



OBSERVATION AND CONSERVATION REPORT ON KANCHANABURI PAPER
MILL; INDUSTRIAL HERITAGE OF THAILAND



An Independent Study Submitted in Partial Fulfillment of the Requirements
for Master of Arts Architectural Heritage, Creative Industries and Tourism
Management (International Program) Plan B
Department of ARCHITECTURAL HERITAGE MANAGEMENT AND TOURISM
Silpakorn University
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ของประเทศไทย



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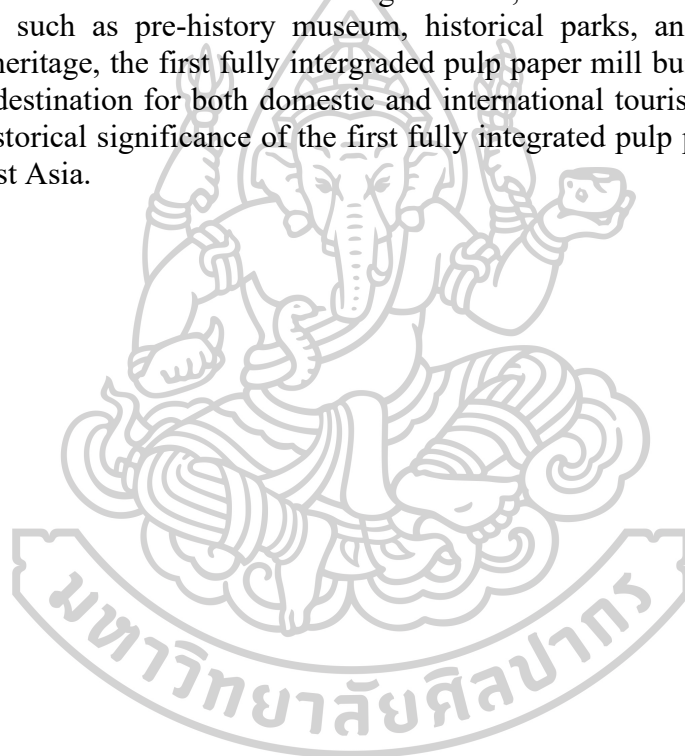


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Kanchanaburi is a province in Thailand known for its rich history and stunning natural landscape. It is situated in the western part of the country and is characterized by its mountainous terrain, lush forests, and numerous rivers. The region is particularly famous for the River Kwai, which is associated with the historical events of World War II, including the construction of the infamous Death Railway. In addition to its historical significance, Kanchanaburi offers a variety of attractions, such as pre-history museum, historical parks, and an obscure site of industrial heritage, the first fully intergraded pulp paper mill build in 1937, making it a popular destination for both domestic and international tourists. This paper delves into the historical significance of the first fully integrated pulp paper mill established in Southeast Asia.



ACKNOWLEDGEMENTS

This conservation engineering investigation report for Kanchanaburi Paper Mill has proven to be an immensely enriching experience, facilitated by the guidance, support, and encouragement of numerous individuals and institutions.

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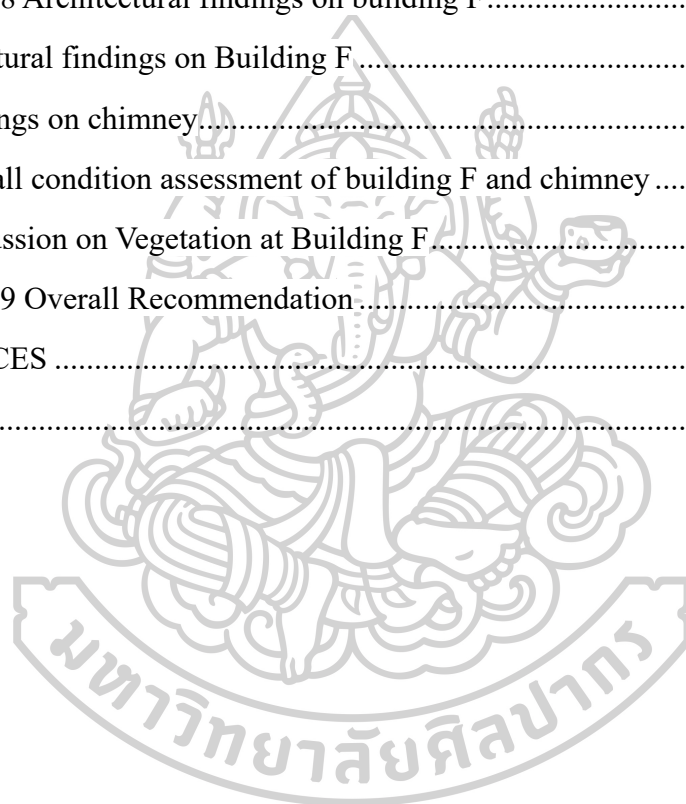
Zay Myo LIN

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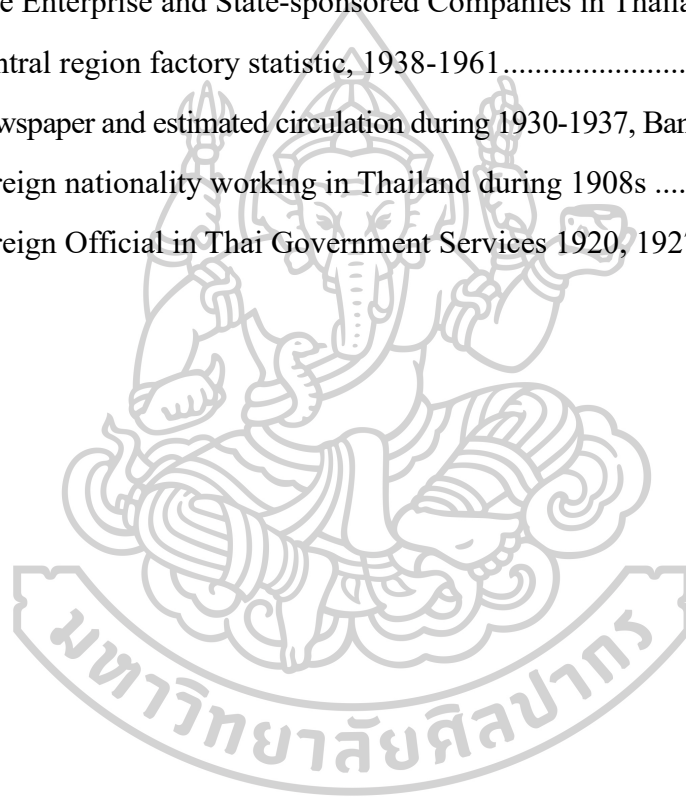
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INTRODUCTION

Industrial heritage refers to the remnants of industrial activity that have historical significance, encompassing structures, machinery, architecture, structural engineering and landscapes that reflect the technological advancements and socio-economic transformations of past eras. This concept highlights the importance of preserving sites such as factories, mills, and railways, which serve as tangible links to the industrial revolution and its impact on society. By safeguarding these elements, not only honor the peoples and innovation of previous generations but also provide valuable insights into the evolution of industry and its role in shaping contemporary culture and environment. The study and conservation of industrial heritage thus play a crucial role in understanding Kanchanaburi's collective history and fostering a sense of identity within communities, region and nation. It examines the backdrop of its construction amidst a unique architectural heritage, civil and structural engineering, the socio-economic impacts on the local community, and untouched heavy industrial machines and equipment that create a dynamic environment for visitors to engage with the region's heritage while promoting sustainable tourism practices that benefit the local community economically and socially. The national project which encompasses 12.9 million baths and was constructed in 1937, serves as more than a mere remnant of history in Kanchanaburi but also as a testament of the region's industrial heritage.

Objectives

- To investigate the historical context of the complex, surrounding brick wall and establishment of paper mill.
- To analyze the significance character and the preservation methods and challenges associated with industrial heritages in Kanchanaburi.
- To conduct technical analysis to Architectural, Civil and Structural aspect to the remaining infrastructure and remnants of heavy-duty industrial machineries.

Research Question

- What is Identification of the historical significance of paper mills within the context of industrial heritage and their contributions to local economies and communities?
- What is Examination of the architectural and technological features of paper mill that exemplify industrial practices and innovations of their time?
- How to conduct analysis of the preservation challenges and opportunities associated with recognizing paper mill as integral components of industrial heritage?

Methodology

- **Documentation:** Assessment of interdisciplinary approaches that combine historical, architectural, and sociocultural viewpoints in the exploration of potential industrial heritage derived from archival materials.
- **Site Survey:** Conducted in 2024-2025, this survey aims to analyze the historical context and evaluate technical aspects of authenticity and integrity, which are essential for establishing a framework for the preservation of the paper mill as an industrial heritage site.
- **Case Study:** Investigation of research methodologies suitable for the study of pulp paper mills, emphasizing a qualitative framework that incorporates observational techniques and a comprehensive review of pertinent documentation.

