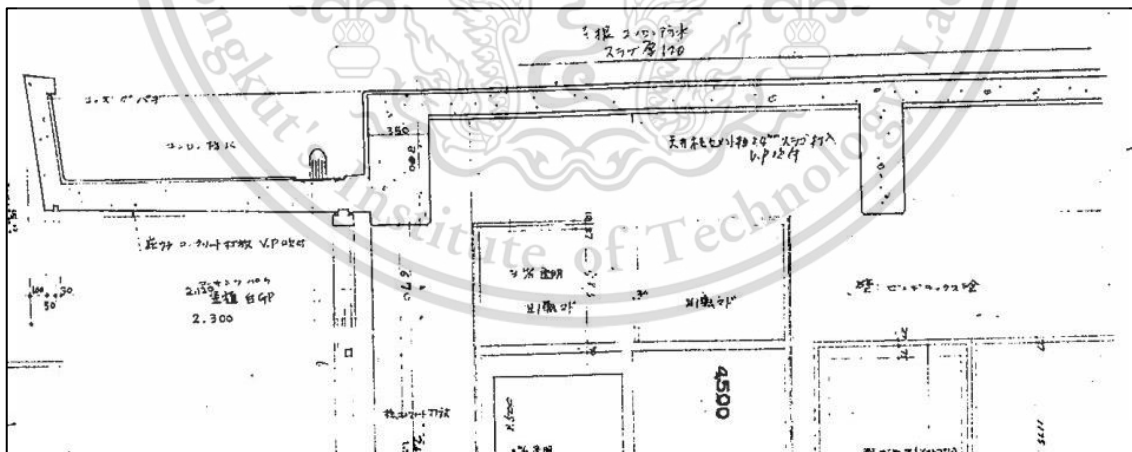


Fig. 26 Hannan High School classroom sectional detail
(Source: Original drawing of the Osaka Prefectural Hannan High School)

4.2.4 Architectonic Detail

The main differences, of architectonic detail, among the two project can be found in the window design. A louver glass window is used for classroom and dormitory in Thai vocational school (Fig. 27) to make ventilation possible even in the rain. On the other hand, the classroom of Hannan High School uses slide glass windows (Fig. 28).

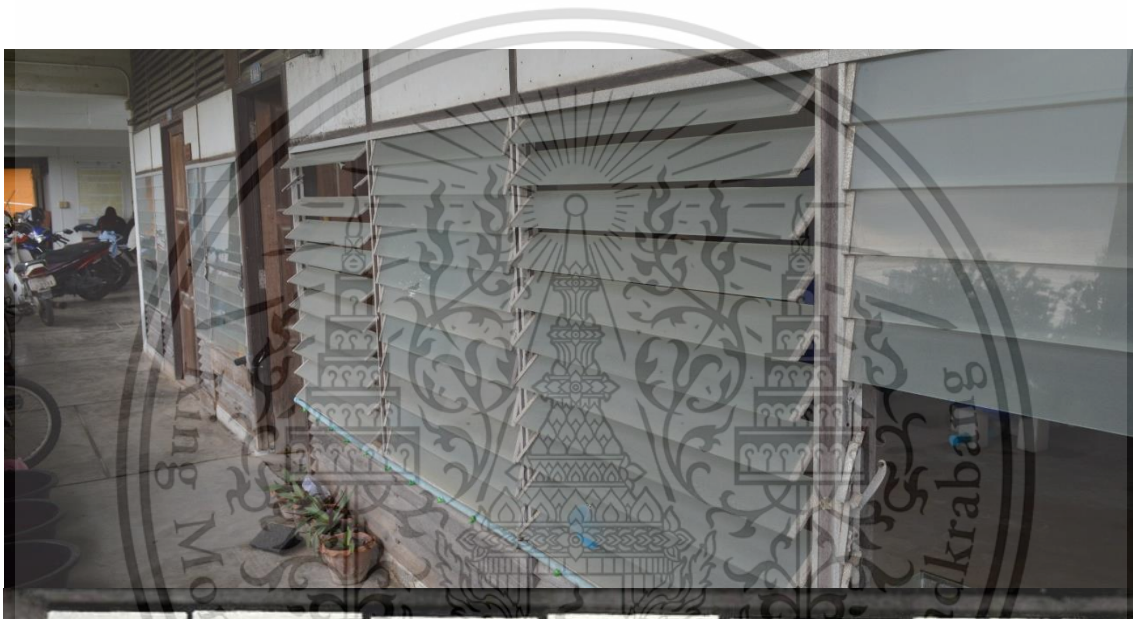


Fig. 27 Louver glass window in Thai vocational school
(Photo by the author)



Fig. 28 Slide glass windows in Hannan High School
(Reference: Shinkenchiu, Vol.39, No.2, p.132, 1964)

Also, as a method of discharging rain, the veranda of Hannan High School has grooves inside for draining rainwater and it is designed to discharge through rain gutters (Fig. 30). However, the semi-outside south corridor of vocational training schools can be discharged directly through the grooves (Fig. 29). This is considered to be due to the need to efficiently discharge the heavy rain in Thailand.



Fig. 30 Inside grooves in veranda of Hannan High School (Photo by the author)

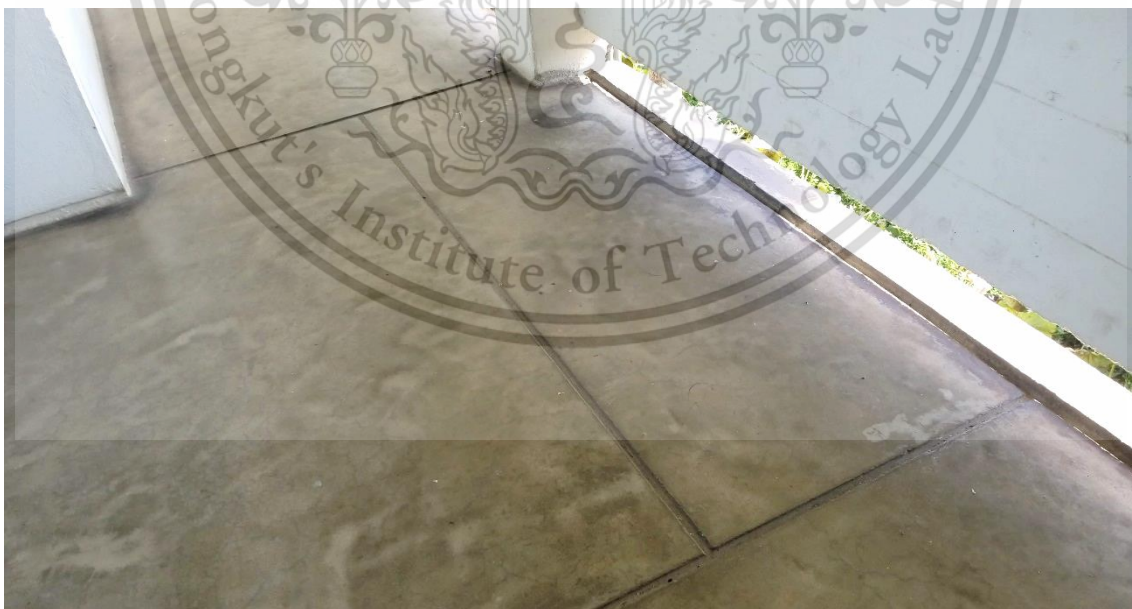


Fig. 29 Grooves in corridor of vocational school (Photo by the author)

The rain gutters of 2 floor corridor of Hannan High School is a fancy design, which pass through the inside of the pillars from roof to underground (), while vocational school rain gutters through rain establish outside the wall. These differences are thought to have arisen from the results of considering building technique of Thailand in that time, budget and easy to maintenance.



Fig. 31 Roof 2 floor corridor of Hannan High School (Photo by the author)

4.3 The Cafetorium

The function of cafetorium is a mainly dining hall and also using as a multipurpose hall (Fig. 32). This facility is the center of the common space, and not only function as a dining room but also various ways of use, such as concerts, badminton, and dance parties depending on the characteristics of certain localities of each school.

This cafetorium is a center facility of the school both mentally and physically. There is no facility corresponding to cafetorium in Hannan High School. Over five decades, Ladkrabang Vocational School has grown into a large university, but the function of cafetorium has remain unchanged from the past and is still being using as canteen for the students of the Faculty of Agricultural Technology. However, direct observation reveals some minor detail modification including the added window panels and ceiling insulation



Fig. 32 Cafetorium in Thai vocational school in Ladkrabang
(Photo by the author)

4. 3. 1 Building layout

The cafetorium in vocational school in Ladkrabang is also situated in the middle of the pond, right by the Prawet Canal, which makes the facilities more relaxing. The user has to approach the Cafetorium structure through the bridge that from the embankment of the pond. The overall floor plan layout of the building is in a square shape, however the Golden ratio is not found in proportion cafetorium design (Fig. 33).

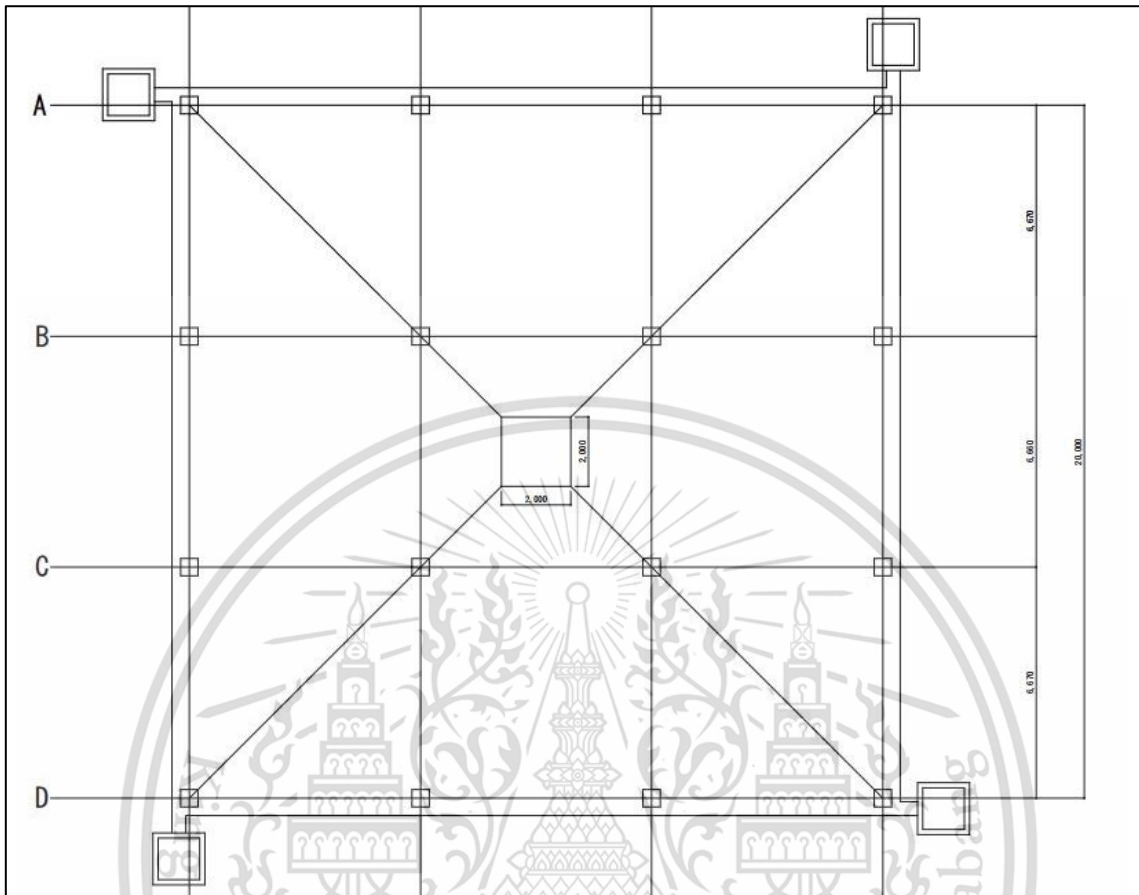


Fig. 33 Roof plan
(Retouch of the original drawing)

4.3.2 Elevation and Section

Sakakura thought that open shelter is closely related to the life of people in the tropical country such as Thailand. As such, he designed the Cafetorium with the inspiration of the form and façade from the vernacular Thai granary (Fig. 34). Originally, Sakakura intended for the Cafetorium to be open shelter. Piloti is also used in the design of the Cafetorium design, which is difficult to determined whether it was influenced from vernacular Thai barn or Le Corbusier. Fibonacci number or golden ratio was not found in the design of elevation or section of the Cafetorium.