Definition of industrial heritage

Industrial heritage consists of the remains of industrial culture which are of historical, technological, social, architectural or scientific value. These remains consist of buildings and machinery, workshops, mills and factories, mines and sites for processing and refining, warehouses and stores, places where energy is generated, transmitted and used, transport and all its infrastructure, as well as places used for social activities related to industry such as housing, religious worship or education. (The Nizhny Tagil Charter, 2003).

The industrial heritage consists of sites, structures, complexes, areas and landscapes as well as the related machinery, objects or documents that provide evidence of past or ongoing industrial processes of production, the extraction of raw materials, their transformation into goods, and the related energy and transport infrastructures. Industrial heritage reflects the profound connection between the cultural and natural environment, as industrial processes – whether ancient or modern – depend on natural sources of raw materials, energy and transportation networks to produce and distribute products to broader markets. It includes both material assets – immovable and movable –, and intangible dimensions such as technical know-how, the organization of work and workers, and the complex social and cultural legacy that shaped the life of communities and brought major organizational changes to entire societies and the world in general. (The Dublin Principles, 2011)

The Industrial Revolution profoundly modified landscapes and life styles. The massive means employed to extract raw materials and exploit the minerals and agricultural products resulted in great achievements and grandiose constructions, testifying to the creative genius of humankind. (Michael Falser, 2001).

We recognize that industrial development in Asia is different from its counterparts in the West. The development of native manufacturing methods and facilities is part of the local history. The definition of industrial heritage in Asia should be broadened to include technologies, machinery and producing facilities, built structures and built environment of pre-industrial revolution and post-industrial revolution periods. (Taipei declaration, 2012)

CHAPTER 1

HISTORICAL CONTEXT

Kanchanaburi is known for its rich cultural heritage, with traces of human existence dating back to prehistoric times. Archaeological evidence found in the Khwae Noi and Khwae Yai river basins showcases the ancient history of the area. The Ministry of Fine Art has recognized the historical significance of Muang Singh and Prasat Muang Singh, and established as Historical Park. King Rama I established the old town of Kanchanaburi in Khao Chon Kai in late 18th century, but it was later relocated by King Rama III in 1831, to the southeast for better geological advantages, including a more fortified defensive system and improved transportation facilities along the riverbank, which is the current pulp paper mill was located. The remnant of brick wall served as an important defensive encampment from Burmese military attack from the Ayutthaya to the Rattanakosin era. The conclusions drawn are informed by the findings from my site survey that, contrary to what might be inferred from its structural fortitude, the wall lacked any defensive purpose against military invasion. The historicity of the wall can be traced to a period when trade and social cohesion were more pivotal to the region than warfare, particularly during the First Anglo-Burmese War (1824-1826). There is lack of documented stated military activity from Burma during this period highlights the peaceful intent behind the wall's construction, suggesting a focus on community or commercial purpose rather than conflict. The establishment of the brick wall reflects the era's architectural trends rather than a military necessity, thereby highlighting the complexities of local identity formation in the face of external challenges. Nevertheless, the wall represents the transitional nature of Kanchanaburi—from an era of relative isolation to one of industrial or commercial influence.

The fortification wall has a height ranging from 2 to 2.4 meters and a thickness of 1.2 to 1.3 meters. It is constructed from bricks, typically measuring 300mm x 145mm x 70mm, which predominantly consist of a mixture of mud and rice husk, a heating component commonly utilized in Thailand since the Ayutthaya period. Two type of mortar are present: a lime-based mortar used for plastering the wall

surface and a mud mortar serving as the primary adhesive for brick laying, discovered at the south entrance gate of the paper mill. The thickness of the mud mortar between the bricks generally measures 3.0 to 3.5 mm in horizontal layers and 2 to 3.5 mm in the vertical gaps. Further research may be necessary to conduct a composition test on the remnants of the mud mortar.

Restoration, reconstruction and re-pointing efforts have been undertaken on certain sections of the brick wall, utilizing bricks of the same dimensions and lime-based mortar. The thickness of the mud mortar between the bricks typically measures 3.5 to 4.5mm in horizontal layers and 2.5 to 3 mm in the vertical gaps. This works has been carried out by the Ministry of Fine Arts, as indicated on the information board. **(Figure 1)**

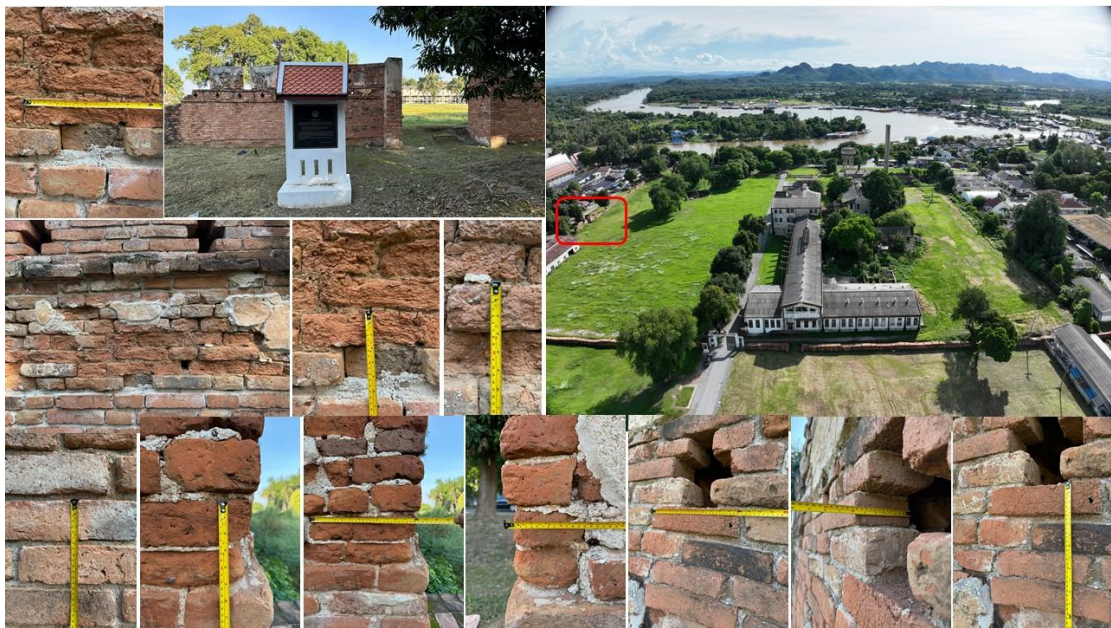


Figure 1: Remnant of ancient brick wall at Kanchanaburi paper mill by 01/12/2024

Photo by Zay Myo Lin

1.1 Siam to Thailand, National Diplomacy and Economy

Although there had been varied and long-established trading and diplomatic contacts with the West since the early sixteenth century (Ayutthaya period), the 1850s became a watershed in Thailand's development. From this period the Thai economy became incorporated into the Western-dominated global economy. The Kingdom also

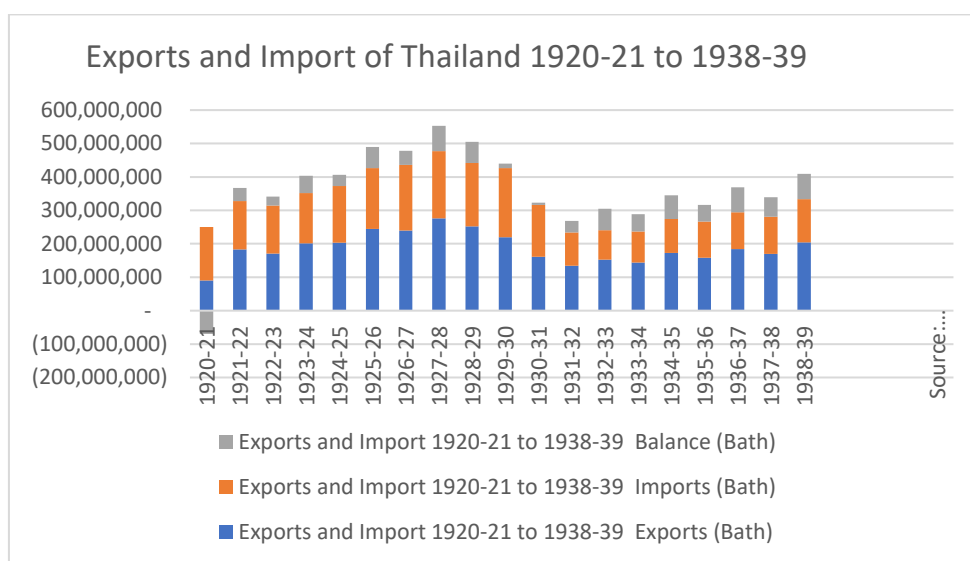
became a supplier of raw materials, a buyer of cheap manufactured goods and a field where foreign, particularly British, capital could develop economic activity (Dixon 1999, 27). Indeed, from the early 1800s Thailand had been brought into close contact with Britain, further solidifying these connections. During the era of rapid colonization, the British spread their influence into the Malay peninsula through Penang in 1786. Singapore was occupied in 1819, Malacca in 1824, and Assam, Arakan and Tenasserim of Burma in 1826. In the 1850s Britain annexed the whole of Lower Burma and in 1885 Upper Burma. Further, during the 1870s the major Malay states were occupied. Meanwhile, the French in the 1860s established control over Cambodia and Cochin China. During the reign of King Mongkut (Rama IV, 1851-1868), the relationship between Thailand and the Western powers was strengthened, mainly owing to Thailand's awareness of the danger posed by imperialism. Moves were made to introduce into Thailand Western ideas, methods and institutions (Dixon and Parnwell 1991, 214).

In the 1920s, the Thai Government significantly increased its involvement in the economy by becoming a principal stakeholder in the Royal Thai Railways, which turned out to be a lucrative venture. Additionally, the government held substantial shares in the waterworks system at Samsem. In 1923, it also initiated the establishment of Thailand's first automated paper manufacturing facility. This factory, which was affiliated with the Royal Thai Survey Department under the Ministry of Defense, was situated in Tambon Samsen and had the capacity to produce one ton of paper per day.

Following 1932, the government embraced a policy of economic nationalism, prioritizing its role as a significant investor in essential manufacturing sectors within a capitalist framework. During this period, there was prevailing belief that the government sector should spearhead industrialization and overall economic development. Consequently, the government engaged in numerous manufacturing industries, including tobacco, paper, textiles, sugar, fuel, and mining, and established the Thai Industrial Promotion Company Limited (*Borisat songserm ustahakhamthai chamkat*) to further these initiatives. Prior to the onset of the Second World War, the manufacturing sector held a marginal position within Thai economy. Between the conclusion of the First World War and the commencement of the Second World War,

there was minimal transformation in the economic framework of Thailand. Although some progress was made during this period, most manufacturing factories faced considerable challenges in achieving profitability (**Table 1**).

Table 1: Exports and Import of Thailand from 1920-21 to 1938-39, data analysis by Zay Myo Lin,



Source: Central Services of Statistics, Statistical Year Book of Thailand 2480-2481 (1938-39), Bangkok, p 74.

The economic challenges and recession experienced during this era significantly fueled the opposition to the absolute monarchy. On June 24, 1932, a coup d'état successfully displaced the monarchy from power. Just two days later, a new constitution was enacted, which curtailed royal authority to its barest minimum while stopping short of completely abolishing the monarchy. The subsequent years from 1932 to 1938 were marked by considerable political instability, characterized by a second coup d'état in 1933, along with elections held in 1933, 1937 and 1938, Field Marshal P. Phibun Songkhram ascended to the position of prime minister.

From 1938 onward, the government intensified its efforts to foster the growth of the industrial sector. Notable developments included the establishment of factories in the Central Region, such as a pulp and paper facility in Kanchanaburi in 1938 and leather manufacturing plants in 1943. The Kanchanaburi factory distinguished itself

as the first pulp paper production site outside of Bangkok and the second in the nation. Following the first paper mill creation of the Royal Thai Survey Department in Samsen, Bangkok, in 1917, the Kanchanaburi paper mill was fully equipped with modern machinery capable of producing high-quality paper from bamboo. The establishment of the pulp paper mill marked a significant transition and, it emerged during a time when national policies were encouraging domestic production and reducing reliance on imports. This paper mill was touted as the first fully integrated facility in Southeast Asia, encompassing all aspects of production from pulp creation to paper manufacturing. The inception of the mill extended beyond mere commercial interests; it represented a manifestation of the Thai government's broader socio-economic objectives. The facility was equipped with amenities that were novel to the local populace, including a tennis court and clubhouse, which illustrated an aspiration for a modern, urban lifestyle that moved beyond traditional norms.

The establishment of a paper mill in Kanchanaburi, which has an invested capital of 12.9 million bath for necessary infrastructure within the complex, presents a significant milestone in the history of Thailand's paper mill industry, serving as a pilot project. This facility is expected to create employment opportunities for 483 workers, thereby contributing to the local economy and the broader industrial landscape of the region (**Table 2**).

Table 2: Central Region Factory Statistic, 1938-61, Source: N.A.M. of Finance 0201.2.1 (1954); N.A.M. of Industry, 0201.1.11/3 (1960)

Central Region Factory Statistic, 1938-61				
Industry	Investment Capital (million bath)	Product	Capacity	Employment Size (no. of workers)
Paper factory, Kanchanaburi (1938)	12.9	Paper	3,000 tons per year	483
Sack-weaving factory, Saraburi (1946)	22	Sack	3,000 sacks per day	415
Thai Sugar factory,	n.a.	White sugar	150 tonnes of	44

Central Region Factory Statistic, 1938-61				
Industry	Investment Capital (million bath)	Product	Capacity	Employment Size (no. of workers)
Saraburi (1951)			sugarcane processed per day	
Chonburi Sugar Industry factory, Chonburi (1956)	126.1	White sugar	8,000 tonnes of sugarcane processed per year	490
Suphan Buri Sugar Industry factory, Suphan Buri (1958)	193.3	White sugar	1,500 tonnes of sugarcane processed per day; 160 tonnes of sugar produced per day	815
Paper factory, Bang Pa In (1961)	380	Paper	40 tons per day; 13,200 tons per year	294

The establishment of paper mill provides significant advantages to the local community, extending beyond the initial construction phase to include a sustained supply of bamboo as its primary raw materials and other essential materials required for daily, monthly and annual operations. This long-term provision of resources fosters economic stability and growth within the community, enhancing both employment opportunities and local business development.

1.2 Kanchanaburi, Royal Family and origin of Siamese Paper Co., Ltd

During the 1920s, the government significantly increased its involvement in the economy, notably through the creation of the Royal Thai Railways, where it held a substantial stake, resulting in considerable profitability. In 1923, the government inaugurated an automated paper manufacturing facility. This plant, which was affiliated with the Royal Thai Survey Department, under the Ministry of Defense, was situated in Tambon Samsen and had the capacity to produce one ton of paper each day. Siamese Paper Co., Ltd. has procured German machinery valued at 1.5 million baths, exceeding the company's capital by a half million bath (Table 3). The

financial institutions associated with the company were unwilling to extend credit beyond the existing account balances, and while the Government declined to provide guarantees for these advances, it expressed readiness to assume control of the company until it reached the production phase. At that point, the company would be reestablished, with Government given priority in the distribution of shares. (Bangkok Time Weekly Mill, 12th October 1934, p. 19)

The government retained a substantial stake in the paper manufacturing sector and subsequently established Siam Paper Company Limited in 1935, with the project situated in Kanchanaburi, marking a crucial turning point in the industrial development of the region. Siam Paper Company Limited was founded with a foundational share capital and diverse group of shareholders. The ownership included significant stakeholders such as the Government, which held 7,382 shares; the King and Queen, who possessed 400 shares; the Privy Purse with 100 shares; H.M. the Queen Aunt with 50 shares; and H.R.H. the Princess of Bejrपुरi, also holding 50 shares. In total, the company has 662 shareholders, of which 401 owned a single share each, while 92 shareholders held two share each. (Bangkok Time Weekly Mill, 12th October 1934, p. 19)

There are other contemporary records indicate that the initiative for the Siam Paper Company was linked to government involvement in industrial ventures, with the state intending to invest 51 percent of the total capital amounting to 1 million baths. A document from the Foreign Office reveals that Phraya Phahon, Phra Sarasas, and other government officials endorsed the company's prospectus, despite the absence of a budgetary allocation or prior discussion within the cabinet. Additionally, European companies based in Bangkok were invited to participate in this project. (details in Coultas to FO No108, 10 May 1934 F3068/21/40 F0371/18207, PRO.)