Fig. 34 Vernacular Thai barn

(Reference: The Kenchiku, Vol.4, No. 127, pp.43, 1971)

4.3.3 Roof Design and Structure

Truss is used for roof structure in cafetorium (Fig. 35). The roof gradient of cafetorium is 31 degree, which is steeper than 20 degree roof gradient of gymnasium in Hannan High School (Fig. 35). The steep roofing angle is characteristically of the vernacular Thai house. It as to drains the heavy monsoon rain quickly, and more effectively to help lessen the weight that might impact or make the roof structure collapes.



Fig. 36 Ceiling of cafetorium (Photo by author)

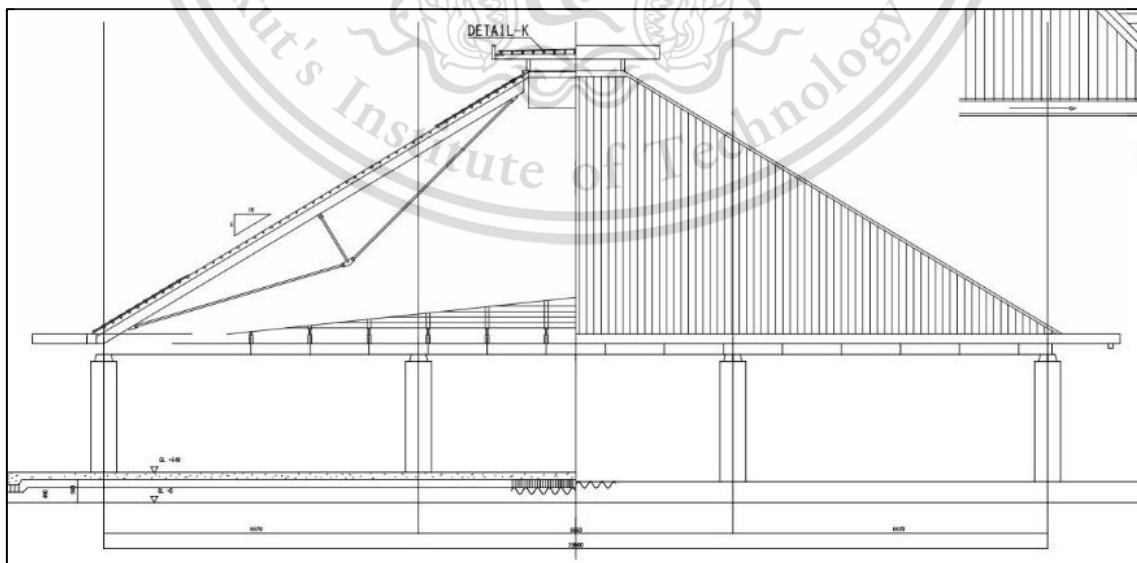


Fig. 35 Section and elevation of cafetorium (Retouch of the original drawing)

Sakakura also use corrugated asbestos sheet as a roofing material in not only the classroom building, the dormitory, but also in the cafetorium (Fig. 38). There is a rain gutter from top to the bottom in the classroom building and the dormitory, but the rain gutter of cafetorium from top of the roof down toward the eaves (Fig. 36).

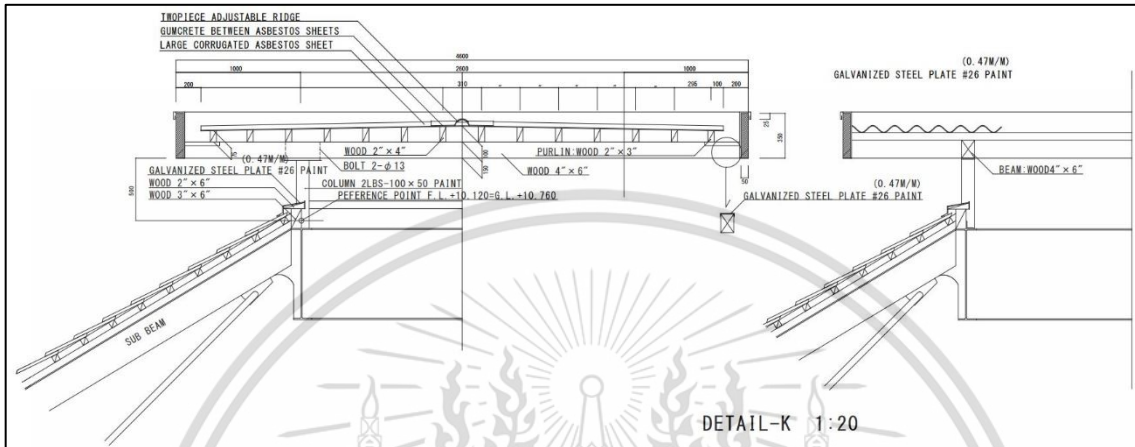


Fig. 38 Detail drawing of cafetorium (Retouch of the original drawing)



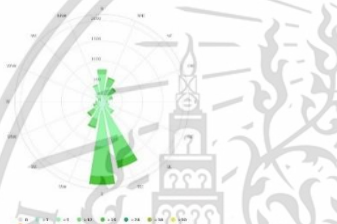

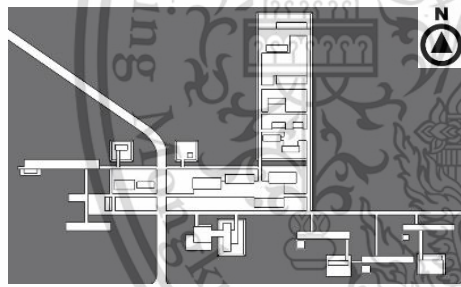
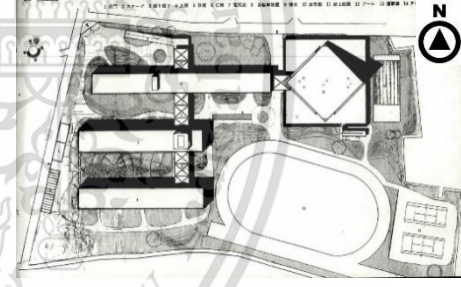
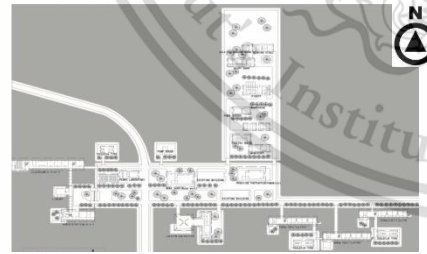
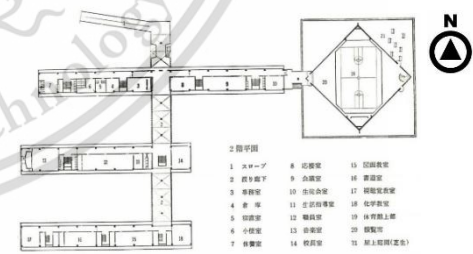
Fig. 37 Rain water drain system in cafetorium (Photo by author)

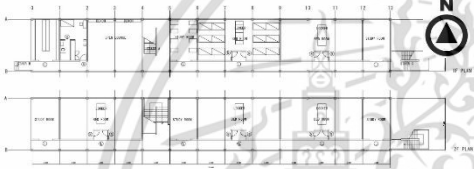
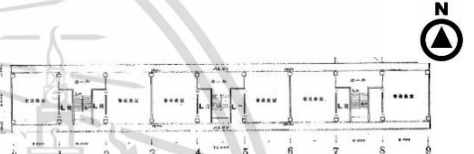
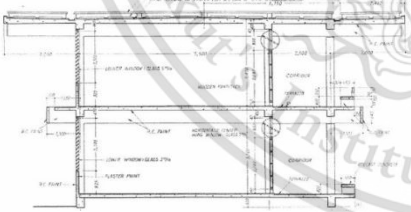

4.3.4 Architectonic Detail


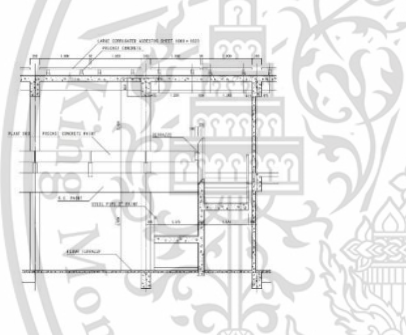
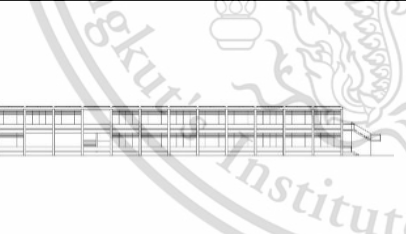
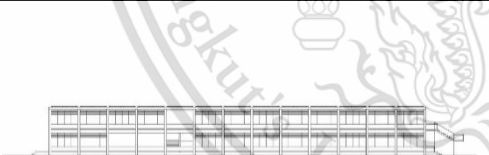
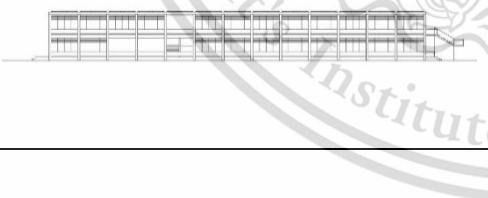
n/a


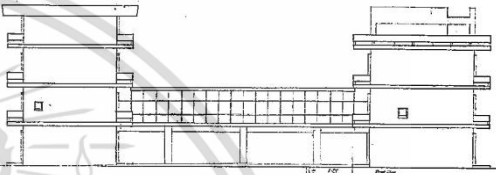
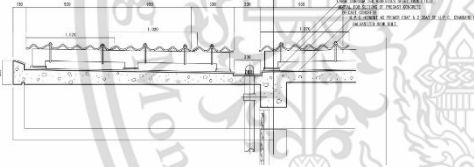
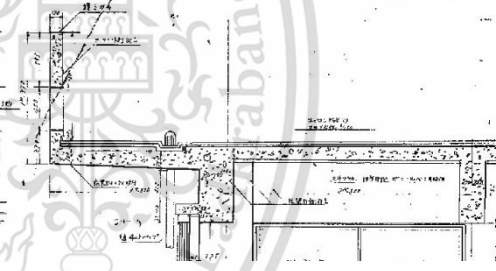
The following table summarizes, and compare the drawings of the Ladkrabang Vocational School and the Hannan High School projects according to the research framework (Table 5). The juxtaposition of Junzo Sakakura's design 1) techniques that had previously been used in Japan and adapted to the Thai climate, and 2) the technique used only in Thailand are shown in Table 6.