Table 3: State Enterprise and State-sponsored Companies in Thailand 1935-1940

Year	Company name	Industry	Share Qty & Value per share	Reg. Capital	Ownership Occupancy (%)	Major shareholders or Supervision
1935	Siam Paper Co., Ltd	Manufacturing	1,000	1,000,000	100 %	Ministry of Defense
1935	Siam Cotton Mill	Manufacturing		State Enterprise		Ministry of Defence
1935	Thai Lampang Sugar Mill	Manufacturing		State Enterprise		Ministry of Economic Affairs
1938	Thai Rise Co., Ltd	Rice	500	500,000	75 %	Ministry of Finance and Ministry of Economic Affair
1939	The Thai Niyom Panich Co., Ltd	Trading & Agriculture		State Enterprise	71%	Government
1939	Phisanulok Textile Factory	Manufacturing		State Enterprise		Ministry of Defence
1939	Mines Organization	Mining		State Enterprise		Ministry of Defence. Ministry of Industry (1943-)
1939	Playing Cards Factory	Manufacturing		State Enterprise		Ministry of Finance
1940	The Thai Navigation Co., Ltd	Rice	3,000	3,000,000	70%	Ministry of Economic Affair
1940	The Thai Maritime Navigation Co., Ltd	Rice	10,000	10,000,000	100 %	Government

Year	Company name	Industry	Share Qty & Value per share	Reg. Capital	Ownership Occupancy (%)	Major shareholders or Supervision
1940	The Changwat Panich	Trading & Agriculture	1,000	1,000,000	51%	Government
1940	The Thai Fisheries Company	Trading & Agriculture	1,000	1,000,000	99.3 %	Ministry of Agriculture
1940	The Thai Salt Co., Ltd	Trading & Agriculture	1,000	1,000,000	60%	Ministry of Finance

Source: Akira Suehiro, *Capital Accumulation in Thailand 1855-1895*, Tokyo: Center for East Asian Cultural Studies, 1989, p.124

Production was expected to begin in 1937, although the facility remains under construction, as evidenced by a photograph captured by Robert Larimore Pendleton. Pendleton, who served as a soil technologist and agriculturist at the Royal Department of Agriculture and Fisheries, as a sister department of Royal Thai Survey Department in the Ministry of Defense, may have been designated as the soil specialist for this paper mill construction initiative. The overall investment in the paper mill amounted to 12.9 million baths resulting in an increased production capacity of 3,000 tons per years. During its operation phase, the factory created job opportunities for 483 workers (**Table 4**). 1937, Chulalongkorn and Thammasat University produced 5,056 graduates, which are Professional included physicians, dentists, nurses, lawyers, engineers, electricians, technicians, architects, artist and other artisans, but 4,000 of whom resided in Bangkok. There were 145,000 people engaged in the manufacturing sector, representing only 2.13 per cent of the total labor force as nationwide. The employment in Kanchanaburi in 1937 was 51,123 in total. The involvement of local professionals, skilled person and workforce by local community played a major role in their time, not only construction stage but also daily operation of the mill. (Porphant Ouyyanont, 2017)

Table 4: Central region factory statistic, 1938-1961

Central Region Factory Statistic, 1938-61				
Industry	Investment Capital (million bath)	Product	Capacity	Employment Size (no. of workers)
Paper factory, Kanchanaburi (1938)	12.9	Paper	3,000 tons per year	483
Sack-weaving factory, Saraburi (1946)	22	Sack	3,000 sacks per day	415
Thai Sugar factory, Saraburi (1951)	n.a.	White sugar	150 tons of sugarcane processed per day	44
Chonburi Sugar Industry factory, Chonburi (1956)	126.1	White sugar	8,000 tons of sugarcane processed per year	490
Suphan Buri Sugar Industry factory, Suphan Buri (1958)	193.3	White sugar	1,500 tonnes of sugarcane processed per day; 160 tonnes of sugar produced per day	815
Paper factory, Bang Pa In (1961)	380	Paper	40 tonnes per day; 13,200 tonnes per year	294

Source: N.A.M. of Finance 0201.2.1 (1954); N.A.M. of Industry, 0201.1.11/3 (1960)

1.3 Why Pulp Paper Mill?

The economic nationalism that emerged in Thailand during the 1930s was characterized by a strong emphasis on self-sufficiency and the promotion of domestic industries. This period saw the government implementing policies aimed at reducing foreign influence and fostering national economic growth. The Thai leadership sought to cultivate a sense of national identity through economic independence, encouraging local production and consumption. This movement was a response to the global economic challenges of the time, as well as a desire to assert Thailand's sovereignty in the face of external pressure.

In the mid-1930s, various initiatives were launched, including the establishment of a cotton mill, a paper mill, and a sugar mill, all of which were

developed as stated-owned enterprises. The significance of pulp paper in the historical development of journalism in Thailand cannot be overstated. Pulp paper served as a crucial medium for disseminating information, enabling the spread of news and ideas throughout the country. Its introduction marked a transformative period in Thai journalism, facilitating the establishment of newspapers and periodicals that played a vital role in shaping public discourse and fostering an informed citizenry. The accessibility and affordability of pulp paper allowed for a broader reach, contributing to the democratization of information and the promotion of literacy among the population. As a result, pulp paper not only influenced the evolution of journalism in Thailand but also had a lasting impact on the nation's cultural and political landscape. Between 1930 and 1937, there were 18 newspaper publishers in Bangkok whose estimated circulation exceeded 66,500 issues, indicating a significant demand for pulp paper within the journalism sector, as illustrated in **Table 5**.

Table 5: Newspaper and estimated circulation during 1930-1937, Bangkok, Thailand

Newspaper in Thailand 1930-1937					
SN	Newspaper Name	Founded Date	Founder/Owner	Circulation (estimated)	Nature / Category
1	Thai Mai (New Siam)	2473 BE (1930)	Banchong, Srisuchat	8000	Commercial.
2	Issara (Independent)	2473 BE (1930)	T Buntiyam	3000	Liberal.
3	Krungthet Warasap (Bangkok Opinion)	2475 BE (1932)	Phaiphee Wityakan Co.	5800	Critical of present regime, neutral towards foreigner.
4	Pracha Chat (The Nation)	2475 BE (1932)	Pracha Chat Co.	6000	Favours present regime, natural towards foreign countries; conservative.
5	Sao Sayam (Miss Siam)	2476 BE (1933)	Banlun Piyaamphongsan	-	Conservative.
6	Dao Nakhon (City Star)	2476 BE (1933)	-	3000	Organ of the military faction, inclined to be sensational, little political, commercial or police

Newspaper in Thailand 1930-1937					
SN	Newspaper Name	Founded Date	Founder/Owner	Circulation (estimated)	Nature / Category
					news.
7	Doed Rathadharmanum (The Constitutional) (The Constitutionalist)	2477 BE (1934)	-	5000	Favors present regime, nationalistic.
8	Khao Sayam (Siam News)	2477 BE (1934)	-	4500	Nationalistic.
9	Phadung Chat (The Nation's Preserver)	2479 BE (1936)	-	2000	Liberal.
10	Pramuan Wan (The days News)	2479 BE (1936)	-	6700	Liberal, progressive
11	Rasadorn (The People)	2479 BE (1936)	-	-	Liberal, progressive
12	Siam Nakorn (Siam City)	2479 BE (1936)	-	2000	Sister paper to the Chronicle; liberal, progressive.
13	Sri Wan (Good News)	2479 BE (1936)	-	2500	Moderate.
14	Naew Thai (Outlook of the Thai People)	2479 BE (1936)	-	-	Unknown
15	Wab Sen Yit Pao (Chinese)	2477 BE (1934)	-	7000	General
16	Bangkok Morning News (Chinese)	2477 BE (1934)	-	5000	General
17	Hwa Siew Yer Pao (Chinese)	2478 BE (1935)	-	1000	General
18	Min Kok Yit Pao (Chinese)	2478 BE (1935)	-	5000	General

Source: Makoto Nambara, Economic Plans and the Evolution of Economic Nationalism in Siam in the 1930s (Feb 1998, Page 239-240)

The 1930-1940 witnessed a significant demand for pulp paper among various sectors, including communities, business, and industries, within the Thai economy. The pulp paper mill situated in Kanchanaburi not only meets the paper requirements of the Ministry of Defense but also has the potential to expand its sales to other business and industries.

In 1935, the new government of Thailand opted to procure machinery and equipment for paper mills from Germany, with an investment totaling 12.9 million bath. This strategic move was likely motivated by the nation's ambition to improve its industrial capacity and modernize its paper manufacturing techniques, ultimately aiming to stimulate economic development and achieve self-reliance within the paper sector. The selection of Germany as the supplier may have been driven not only by the sophisticated technology and expertise present in the German manufacturing industry but also by the longstanding Friendship, Trade, and Navigation agreement established in 1858. It was natural to have offices in these countries because they had been the main Siamese trade ports for a long time. Additionally, a commercial attached for Europe, in Germany at Hamburg or Bremen, would be considered better strategy. Germany was chosen because it had no colonies, and would be less discriminatory regarding tariffs.

1.4 Relationship with Germany

In 1858, the Kingdom of Siam entered into its inaugural agreement with Germany, formalizing a contract of "Friendship, Trade and Navigation" with the Hanseatic cities of Bremen, Hamburg, and Lubeck. These three city-states subsequently become essential components of a unified German nation in 1871. (Warning, Christina, Thailand's Trade Relations with the German Democratic Republic: The Example of Carl Zeiss Jena, May 72021)

In 1860, Prussia dispatched its steam corvette "Arcona" along with three additional vessels from the Baltic Sea to the China Seas to initiate diplomatic relations with regional powers. A significant outcome of this mission was the signing of the "Treaty of Amity, Commerce and Navigation between the States of the German Customs and Commercial Union, and the Grand duchies of the Mecklenburg-Schwerin and Mecklenburg-Strelitz, on the part and the Kingdom of Siam, on the

other part” on 7 February 1862. This treaty serves as the foundational document for the establishment of diplomatic ties between Germany and contemporary Thailand (Figure 2).



Figure 2: Signing of the “Treaty of Amity, Commerce and Navigation between the States of the German Customs and Commercial Union, and the Grand duchies of the Mecklenburg-Schwerin and Mecklenburg-Strelitz, on the part and the Kingdom of Siam, on the other part” on 7 February 1862.

Source: Federal Foreign Office, Germany

1.5 Rice Manufacturing Industry and Germany

The evolution of the rice mill industry in Thailand is a significant aspect of the country’s agricultural and economic development. Historically, rice has been a staple food and a vital crop for the Thai population, leading to the establishment of milling practices that date back centuries. The industry has undergone substantial transformation, particularly during the 20th century, when modernization and technological advancements began to reshape traditional milling methods. The introduction of mechanized processes not only increased efficiency but also enhanced the quality of rice production, allowing Thailand to emerge as one of the world’s leading rice exporters. The interplay between government policies, market demands, and global trade dynamics has further influenced the growth and sustainability of rice mill sector, making it a crucial component of Thailand’s agricultural landscape.

The engagement of Germany in Thailand's rice industrial landscape dates back to the founding of the nation's third rice mill, referred to as "A Markwald's Mill, "which began its operations in 1864. Additionally, Economic Mangkorn Samsen, who was the eldest son of Keengsan Samsen and Poo Samsen, and he was born on 3 July 1888. His business in Bangkok included a coconut plant and a small rice mill at Samsen. It is interesting to note that he was keen on the latest machinery and technology. In fact, he imported a compressor from Germany in 1926, and established the largest coconut oil plant in Siam at Samsen at that time.

1.6 Railway Construction and Germany

In November 1895, King Chulalongkorn, deeply influenced by his previous encounters, traveled along different sections of the railway line that was under construction. This initiative was carried out with the support of German technical specialists and a substantial labor force made up of Chinese workers.

In 1908, a total of 110 English nationals were employed by the Siamese government, exerting significant influence over various departments, including survey, mining, police, education, justice, and customs. That same year, the workforce included forty-five Germans, primarily railway engineer; forty-two Danes, who were predominant in the naval sector; thirteen Italians, mainly engaged in public works; eight Dutchmen, focused on irrigation projects; seven Frenchmen, serving as judges and civil engineers; and three Americans, one of whom held the position of the nation's General Adviser (**Table 6**). The ratification of the Siamese-British treaty in 1909 resulted in the division of the remained under German oversight, and a southern section that came under British supervision. (Terwiel, Barned Jan, 1983)

Table 6: Foreign nationality working in Thailand during 1908s

Nationality	Industry Sector	Qty
English	Survey, Mining, Police, Education, Justice, Custom	110
Germans	Railway	45
Danes	Naval	42
Italians	Public works	13
Dutch	Irrigation	8
French	Judges, Civil Engineering	7
American	Government services	3

Source: Terwiel, Banned Jan, A history of modern Thailand, 1767-1942, published in 1983

1.7 Shipping Industry and Germany

The historical development of the German shipping industry in Thailand reflects a complex interplay of trade, cultural exchange, and economic growth. Beginning in the late 19th century, German merchants and shipping companies established a presence in Thailand, capitalizing on the country's strategic location as a hub for maritime trade in Southeast Asia. Over the decades, these enterprises contributed significantly to the expansion of Thailand's shipping infrastructure, fostering bilateral trade relations and facilitating the movement of goods between Europe and Asia. The evolution of this sector has been marked by various challenges, including geopolitical shifts and changes in global trade patterns, yet the resilience and adaptability of German shipping firms have allowed them to maintain a prominent role in Thailand's maritime economy.

The North German enterprise Lloyd established shipping routes connecting Bangkok with various nations, which diminished the competitiveness of British vessels. By 1914, German ships represented over fifty percent of the total fleet docked at Bangkok Port. However, following the conclusion of the First World War, Germany's preeminence in maritime trade waned, allowing British shipping companies to regain their leading position. Notably, British firms such as Straits Steamship (Singapore) and China Navigation not only assumed control of the shipping routes that were once operated by Lloyd but also acquired the private dock in Bangkok that belonged to the German company. (Porphant Ouyyanont, 2017)

1.8 Pharmaceutical Industry and Germany

The evolution of the pharmacy industry in Thailand is marked by significant developments that reflect both traditional practices and modern advancements. Initially rooted in herbal medicine and local remedies, the industry has gradually transitioned towards a more structured and regulated frameworks, influenced by global pharmaceutical trends and innovations. The establishment of formal educational institutions and regulatory bodies has played a crucial role in shaping the professional landscape, ensuring that pharmacists are equipped with the necessary knowledge and skills to meet contemporary healthcare demands. Furthermore, the integration of technology and the rise of pharmaceutical manufacturing have contributed to the industry's growth, positioning Thailand as a key player in the Southeast Asian market. This historical trajectory underscores the dynamic interplay between cultural heritage and modernity within the Thai pharmacy sector.

By 1878, in Bangkok, where German pharmacist Bernhard Grimm, alongside his Austrian associate Erwin Mueller, established a chemist's shop known as the Siam Dispensary. Located on Oriental Hotel Avenue, adjacent to Bangkok's New Road, this establishment emerged as one of the first modern European pharmacies in Thailand and quickly gained prominence, earning the designation of official "Court Pharmacy" for the Thai royal family. During this period, the company collaborated with the Snidvongse family to undertake the construction of the Rangsit irrigation canals, which at 1,500 kilometers, become the largest infrastructure project in Southeast Asia.

In 1903, following King Chulalongkorn's extensive tour of Europe, he initiated a series of reforms aimed at modernizing Thailand to align it more closely with European standards. To facilitate the expansion of the burgeoning enterprise, Adolf Link was appointed as manager. A young and ambitious pharmacist hailing from Luebeck, Link possessed a visionary outlook that positioned him advantageously to steer the company towards a promising future. In 1914, Link acquired the interests of the original founders of Siam Dispensary, a pharmacy that had been established in 1878 by Bernhard Grimm and Erwin Mueller. (<https://bgrimmgroup.com/history/>)

1.9 Siam Commercial Bank, Cooperative Type, and Germany

The Siam Commercial Bank has a rich historical background in Thailand, tracing its origins back to the late 19th century. Established in 1906, it was the first bank in the country to be founded under the royal decree, marking a significant milestone in the development of the Thai banking sector. Over the years, the bank has played a pivotal role in the economic growth of Thailand, adapting to various financial challenges and evolving alongside the nation's changing landscape. Its commitment to innovation and customer services has solidified its position as one of the leading financial institutions in the country, contributing to both local and regional economic stability.

The administration of Siam Commercial Bank involved both foreign and Thai individuals. Among the seven directors, there were foreigners, with F. Killian from the Deutsch-Asiatic Bank significantly influencing the operations of the foreign department. Despite the fact that the combined share capital of the foreign banks, namely the Deutsch-Asiatic Bank from Germany and the Danske Landmanns Bank from Denmark, constituted less than 20% of the overall capital, the management of the foreign department was predominantly led by European directors, particularly those from Germany and Denmark, who possessed considerable expertise in foreign exchange business.

The inaugural form of co-operative society established in Siam was the Raiffeisen model, which has its roots in Germany. This particular model was chosen due to the government's recognition of the necessity to furnish farmers with essential capital. The foundational principles of the Raiffeisen co-operative included unlimited liability, a restricted geographical scope, non-profit distribution, and the provision of free services. The initial implementation of this framework was managed by the Co-operative Division within the Ministry of Finance, which began its operations in 1915. Following this, the creation of a credit institution was contemplated, especially since Siam had already introduced co-operative credit societies in 1917. Consequently, the government explored additional forms of credit institutions, including the *Landschaften*, or Cooperative Land Mortgage Bank, from Germany.

1.10 Brewing Industry and Germany

The brewery industry in Thailand has a rich and complex history that reflects the country's cultural and economic evolution. Initially influenced by Western brewing techniques introduced during the colonial period, the industry took shape in the late 19th century. The establishment of the first commercial breweries marked a significant turning point, as local production began to cater to the growing demand for beer among both Thai citizens and expatriates. Over the decades, the industry has undergone substantial transformations, including modernization and consolidation, leading to the emergence of major players that dominate the market today. The interplay of traditional brewing practices with contemporary innovations has not only shaped the flavor profile of Thai beers but has also contributed to the country's burgeoning craft beer movement, which seeks to celebrate local ingredients and brewing heritage. As Thailand continues to navigate globalization and changing consumer preferences, the brewery industry remains a vital component of its economic landscape and cultural identity.