		Ladkrabang Agriculture School	Hannan Senior High School	Similarities
General information	Completion	April 1970	November 1962	
	Site area	320,000 m ²	26,980 m ²	
	Total floor area	8,430 m ²	10,244 m ²	
	Windrose			
Building layout	Layout	<p>Built on water</p> <p>Straight design garden</p> 	<p>Built on ground</p> <p>Curved design garden</p> 	East-West axis building
	Building plan	<p>External circulation</p> <p>South corridor</p> 	<p>Internal circulation</p> <p>North corridor</p> 	

		Ladkrabang Agriculture School	Hannan Senior High School	Similarities
Section	Classroom plan	<p>4,000mm long beam span</p> 	<p>8,000mm long beam span</p> <p>Both north and south side is balcon</p> <p>Emphasis on vertical circulation</p> 	<ul style="list-style-type: none"> 8,000mm×8,000mm size classroom 4,000mm multiple long beam span
	Section north-south	<p>3,000mm-5.500 mmm depth cantilever</p> <p>South semi outside corridor</p> <p>Glass louver window</p> 	<p>1,800mm-2,300mm depth cantilever</p> <p>Both north and south side is veranda</p> <p>Slide glass</p> 	<p>3.5m cealing high</p> <p>Precast concrete</p> <p>Terrazzo finished</p>

		Ladkrabang Agriculture School	Hannan Senior High School	Similarities
			<p>window</p> 	
	Section details	<p>1,800mm×1,020mm corrugated asbestos sheet</p> 	<p>24mm thick cemented excelsior</p> 	<p>Precast concrete</p> <p>R.C paint</p> <p>Terrazzo finished</p>
Elevation	Elevation east-west	<p>Walk-way across the canal</p> 	<p>Using slope for main approach</p> 	<p>Horizontal window</p> <p>Système Domino</p>

	Ladkrabang Agriculture School		Hannan Senior High School		Similarities	
	Elevation north-south	3,000mm-5,500mm depth cantilever		1,800mm-2,300mm depth cantilever		Systeme Domino
Roof design	Roof details	1,800mm×1,020mm corrugated asbestos sheet		24mm thick cemented excelsior		

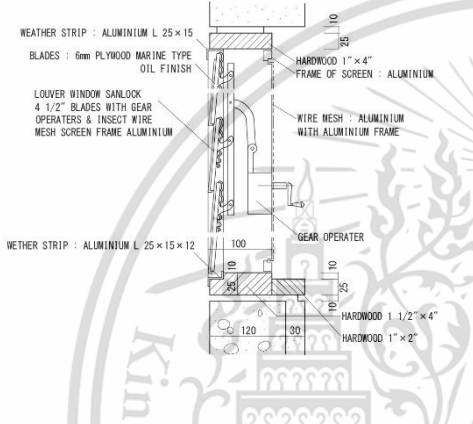
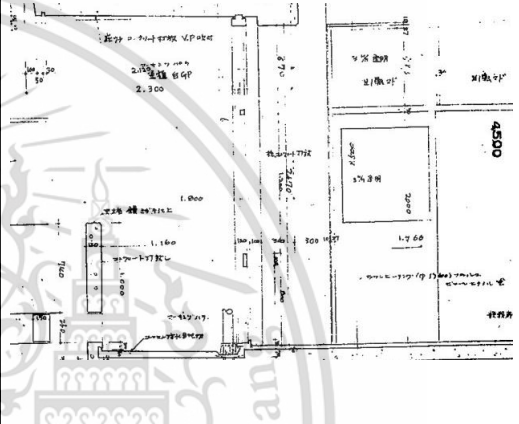
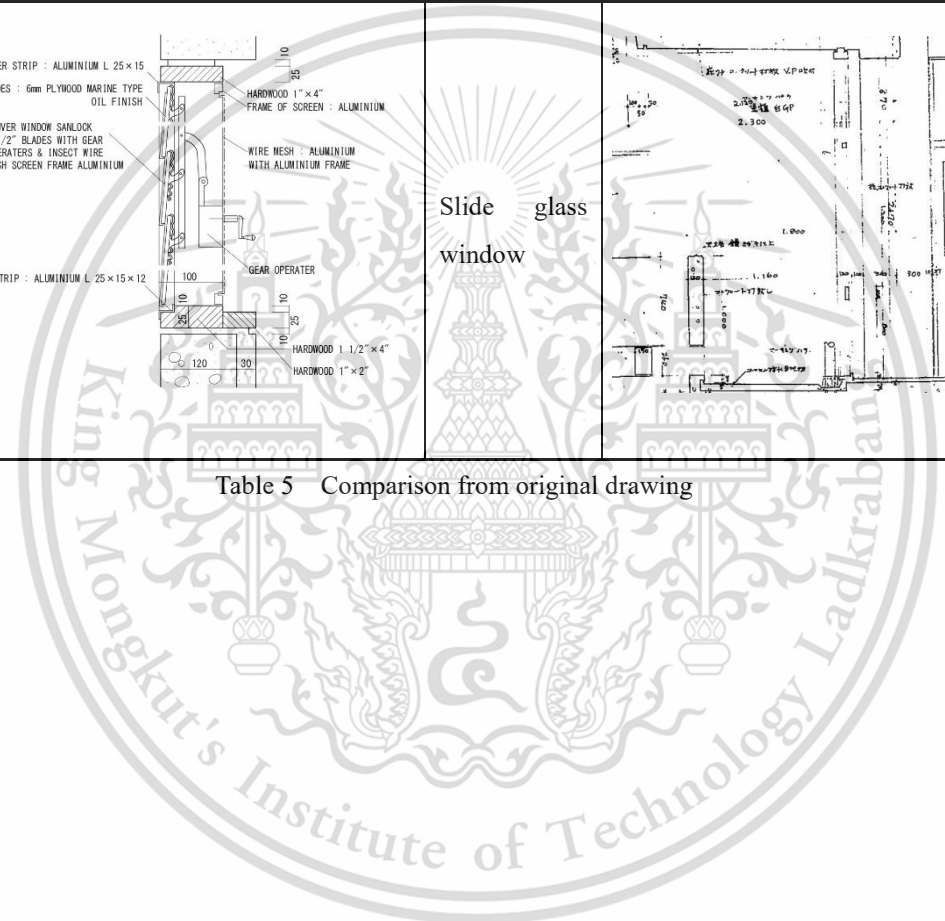
		Ladkrabang Agriculture School	Hannan Senior High School	Similarities
Detail design	Window details	Louver glass window	Slide glass window	Using glass
		 <p>WEATHER STRIP : ALUMINIUM L 25×15 BLADES : 6mm PLYWOOD MARINE TYPE OIL FINISH LOUVER WINDOW SANLOCK 4 1/2" BLADES WITH GEAR OPERATORS & INSECT WIRE MESH SCREEN FRAME ALUMINIUM WETHER STRIP : ALUMINIUM L 25×15×12 HARDWOOD 1"×4" FRAME OF SCREEN : ALUMINIUM WIRE MESH : ALUMINIUM WITH ALUMINIUM FRAME GEAR OPERATOR HARDWOOD 1 1/2"×4" HARDWOOD 1"×2"</p>		

Table 5 Comparison from original drawing



	The design techniques that had previous been used in Japan and adapted to the Thai climate	The design technique used only in Thailand
Building Layout & Axis	<ul style="list-style-type: none"> - 4.0 m beam span - Common area placed in the cluster center - Building structure in the water - 8.0 m. × 8.0 m. class room size - Golden ratio - East-west axis rectangular building 	<ul style="list-style-type: none"> - South side corridor - Bench established in front of classroom
Elevation & Section	<ul style="list-style-type: none"> - Piloti 	<ul style="list-style-type: none"> - Open-air Cafetorium
Roof Design & Structure	<ul style="list-style-type: none"> - Depth of cantilever - Truss 	<ul style="list-style-type: none"> - Corrugated asbestos sheet roofing design
Architectonic Detail	<ul style="list-style-type: none"> - 	<ul style="list-style-type: none"> - Louver glass window - Use asbestos sheet

Table 6 : Results categorized according to the research framework

CHAPTER 5: CONCLUSION & DISCUSSION

This chapter summarizes the findings of this research, and discuss the results with previous research related to Junzo Sakakura and his work. It compares two educational setting design by the reknown Japanese architect, Junzo Sakakura, who had apprenticed and influenced from the great Le Corbusier during the peak of Modern Movement era.

The objectives of this study seek to clarify and differentiate the design signature that Junzo Sakakura adapted from his previous work in Japan and elsewhere to the project in tropical climate that he was commissioned to design for. And this study also aim to discern the new design techniques Sakakura invented or start using in his tropical architecture project.

The case study selected as representative of Sakakura's tropical architecture project was the Ladkrabag Vocational School, which was one of the 25 vocation school project he designed in the late 1960s. The Japanese counterpart selected as a case study representative of Sakakura's educational architure design is the Osaka's Hannan High School that he designed 8 years prior to the Thailand project.

The results of this study indicate that Junzo Sakakura brought several of his design signature to the Vocation School project in Thailand (Apichartworapan & Watanabe, 2016; 2017). to adapt to the Thai tropical climate in the 1960's vocational school project. It is found that the 4.0 m beam span was fundamental to the design of column/beam span although the Hannan High School is designed by 8.0 m. long or is twice as long as that of the Thai vocational school. Speculately, the shorter beam span in the Thai project might is due to Sakakura's adaptation to the limited construction expertise in Thailand during that time. Others design signature Sakakura brought and adapt from his previous work in Japan include the use of Golden ratio (Wada, 2005; 2006), piloti, and deep cantilever.

The design techniques Junzo Sakakura introduced to his Thai Vocational school project may either due to the attempt to adapt and create the building design suitable for a tropical climate, or the limitation of construction tecniques and availability of materials. These design features include the arrangement of south corridor, the use corrugated asbestos roofing material as well as the use of louver glass window. However, even in limited circumstances, Sakakura challenged for minimal design. Such as, the handrail of staircase is designed as part of a structure, no finishing for instance without using plaster and sealing is not attached.

To cope with the high temperature and humidity of the tropical zone, Sakakura adopted, the local materials corrugated asbestos, into the roofing design and structure of the classroom building, the dormitory and cafetorium. By using 8.0 m × 8.0 m corrugated asbestos sheets for the double roof of the classroom and the dormitory. It against heat with local materials by economical and it is to easy for maintenance. AlsoThe monitor roof of cafe thorium is a design method for ventilation which is also found in traditional Japanese houses. Sakakura also used the louver glass window, instead of the sliding glass panel like what he did in Japan, for the classroom and dormitory buildings as it allows the whole surface and ventilate more efficiently. It was sometimes used in the ventilation space such as bathroom, kitchen, and toilet until the late 1990 's in Japan, but it was used less frequently because the security performance and heat insulation were very bad. However, it has been used in hot climate regions including Thailand, because it has advantages such as large opening, ventilation even in rainy weather, replacement cost can be suppressed even if a part is broken. Sakakura seems to try to adapt to the tropical climate and intense rain in Thailand by using the louver window which was not used much in Japan. But, it is not certain whether Sakakura's design decision worked properly. The temperature of the dormitory rooms is too high to live comfortably. Eventually, the dormitory was turned into the classroom facility. And currently, after renovated and change the function to a laboratory fully equipped with airconditioning, the louver glass window was, then again, changed to slide glass window to keeps the cool air inside the room.

And also, Sakakura implemented designs in Thai vocational school which is inspired from Thai traditional architecture such as, waterfront building, opens-shelter and steep roof. Sakakura designed the Cafetorium with the inspiration of the form and façade from the vernacular Thai granary because he thought that open shelter is closely related to the life of people in Thailand. Piloti is also used in the design of the Cafetorium, but it is difficult to determined whether it was influenced from vernacular Thai barn or Le Corbusier. And the roof gradient of cafetorium is 31 degree, which is steeper than 20 degree roof gradient of gymnasium in Hannan High School. The steep roofing angle is characteristically of the vernacular Thai house. It as to drains the heavy monsoon rain quickly, and more effectively to help lessen the weight that might impact or make the roof structure collapes.

It compare this research and previous study about Sakakura by using framework. As for the influence from Le Corbusier, it was found that golden ratio and piloti were used as in the previous study, but Fibonacci number could not be found (Table 7). And, influenced from traditional Japan could not find the design method

seen in previous study, but monitor roof was found on the roof of cafeteria (Table 8). Finally, assimilation of the surroundings is similar to previous study which is built in water (Table 9).



<u>Influenced from Le Corbusier</u>		
	Previous studies	Result of this paper
Building Layout & Axis	- Golden ratio	- Golden ratio
Elevation & Section	- Piloti - Horizontal window - Fibonacci number - Dry construction	- Piloti - Horizontal window
Roof Design & Structure	N/A	N/A
Architectonic Detail	- Deep splayed window - Board formed concrete finish	- Deep splayed window - Board formed concrete finish

Table 7 Influenced from Le Corbusier

<u>Influenced from traditional Japan</u>		
	Previous studies	Result of this paper
Building Layout & Axis	<ul style="list-style-type: none"> - Garden layout - Terrace design 	N/A
Elevation & Section	<ul style="list-style-type: none"> - Namako-wall - Oya-Ishi 	N/A
Roof Design & Structure	N/A	<ul style="list-style-type: none"> - Monitor roof
Architectonic Detail	<ul style="list-style-type: none"> - Details around the pillar 	N/A

Table 8 Influenced from traditional Japan

Assimilation of the surroundings		
	Previous studies	Result of this paper
Building Layout & Axis	- Built on the water	- Built on the water
Elevation & Section	N/A	N/A
Roof Design & Structure	N/A	N/A
Architectonic Detail	N/A	N/A

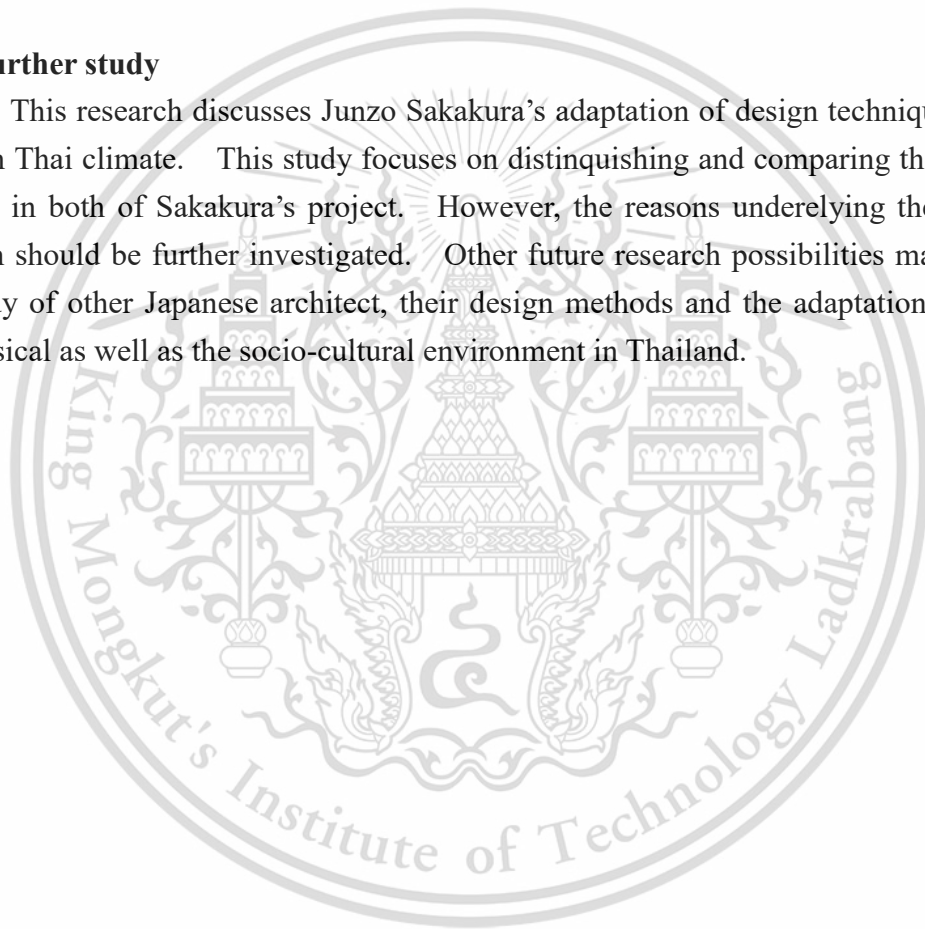
Table 9 Assimilation of the surroundings

5.1 Limitation of the study

This research mainly took place in Thailand, and the major part of the investigation was devoted to the field survey and artefactual investigation of the Ladkrabang Vocational school. The interview of Mr. Tsutomu Abe and Mr. Jiro Murofush, the former staff of Junzo Sakakura who directly involved in the design of Thai Vocational school project at that time, would help elucidate the design the design process and programing for both of the projects used as the comparative case studies in this research.

5.2 Further study

This research discusses Junzo Sakakura's adaptation of design technique, from Japan in Thai climate. This study focuses on distinguishing and comparing the design features in both of Sakakura's project. However, the reasons underlying the design decision should be further investigated. Other future research possibilities may entail the study of other Japanese architect, their design methods and the adaptation to both the physical as well as the socio-cultural environment in Thailand.



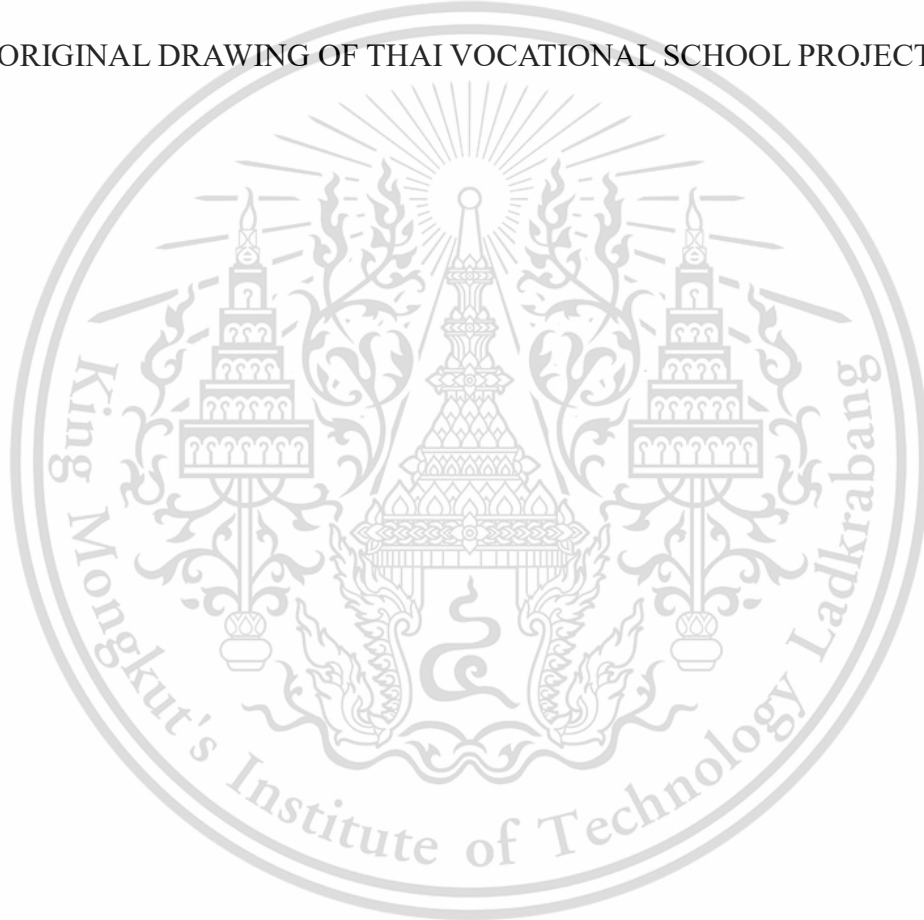
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- The original drawing of vocational school project, National Archives of Modern Architecture Agency for Cultural Affairs
- Wind rose of Bangkok and Osaka, meteoblue weather close to you, <https://www.meteoblue.com> (Accessed 2018-11-22)

APPENDIX A

ORIGINAL DRAWING OF THAI VOCATIONAL SCHOOL PROJECT



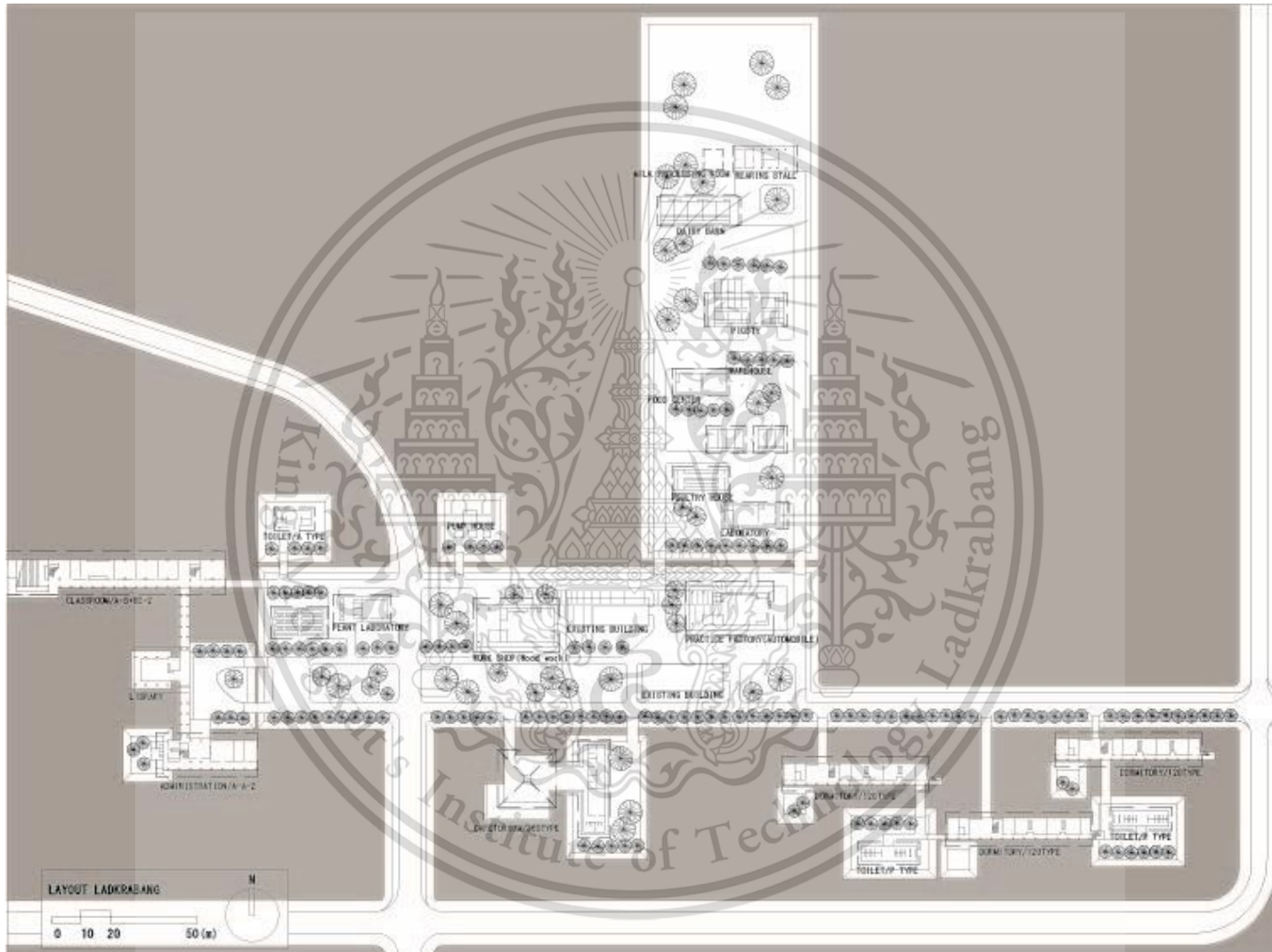


Fig. 39 Layout of vocational school in Ladkrabang (Retouch of the original drawing)

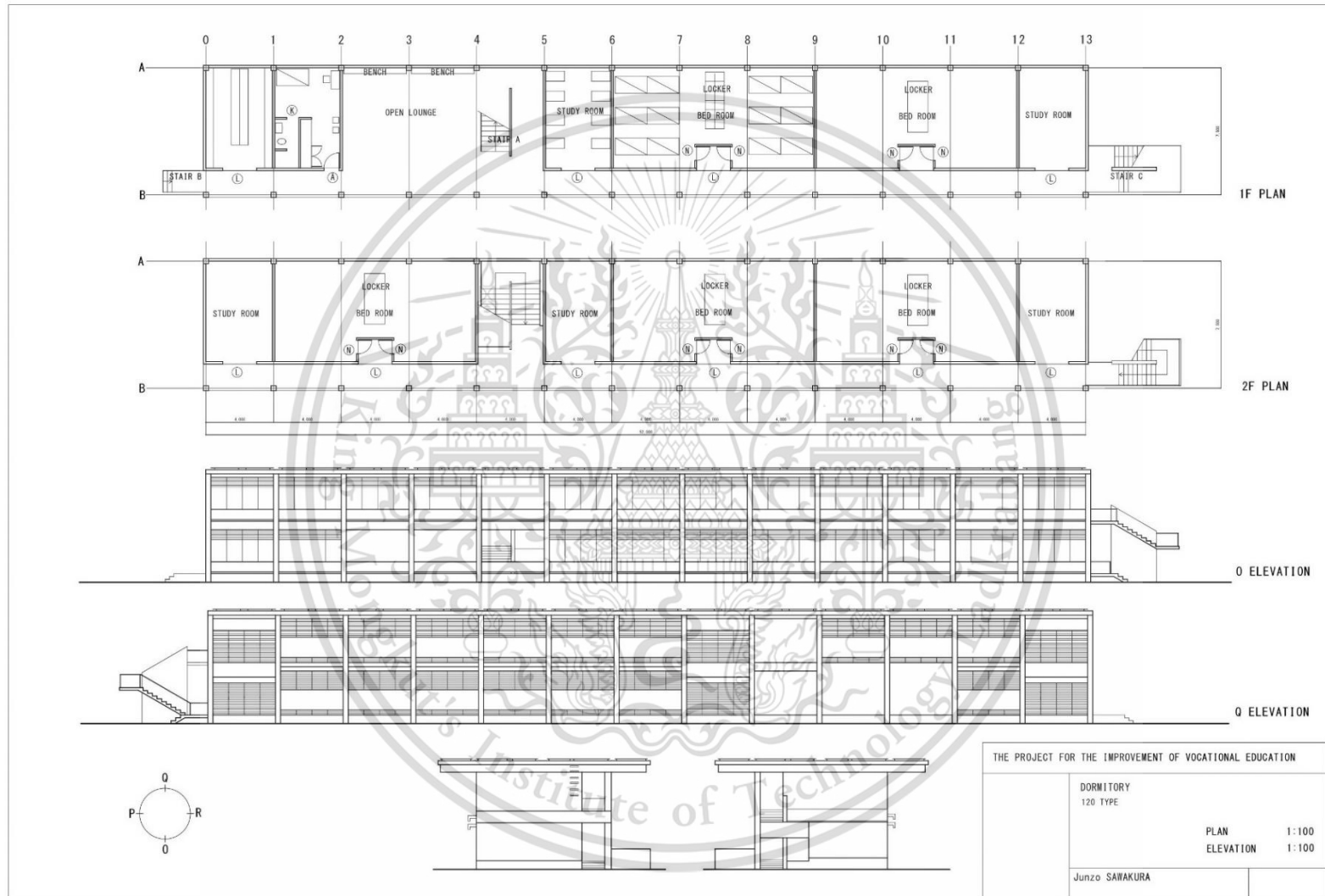


Fig. 40 Thai vocational school dormitory TYPE 120 (Retouch of the original drawing)