In 1931, Phya Bhirombakdi sought authorization from the Ministry of Finance to set up a brewing facility with a registered capital of 500,000 bath. The share distribution was structured such that 75 percent was designated for Siamese investors, while the remaining shares were allocated to German stakeholders. By the following year, 1932, Phya had acquired brewing plants valued at 400,000 baths.

1.11 Foreign Official in Thai Government and Germany

The participation of foreign consultants in the ministries of Siam between 1920 to 1940 played a significant role in shaping the administrative landscape of the country. During this period, Siam, which later became known as Thailand, sought to modernize its governance and infrastructure in response to both internal challenges and external pressures. The expertise brought by foreign advisors was instrumental in implementing reforms that aimed to enhance efficiency and effectiveness within various governmental departments. Their contributions were particularly notable in areas such as finance, education, and public works, where they introduced new methodologies and practices that aligned with contemporary global standards.

Furthermore, the engagement of these foreign consultants reflected a broader trend of international collaboration and knowledge exchange during the early 20th century. As Siam navigated its path towards modernization, the insights and experiences of foreign experts facilitated a deeper understanding of administrative practices that could be adapted to local contexts. This period marked a critical juncture in Siam's development, as the integration of foreign expertise not only influenced policy-making but also contributed to the gradual transformation of the nation's identity in the face of globalization. During the period from 1927 to 1939, the Thai government employed five foreign officials from Germany in its services (**Table 7**).

Table 7: Foreign Official in Thai Government Services 1920, 1927 and 1939

Foreign Officials in Thai Government Services 1920, 1927 and 1939				
SN	Nationality	Year 1920	Year 1927	Year 1939
1	American	7	12	5
2	Belgian	0	1	0
3	British	107	64	22
4	Danish	21	8	3
5	Dutch	1	1	1
6	French	24	21	14
7	German	0	1	4
8	Italian	25	14	3
9	Japanese	0	0	0
10	Norwegians	1	1	1
11	Filipino	0	0	2
12	Portuguese	1	0	1
13	Swiss	0	1	1
14	Swedish	0	0	1
	TOTAL			58

Source: Richard J. Aldrich, *The Key to the during the Approach of the Pacific War, 1929-1942*, Kuala Lumpur: Oxford University Press, 1993, p. 379 and Waterloo to FO, No.17, 21 January 1927, F1889/1889/40, FO371/12535

1.12 Thai Royal Families relationship with Germany

In 1886, King Chulalongkorn established a Siamese embassy in Berlin. Soon more than 30 German advisers were working with the Siamese government in banking, finance, and other fields. German capital and advisers were engaged to build the telegraphs and postal system and much of the new railway system. Some of King Chulalongkorn's many sons became the first foreigners ever to be accepted into the German Imperial Military Academy. German advisers joined the Siamese military and soon Germany, not Britain, was supplying the Siamese army most of its weapons. The efficient Germans also took over much of Siam's trade from Britain and by 1901, of 576 ships that came to Siam that year, 272 or 53 percent were German, while only 24 percent were British.

By 1900, it was reported by the Singapore press that the Germans had struck a deal with the sultan of Deddah to lease Langkawi Island as a coaling station and port. The sultan, when questioned by British journalist, did admit to dealing with the German company Bahn Mayer and Ce. Another large German company, Deutsche Uversec Gesellschaft, also applied for a mining concession on Langkawi and was also turned down, again due to British pressure. Prince Damrong, the king's half-brother, was forced to write to the Germans that "it is unnecessary to say what danger it will be to grant such concession especially to a German company, which may have political power at its back. (Mackay, Colin Robert, 2013, A history of Phuket and the surrounding region.)

In 1917, when the USA entered the war against the central powers, President Woodrow Wilson called on all neutral countries to do the same. Now that it seemed the Allies would win, Siam joined the USA in declaring war on Germany and the Austro-Hungarian and Ottoman empires, mainly to gain favorable treatment in postwar dealing with the Allies. Forty German ships in the East had taken shelter in the neutral ports of Siam, three of them in Phuket. These were immediately seized by the Siamese military before their crews could scuttle them. These ships were then divided among Britain, France and Japan as supply ships and Siam, which had actually captured them, was given 250 German, Austrian and a few Turkish civilian livings in Siam at the time were arrested and confined to the German Club in Bangkok. Just when they were resigned to having to play billiards and drink gin and

tonics schnapps for the rest of the war, the British complained that the Siamese were being far too nice to them, and the prisoners were all later interned in civilian POW camp in India. The British were of course most enthusiastic to take this opportunity to remove their successful German commercial rivals from Siam completely. (Mackay, Colin Robert, 2013, A history of Phuket and the surrounding region.)

Prince Mahidol, who had previously attended Harrow and the German Naval College, was the second son of a younger sister of the renowned Queen Sunandha, who drowned in the Chao Phraya River because no one dared to extract her. His wife, whom he met at Cambridge when she was studying nursing there, was the pretty maid of honor to another queenly sister, a somewhat hypochondriacal dowager who often send her court ladies overseas to before that throne passed to his offspring. Young Bhumibol, like his older brother, was educated in Switzerland, where he acquired his enthusiasm for what in Europe was then beginning to be ultra-fashionable as “le jazz hot”. It was during this European sojourn also that he made the acquaintance of the glamorous Sirikit, daughter of the Thai Ambassador to France, who understandably attracted his attention when he saw her for the first time at a Paris reception in 1945.

Prince Paripatra son of King Chulalongkorn was educated in Germany the guiding eye of the Emperor, William II, and he distinguished himself in the German Army. He had been commissioned in the German Army after passing out of the Military Academy, remained in Germany at Naval Colleague.

Prince Mahidol born in 1892, the only surviving son of Queen Sawang, returned shortly after him. Although he was a half-brother of Chakrabongse, their relationship was close because they were also cousins, their mothers being sisters. He had first been to Harrow School in English before he was transferred to the German Navy.

Prince Rangsit, son of King Chulalongkorn had married a German lady, Elisabeth when he was a student at Heidelberg, and they had two sons and a daughter.

1.13 Siam Society and German

A club of gentlemen-scholars, the Siam Society, was modelled on eighteenth-century learned societies, such as the Asiatic Society of Bengal, rather than modern colonial archaeological services. Among its founding members, an especially important role was played by its second president, Dr Oscar Franfurter, the German secretary of the Royal Library; and Colonel G.E. Gerini, an Italian instructor at the Cadet Academy, who wrote essays on archeology, historical geography, rituals and ancient laws. The Siam Society's initiatives, most notably the publication of scholarly journal which started in 1904 and till continues, were entirely financed through membership subscriptions. (Peleggi, Maurizio, 2007, Thailand: the worldly kingdom)

1.14 Noble families and Education sector with Germany

King Chulalongkorn's stay in the country residences of the European royalty in 1897 is often regarded as the inspiration behind the construction of Dusit Park, which was designed by Italian and German architects employed by the Public Work Department. If the architecture of the Grand Palace and layout of Rattanakosin Island had restated the Thai royalty's palace in the Indie ecumene at the moment of foundation of the Bangkok kingdom, Dusit Park and the other princely places. (Peleggi, Maurizio, 2007, Thailand: the worldly kingdom)

Phahon Phonphayuhasena, Pharaya (1887-1947). Born Phot Phahonyothin, son of army general from aristocratic family. Studied at military college in Germany and attached to German army. Leader of senior military officers who supported 1932 revolution. (Baker, Chris, History of Thailand, Page 305) Although western firms dominated the first phase of the rice trade, this domination did not last. Former junk traders and tax-farmers discovered it was not difficult to buy the machinery and hire a Scottish or German engineer to run it. (Page 92)

The period between 1920 and 1940 saw a significant number of Thai government officials and nationals pursuing their studies in Germany. This era marked a crucial phase in the development of Thailand's educational and administrative frameworks, as these individuals sought to acquire knowledge and skills that could be applied to the modernization of their home country. The

experiences gained during their time in Germany not only influenced their personal and professional trajectories but also contributed to the broader socio-political landscape of Thailand in the subsequent decades. Their experiences in Germany not only enriched their knowledge but also facilitated the exchange of cultural and political concepts, which played a vital role in shaping modern Thai statecraft.

Chote Khumphan served as the Director-General of the Department of Commerce within the Ministry of Economic Affairs during the tenure of Phra Sarasas. While much of the scholarly focus on Chote has centered around his political ideologies and extreme nationalism, it is essential to also consider his economic perspectives and his academic pursuits in Germany. Upon his return to Siam in 1933, he brought with him a doctorate in Politics and Economics, which he obtained from a German institution.

Boriphanyutthakit, Minister of Economic Affairs, submitted his economic plan to the Secretary-General of the Cabinet on 15 January 1938. studies in Germany, Switzerland and France from 1909 to 1919 did not involve economics.⁶⁸ However, his positions as Minister of Economic Affairs, Minister of Finance, and Minister of Commerce under the Phibun Government suggest that he had economic training.



CHAPTER 2

ARCHITECTURAL AND ENGINEERING SECTOR IN THAILAND BEFORE 1937

Karl Siegfried Döhring (1879-1941) was a German architect who significantly contributed to the evolution of modern architecture in Thailand. His innovative designs and unique approach reflect a blend of traditional Thai elements with modern architectural practices, showcasing a deep appreciation for the local culture and environment. Through his work, Döhring has not only enhanced the aesthetic appeal of various structures but has also fostered a greater understanding of sustainable architecture in Thailand.

Döhring pursued his architectural education in Berlin, where he developed a keen interest in the intricate art and architecture of Burma. Upon completing his studies in 1905, he sought employment with the Royal Siamese government in Bangkok. In July 1906, he commenced his role as an engineer with the Royal State Railways of Siam, where he was instrumental in planning and overseeing the construction of various railway facilities from 1906 to 1912. His projects included headquarters, crew accommodations, warehouses, a printing facility, and multiple train stations located in Bangkok Noi (Thonburi), Phitsanulok, Phichit, Phichai (Tambon), Uttaradit, and Sawankhalok. In addition to his railway work, he also designed several residential and commercial structures, some of which remain unidentified.

In 1909, Döhring transitioned to a position as an architect and engineer within the Siamese Ministry of Interior, where he forged connections with numerous high-ranking officials and garnered the interest of royal family members involved in the ministry, including Prince Damrong Rajanubhab, the half-brother of King Chulalongkorn and the first interior minister of Thailand, as well as Prince Dilok Nopparat. During his initial two years at the Ministry, he was tasked with designing and supervising the construction of four significant private residences for royal family members. His notable projects included a residence for King Chulalongkorn in Phetchaburi, palaces for Prince Damrong and Prince Dilok, and a residential building

for Queen Sukhumala Marasri, the sixth wife of Chulalongkorn, located within the palace of her son, Prince Paribatra Sukhumbandhu. Additionally, he was responsible for creating detailed maps of Nakhon Pathom and Phetchaburi.

In contrast to the contemporary Western architects active in Siam during that period, Döhring's architectural creations transcended mere imitation of European styles. He sought to merge Western and Thai architectural elements, skillfully adapting traditional forms to meet modern requirements in a distinctly personal manner. His structures are unique, as they were meticulously crafted to align with the specific needs and aspirations of his clients. For instance, the villa he designed for King Chulalongkorn in Phetchaburi stands as a magnificent and striking edifice, reminiscent from afar of the theaters designed by Oskar Kaufmann, who enjoyed considerable acclaim in Germany at the time. In contrast, the palace of Prince Damrong exemplifies a refined simplicity, while for Prince Dilok, Döhring employed bold, masculine lines. The residence of Queen Sukhumala Marasri, on the other hand, reflects the essence of its female inhabitant, embodying grace and femininity.

In 1913, he found that his responsibilities within the Interior Ministry had significantly broadened. Beyond his roles as an architect and engineer, he was also assigned to conduct archaeological excavations and evaluations in several northern provinces of Siam. In the aftermath of the World War I (1914-1918), he transitioned from his architectural career to pursue roles as an art historian and archaeologist. Additionally, he engaged in product design and served as a translator for English and American literary works. His extensive expertise and fervent enthusiasm for Siamese art, architecture, and culture contributed to the positive reception of his writings on Siam in Western circles.

There is a lack of definitive documentation to confirm that the Kanchanaburi Paper Mill was designed and constructed by a German architect and engineer. However, the political, economic, and industrial ties between Thailand and Germany lend credence to the theory that the mill was indeed built by German professionals. Furthermore, the logos and brands of the founding companies strongly indicate that the machinery and equipment were sourced from German suppliers. These suppliers are tasked with ensuring that their equipment is compatible with the required

infrastructure, which suggests that the architectural design and structural engineering plans were likely developed by German architects and engineers.

Despite a long tradition of Thai architecture, there was no architecture or crafts education in a formal school in Siam prior to 1910. Traditionally, the construction of large houses and more sophisticated structures, such as temples and palaces, was executed or supervised by a Chang (ช่าง, craftsman, carpenter, builder), who was trained through an apprenticeship involving the oral knowledge transfer from their master(s). Moreover, there were no Thai words for ‘architecture’ and ‘architect’, as it is known today, because the terms were only translated to Sathapattayakam (สถาปัตยกรรม) and Sathapanik (สถาปนิก) in 1920. In Thai society, the house, Buddhist temple, palace, and other traditional building types had their own secular and sacred meanings (Aasen, 1998), which were not necessarily the same as today’s understanding by Thai society. In sum, both the formal training of crafts and architecture in a school and the concept of Sathapattayakam and Sathapanik were modern in the 1920s. (Chomchon Fusinpaiboon, Thomas Coomans, Pirasri Povatong, 2021)

From the mid-nineteenth century up to the 1920s, European-style buildings became much needed by the royal government, the royal family, noblemen, and international businessmen and merchants in Siam, due to both their functional practicality and symbolic affiliation of power and wealth after the opening of Siam to global trade and politics. Originally, only a few princes and Siamese Chang were engaged in the transfer of modern knowledge and practice in construction from European architects who were employed by the royal government (Povatong, 2011)

Sarot Sukkhayang (สารวัตร สุขยางค์, 1895-1950), a scholarship student of the Ministry of Public Instruction, today Ministry of Education, studied architecture at the University of Liverpool from 1915 to 1920 in order to become a teacher in architecture (Carter, 1915). Nat Phothiprasat (นารถ โพธิประสาท, 1901-1954), another scholarship student under the same ministry, studied at the same university from 1924 to 1929 (Carter & Stevenson, 1930).

It happened that Sarot Sukkhayang mostly designed a great number of the Ministry of Education’s modern buildings for education and health care, including the

new masterplan of Siriraj Hospital in Bangkok and its sixteen buildings, funded by the Rockefeller Foundation and erected between 1923 and 1935 (Phra Sarot Rattanimman, 1976). He became the Director of the Department of Architecture, Ministry of Education, in 1925. He only started to teach architectural drawing (Wicha Paenbaeb Sathapat วชิาแผนแบบสถาปัตยกรรม) and building construction (Wicha Kosang Akhan วชิาก่อสร้างอาคาร) in 1931 to the fourth-year class of the Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University (Ladawan, 1961, p. 138).

The early career of Nat Phothiprasat was more directly engaged in architectural education than that of Sarot Sukkhayang. He returned to Siam in 1930 and immediately became Head of the newly established Department of Architecture at Poh Chang School (โรงเรียนเพาะช่าง), where students were trained in both Siamese and Western crafts and carpentry since 1910. The school was expected to train students in Thai and other crafts that were correlated to the market's demand. These Thai craftsmen would gradually take over the jobs from the foreigners, especially the Chinese migrants (Seidenfaden, 1927).

Chulalongkorn University, completed 1939, was the best contemporary example of "sticking with ancient principles and improving them". Sarot Sukkhayang, a Liverpool University graduate, accommodated plans and reinforced concrete structure within an unmistakably Thai form designed by the master builder Ou Laphanon (Phra Phromphichit) (อ. ลากานนท์ [พระพรหม พดฺร], 1890-1965) (Fusinpaiboon, 2016b).

Nat Phothiprasat (นารถ โพรประสาท, 1901-1954), The early career of was more directly engaged in architectural education than that of Sarot Sukkhayang. He returned to Siam in 1930 and immediately became Head of the newly established Department of Architecture at Poh Chang School (โรงเรียนเพาะช่าง), where students were trained in both Siamese and Western crafts and carpentry since 1910. The school was expected to train students in Thai and other crafts that were correlated to the market's demand. These Thai craftsmen would gradually take over the jobs from the foreigners, especially the Chinese migrants (Seidenfaden, 1927).

The Department of Architecture at Poh Chang School was developed out of the Department of Construction Design, which had taught sketching, Thai ornaments,

Western ornaments, drawing, brush painting, architectural drawing, and geometry since 1912 (Rong Rian Poh Chang, n.d.). Considering that these aforementioned courses focused mainly on draughtsman ship, Nat Phothiprasat's main task in 1930 was to upgrade the curriculum in terms of both the theoretical and technical aspects. (Chomchon Fusinpaiboon, Thomas Coomans, Pirasri Povatong, 2021)

Nat Phothiprasat's first two years at Poh Chang School coincided with three major events in the modernization of Siam's education, construction, and politics. First, a proposal to expand the curriculums of Chulalongkorn University to Agriculture, Veterinary Medicine, Forestry, Mining, Law, Archaeology, Fine Arts, and Music was discussed in 1928 and 1931. This first higher educational institution in Siam had been founded in 1917 by **King Vajiravudh** (พระบาทสมเด็จพระมงกุฎเกล้า เจ้าอยู่หัว, reigned 1910-1925) by upgrading the Civil Service College, founded in 1899 by his father **King Chulalongkorn** (พระบาทสมเด็จพระจุลจอมเกล้าเจ้าอยู่หัว, reigned 1868-1910). The university had four founding faculties: Science and Arts, Engineering, Medicine, and Public Administration. Second, the Ministry of Education seriously initiated a plan in early 1932 to promote construction education at all levels in order to stimulate the Siamese to completely take over the low and middle level jobs from the Chinese, as well as the high-level governmental positions related to construction industry that were mostly held by Europeans (Khana kammakan borihan chulalongkorn mahawitthayalai pho so 2475, 1932).