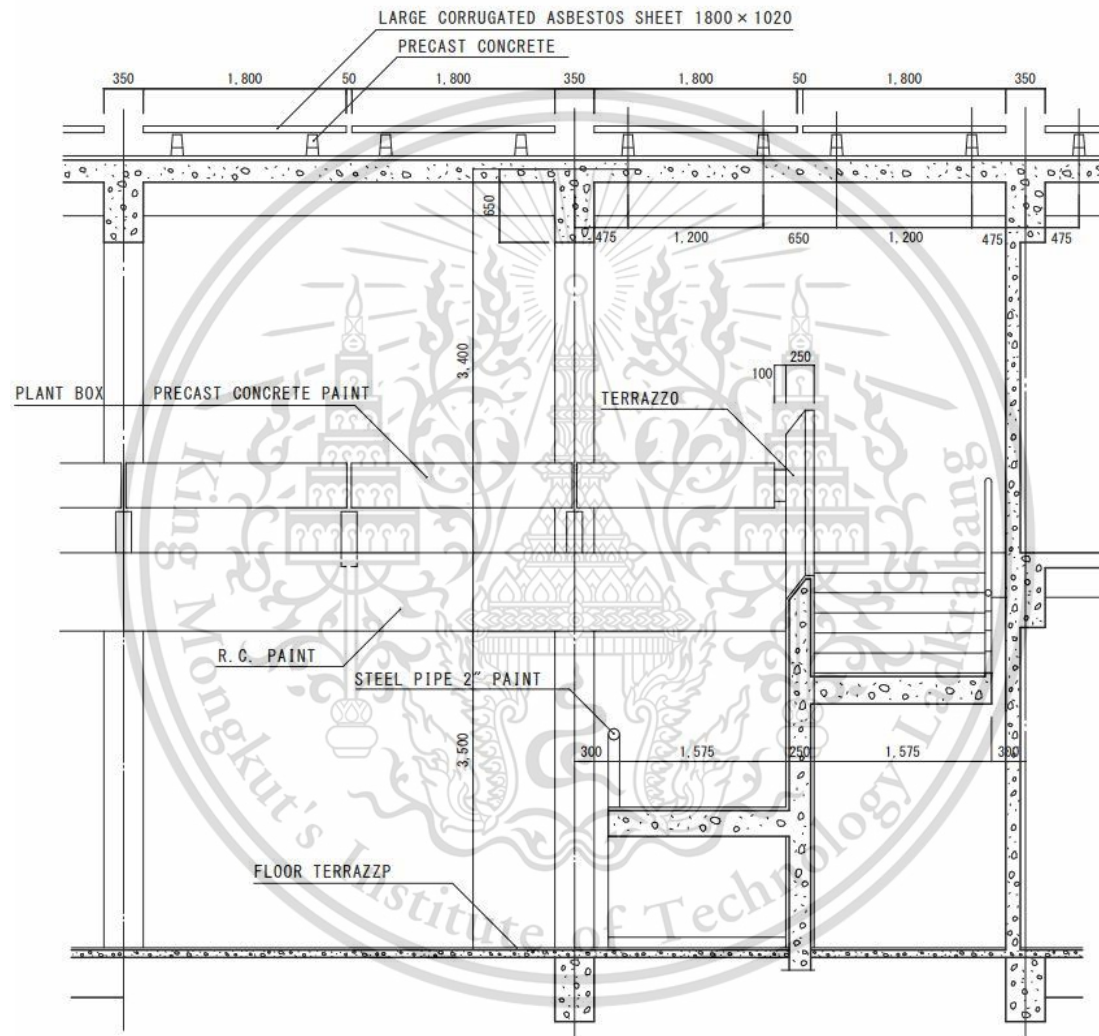


Fig. 41 Section of Thai vocational school classroom (Retouch of the original drawing)

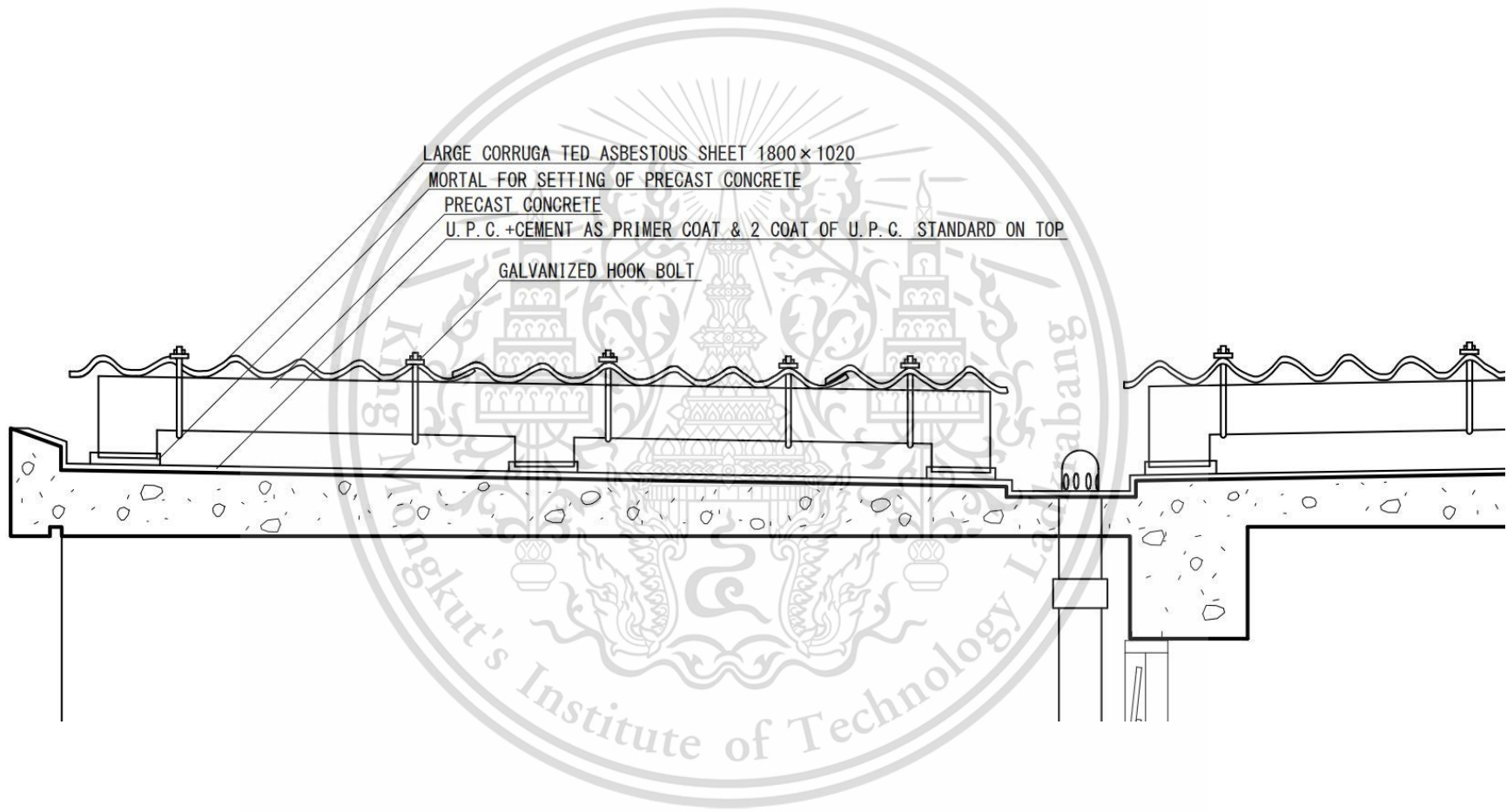


Fig. 42 Roof details of Thai vocational school (Retouch of the original drawing)

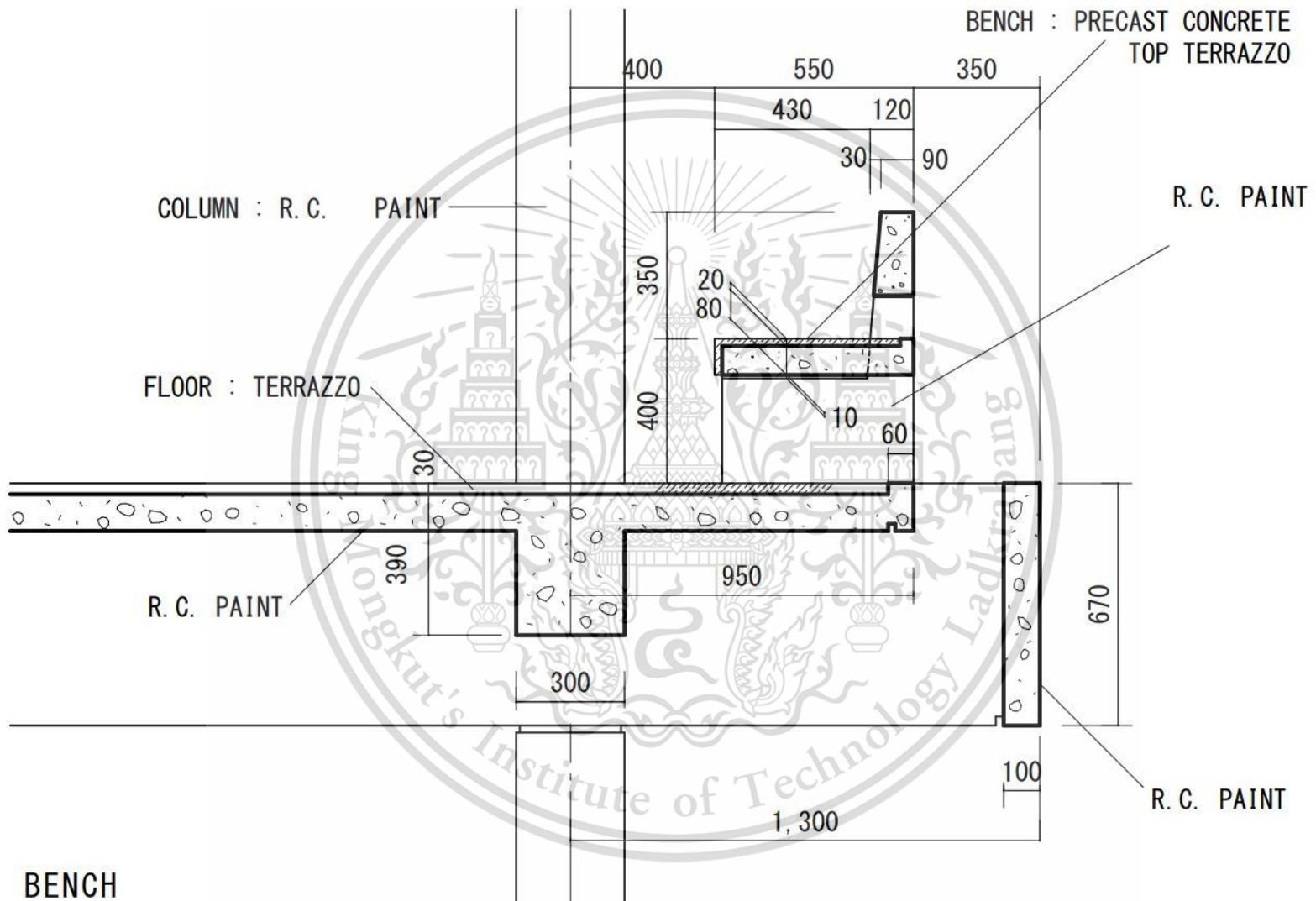


Fig. 43 Detail of bench in Thai vocational school (Retouch of the original drawing)

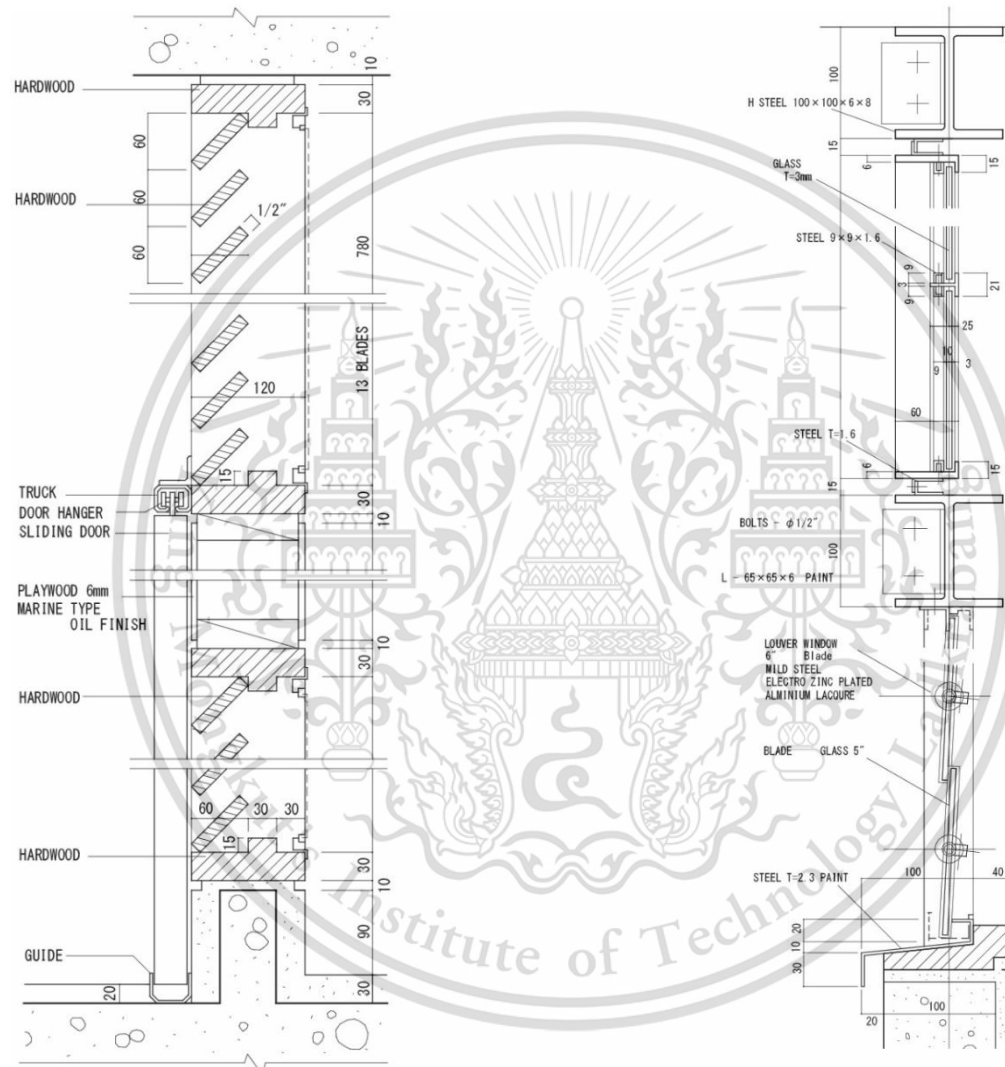


Fig. 44 Detail of window in Thai vocational school (Retouch of the original drawing)

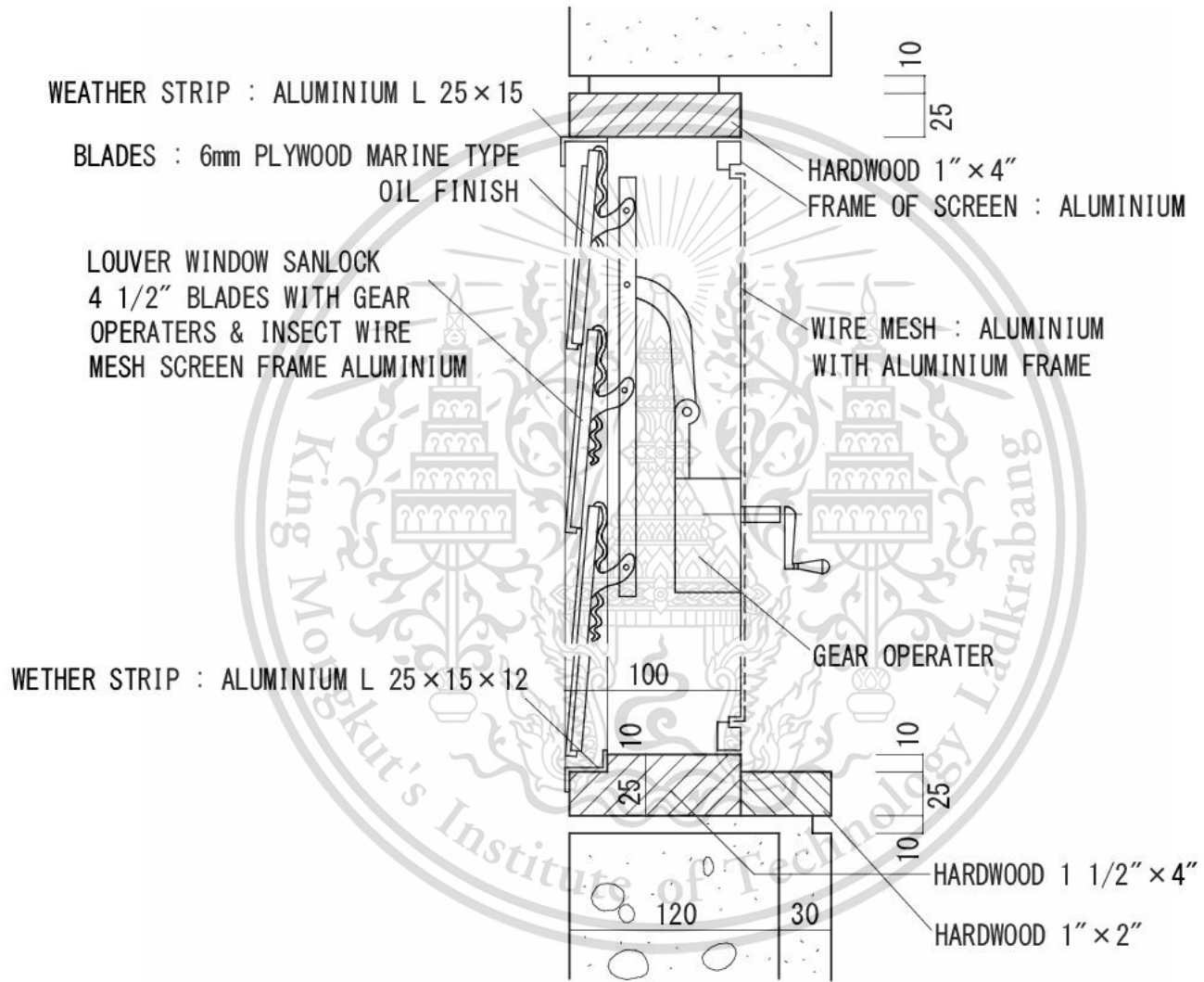


Fig. 45 Detail of louver glass window (Retouch of the original drawing)

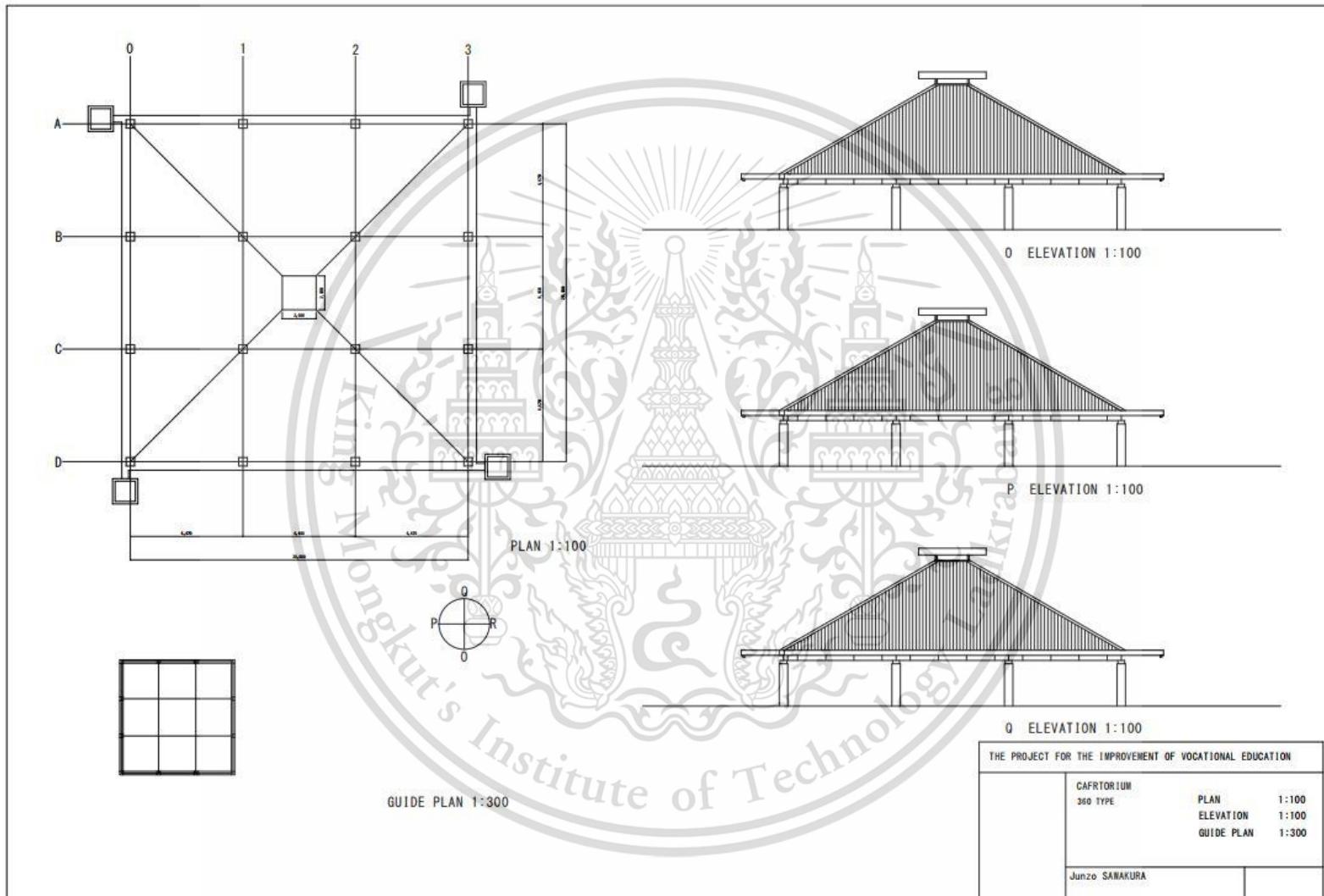


Fig. 47 Cafetorium 360 TYPE (Retouch of the original drawing)

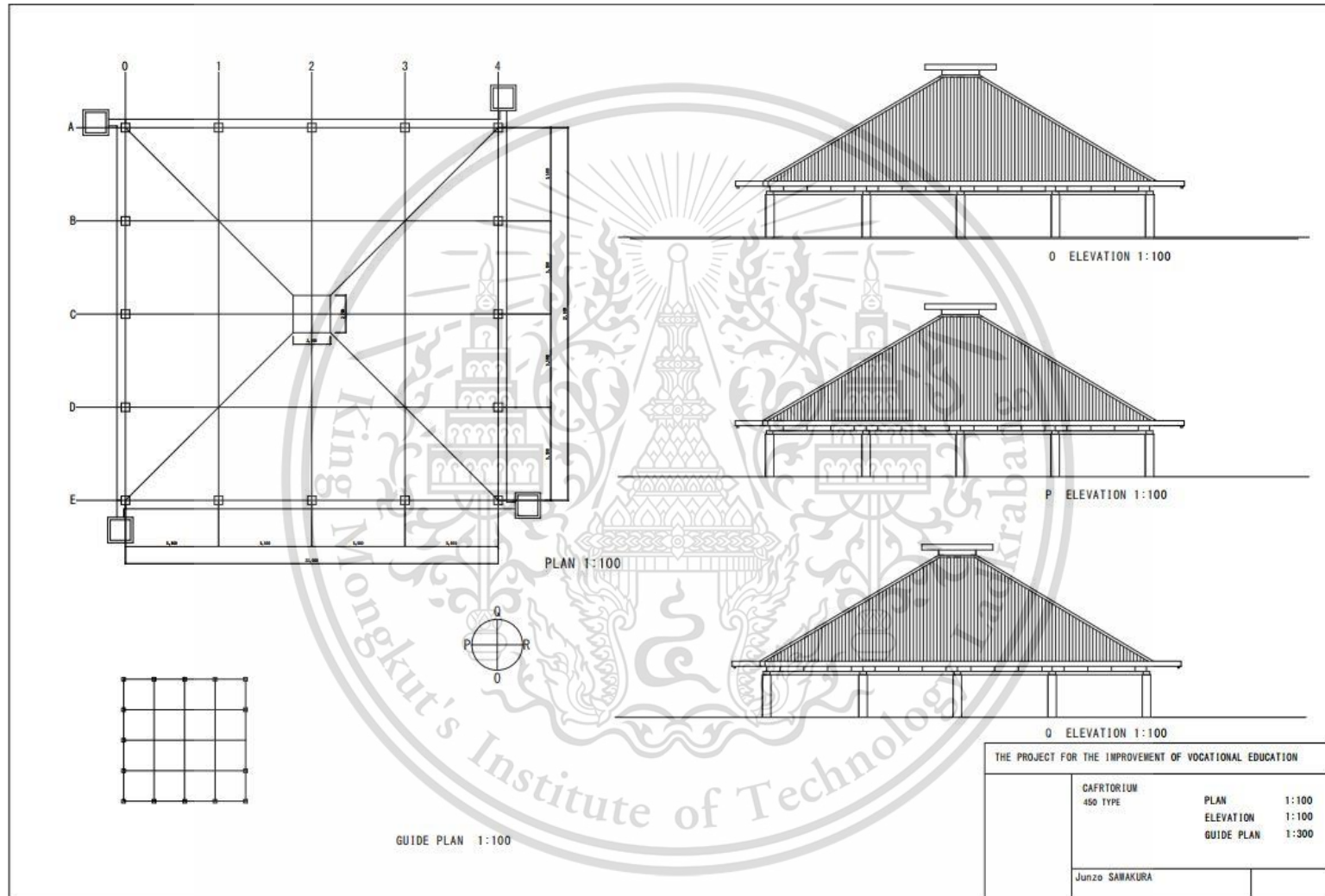


Fig. 48 Cafetorium 450 TYPE (Retouch of the original drawing)

APPENDIX B

PICTURE OF
THAI VOCATIONAL SCHOOL PROJECT IN LADKRABANG





Fig. 49 Dormitory building in Ladkrabang (Photo by the author)



Fig. 50 Corrugated asbestos sheet on the dormitory building (Photo by the author)



Fig. 51 South side semi outside corridor (Photo by the author)



Fig. 52 Classroom in Ladkrabang (Photo by the author)



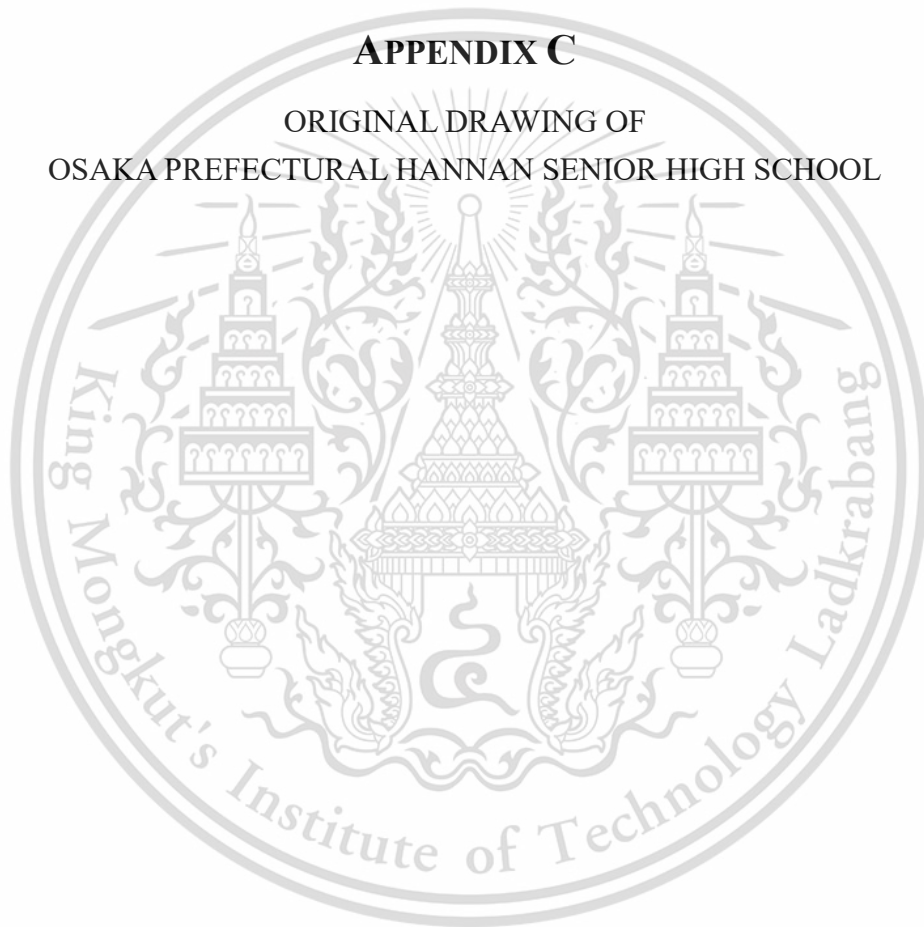
Fig. 53 Cafetorium in Ladkrabang (Photo by the author)



Fig. 54 In side of cafetorium in Ladkrabang (Photo by the author)

APPENDIX C

ORIGINAL DRAWING OF
OSAKA PREFECTURAL HANNAN SENIOR HIGH SCHOOL



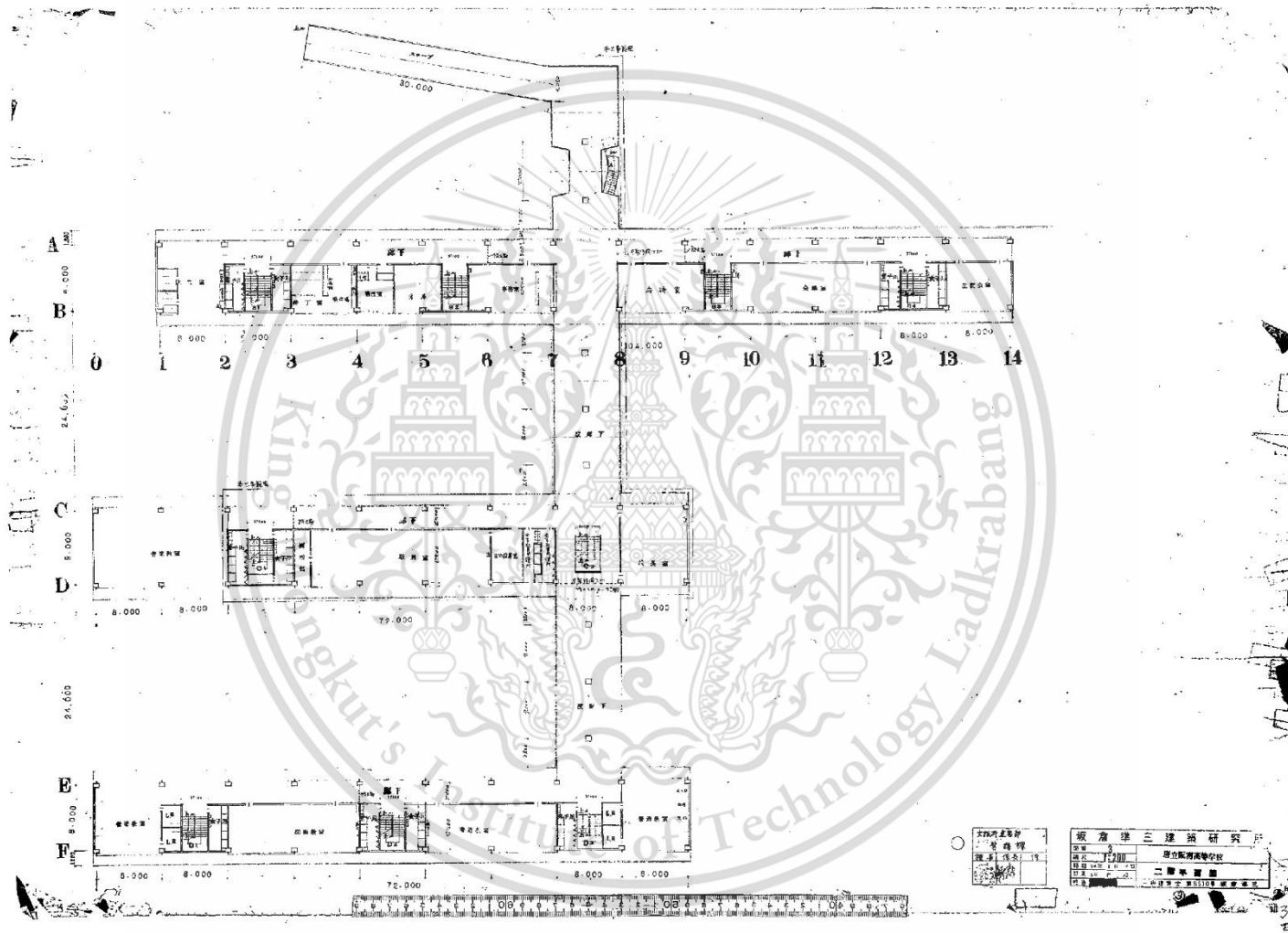


Fig. 55 Plan of Hannan High School (Source: Original drawing)

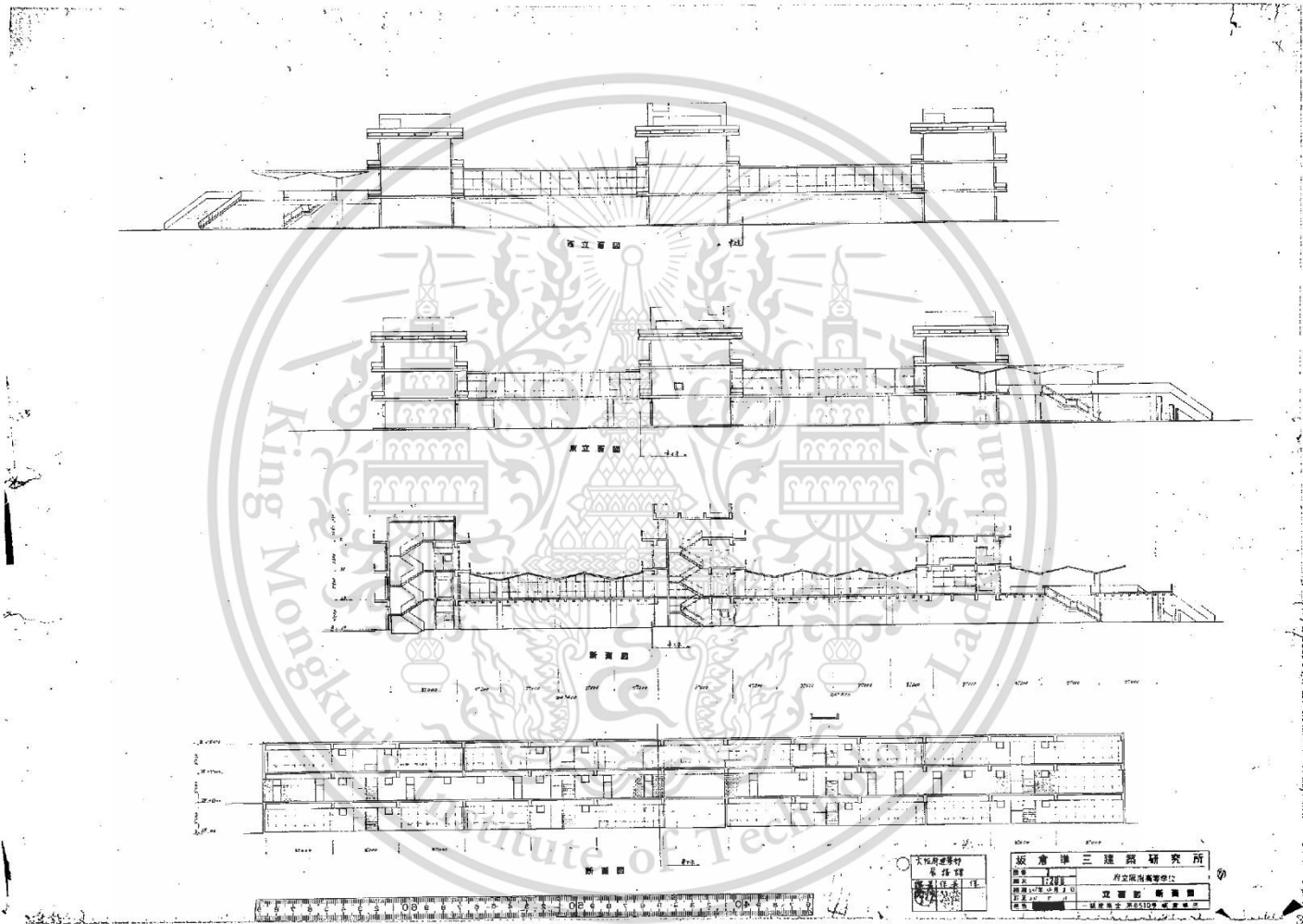


Fig. 56 Elevation and section of Hannan High School (Source: Original drawing)

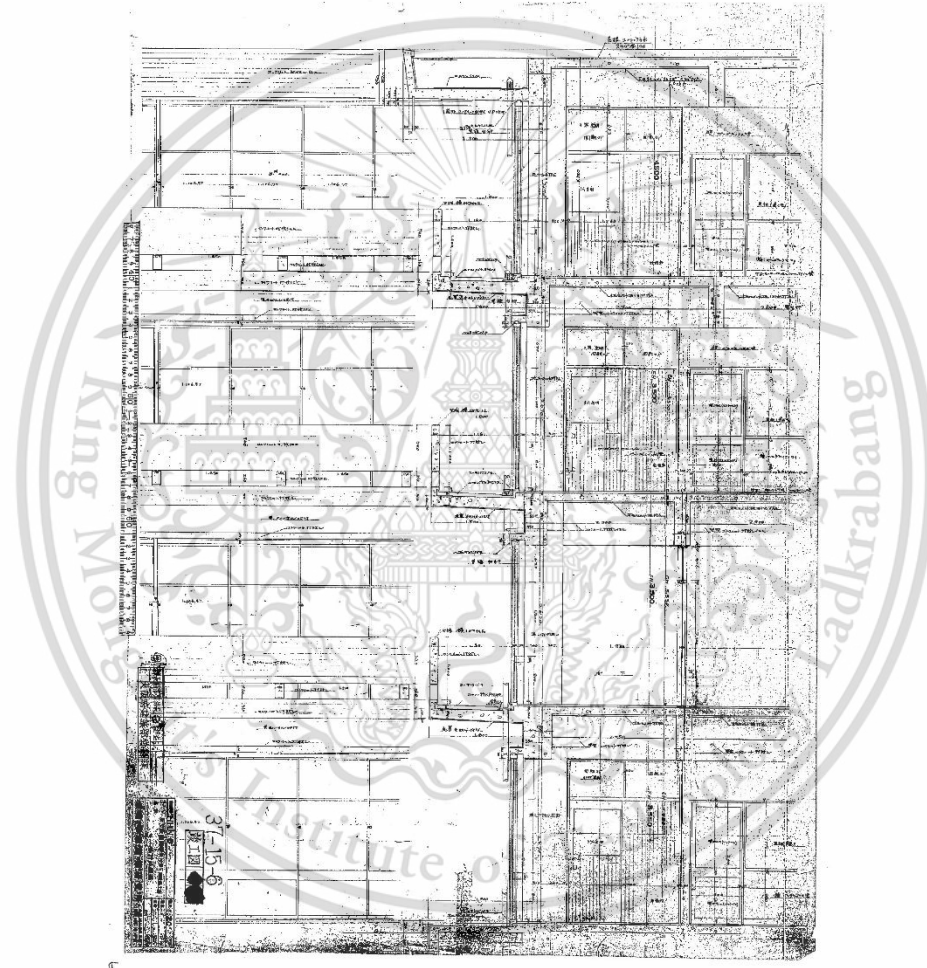


Fig. 57 Section of Hannan High School (Source: Original drawing)

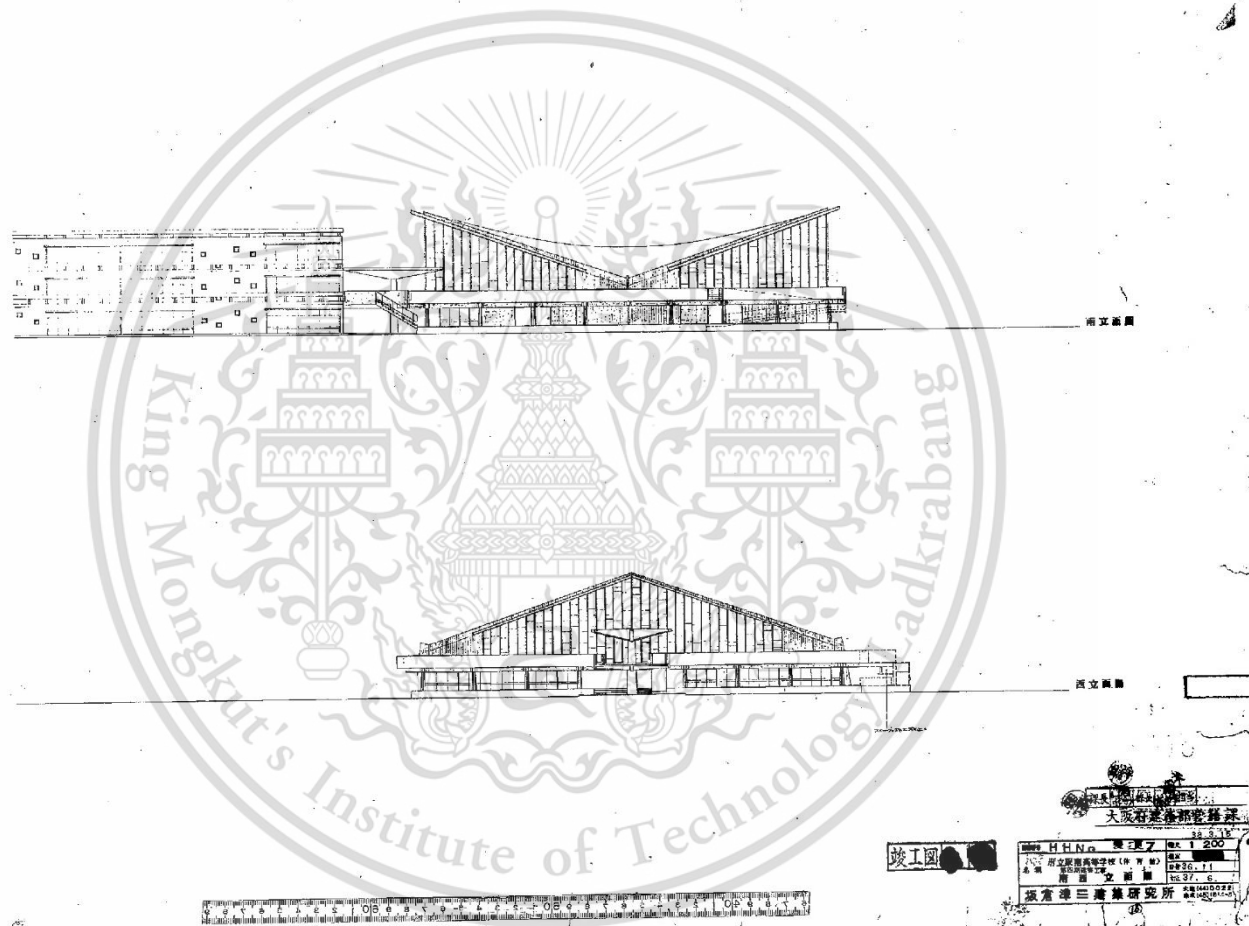


Fig. 59 Elevation of gymnasium in Hannan High School (Source: Original drawing)

APPENDIX D

PICTURE OF
OSAKA PREFECTURAL HANNAN SENIOR HIGH SCHOOL

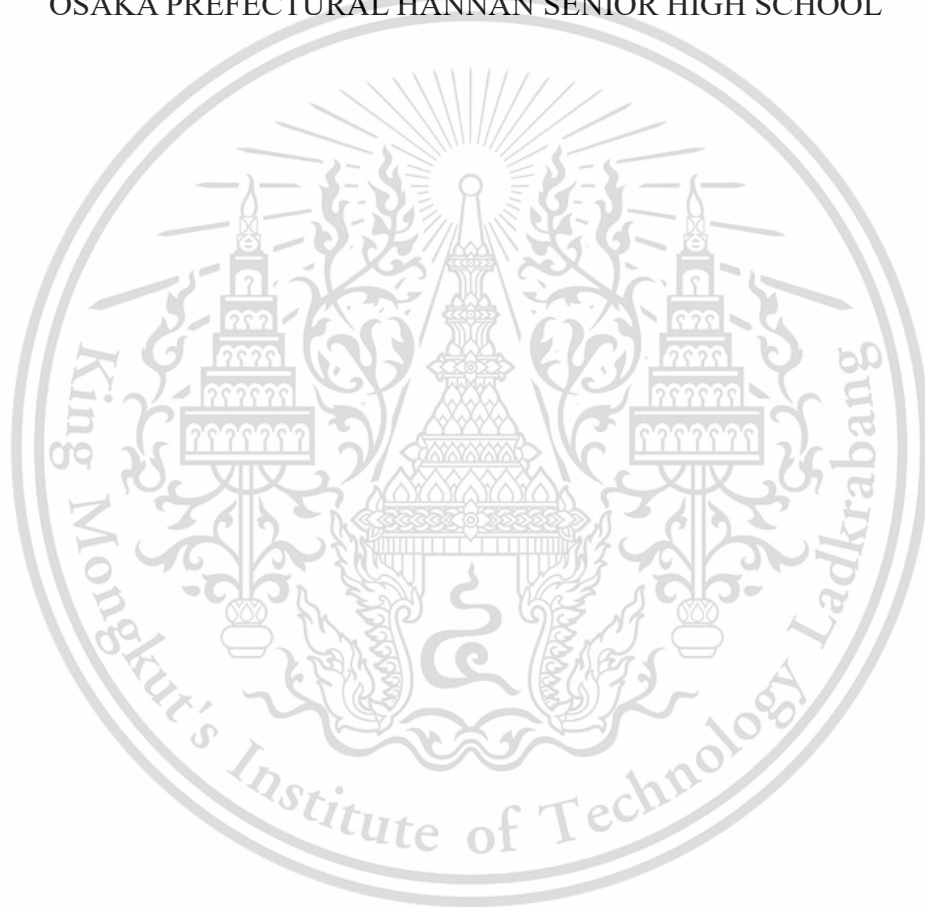




Fig. 60 Hannan High School from main gate (Photo by the author)



Fig. 61 Roof of 2nd floor corridor (Photo by the author)



Fig. 62 South side velanda (Photo by the author)

Curriculum Vitae

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2017: B.A. in Engineering, University of the Ryukyus, Okinawa, Japan

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List of Publications

(M.E. Thesis)

Junichi SAWAKI: From Temperate to Tropical: The Design Method of Junzo Sakakura in the Thailand Vocational School Project. King Mongkut's Institute of Technology Ladkrabang 2019

(Peer-Reviewed Papers)

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Other

Experience of Teaching Assistant 2017, University of the Ryukyus