The Department of Architecture was finally established in the Faculty of Engineering, Chulalongkorn University, in 1933. It received 11 students from Poh Chang School's Department of Architecture to continue their studies as second year students, and accepted 11 new students (of the 25 originally expected) (Khana kammakan borihan borihan chulalongkorn mahawitthayalai pho so 2475, 1932). Its curriculum was a three-year diploma. Nat Phothiprasat was transferred from Poh Chang to be the head of the department with the assistance of Siwawong Kunchon Na Ayutthaya (ศิววงศ์ กัญชร ณ ออยุธยา) as lecturer and studio tutor, and Bunchuai Utcharat (บุญชูชาติ อจรรตน) as a secretary and drawing tutor (Khana sathapattayakammasat, Ch 10, Box 1, Folder 4, n.d.).

In 1935, **Nat Phothiprasat** was appointed as the Director of the Architecture Division within the Department of Municipal Works at the Ministry of the Interior, where he worked alongside the German architect and engineer **Karl Siegfried Döhring**. Following his transition to this demanding role at the Department of Municipal Works, Phothiprasat took on the position of part-time studio tutor at the Department of Architecture at Chulalongkorn University.

Despite the removal of Nat Phothiprasat from his position at the Department of Architecture, Chulalongkorn University, the curriculum remained what he had laid down. The three-year course was oriented towards the artistic side rather than the engineering side of architecture, with a special emphasis on Western classical architecture. Most of the subjects followed the curriculum of Liverpool University's School of Architecture and used English textbooks. The first version of the document reporting the curriculum in 1934 submitted to the Ministry of Education had been written in English, but was then requested to be translated into Thai (Khana sathapattayakammasat, 1934).

Ercole Pietro Manfredi (1883-1973) was an Italian architect who made significant contributions to the architectural landscape of early twentieth-century Siam, now known as Thailand. Born in Turin, Italy, he pursued his studies at the Albertina Academy of Fine Arts before relocating to Bangkok, where he became one of the numerous Western professionals engaged by the Siamese government. In 1909, Manfredi was appointed by the academy to serve as an architect for the Siamese government. His architectural portfolio reflects a blend of Thai and Western styles, which he skillfully adapted to align with local traditions. Among his most distinguished works are royal palaces and villas, alongside various public institution buildings. Manfredi worked in collaboration with fellow Italian architects on the Ananta Samakhom Throne Hall, a project that commenced in 1908 and concluded in 1915. He played a pivotal role in the design of the dome and roof, which were inspired by Italian Renaissance and neoclassical architecture, with influences drawn from the Basilica of Superga. As the chief architect for Mrigadayavan Palace in Chiam, Manfredi oversaw its construction from 1923 to 1924. The seaside villa's designs were executed by Manfredi, resulting in a complex of sixteen buildings that harmoniously fused the elevated Thai architectural style with Western influences.

Additionally, he was involved in the design and construction of **Villa Norasingh (1923–25)**, which is now known as the Thai Khu Fa Building of the Government House, although it is not officially credited to him. This building predominantly showcases the Venetian Gothic style, featuring a façade reminiscent of Venice's Ca' d'Oro.

In the 1930s, Manfredi created numerous modernist architectural designs, notably the Manfredi Residence (1935) and Asawin Villa (1930), both of which were inspired by the principles of the Bauhaus movement and represent some of the earliest examples of modernist architecture in Thailand. This decade marked a significant shift towards the International style, particularly in the design of public and educational buildings. Noteworthy contributions from Manfredi during this period include his designs for the Rajvithi School of Nursing (1930) and the Faculty of Dentistry at Chulalongkorn University in 1939.

2.1 Who is the Architect and Engineer of Kanchanaburi Paper Mill?

The architectural features of the Kanchanaburi Paper Mill, including its facade, window design, number of floors, and roofing, exhibit distinct differences from those of structures designed by various Western architects and engineers in Bangkok, despite both being categorized under modern architecture. It is challenging to assert that any Western architect or engineer based in Bangkok was responsible for the design and construction of the Kanchanaburi Paper Mill. Furthermore, during that period, there were only a limited number of buildings designed and constructed by Western professionals outside of Bangkok, suggesting that there should be substantial documentation confirming the involvement of such architects in the mill's construction. There is a possibility that the Kanchanaburi Paper Mill was constructed using reinforced concrete techniques, potentially under the expertise of Sarot Sukkhayang, a graduate of Liverpool University who specialized in reinforced concrete structures. However, this possibility is tenuous, particularly given that all machinery and equipment were imported from Germany. Additionally, if Sarot Sukkhayang or his students were indeed involved in the design, there should be concrete evidence to support this claim.

The contemporary architectural landscape and civil engineering practices in Thailand significantly rely on the contributions of graduates from Chulalongkorn University, particularly within the national construction sector. In 1937, both Chulalongkorn and Thammasat Universities collectively graduated 5,056 individuals, encompassing a range of professions such as physicians, dentists, nurses, lawyers, engineers, electricians, technicians, architects, artists, and various other skilled trades. Notably, approximately 4,000 of these graduates settled in Bangkok. The individuals involved may be local graduates from Chulalongkorn or Thammasat Universities; however, the likelihood of this is minimal. This is primarily due to the fact that the Architectural, Structural, and Civil engineering aspects of the Kanchanaburi Paper Mill were executed by highly experienced professionals or experts within the construction industry, indicating a significant level of expertise in the design and construction processes.



CHAPTER 3

FINDINGS OF THE ARCHITECTURAL AND TECHNOLOGICAL FEATURES OF PAPER MILL

This observation report primarily focuses on the seven main sets of buildings, designated as A, B, C, D, E and F, along with several smaller structures utilized for utilities and dormitory purposes. The analysis will emphasize the *architectural, structural and construction materials* findings associated with each of these primary buildings.

3.1 Architectural Findings on Building A, production hall

The identity of the architect and builder engineer remains unknown that required to do further research; however, the essence of modern architecture, which prevailed in the Western world from the 1930s to the 1960s, is evident in this structure. This architectural style is marked by a pragmatic and analytical approach to design, this paper mill exemplifies a design philosophy that emphasizes analytical and functional principles, featuring elements such as mansard roofs, open floor plans, curtain walls, and expansive volume that enhance natural lighting and cross ventilation, all while adhering to a minimalist aesthetic. The visual appeal of this modern industrial edifice, marked by its adorned columns, is closely linked to the early developments of Brutalist architecture that gained prominence in the 1950s. The architect's intention was to maximize natural light and open spaces, thereby fostering a work environment that promotes well-being and reduces stress for its occupants. The Introduction of modern architecture, often referred to as international modernism, reached Thailand in the context of industrial development in 1937, at Kanchanaburi. This architecture style was particularly suited for building designed to accommodate heavy industrial machinery imported from Germany, necessitating specific requirements regarding land area, spatial configuration, and essential infrastructure **(Figure 3)**.



Figure 3: South side of Kanchanaburi paper mill

Photo by Zay Myo Lin (2024).

Based on a site survey carried out in 2024 indicates that a significant portion of the remaining heavy-duty machinery is sourced from the German company *J.M. Voith Heidenheim*, located in Berlin (**Figure 4, 5**). The supplier of machinery for Kanchanaburi paper mill, *J.M. Voith Heidenheim*, is likely to possess valuable insights regarding architectural, civil, and structural designs that have been implemented in similar projects across Europe. These insights are essential for meeting the stringent structural requirements, layout specifications, and mechanical and electrical needs of paper mills, where precision is paramount. It is plausible that *J.M. Voith Heidenheim* collaborates with architects and engineers to develop a comprehensive master plan (**Figure 6**).



Figure 4: Company logo founded at the heavy machinery at Building A, production hall

Photo by Zay Myo Lin, (2024)



Figure 5: German company logos and signs founded at the heavy machinery at paper mill
 Photo by Zay Myo Lin, (2024)



Figure 6: Existing Master Plan of Kanchanaburi Paper Mill complex.
 Aerial photo by Professor Isarachai Buranaut, 2024.

This innovative facility was instrumental in promoting the principles of modernism, emphasizing functionality, simplicity, and the use of new materials and construction techniques. By integrating unique vision with industrial processes, the factory not only contributed for future architectural practices that sought to harmonize form and function in a rapidly changing world. Another possibility of Architectural or construction technique provider is *August Borsig Berlin* company according to the logo founded on locomotive that installed in the building beside electrical power distribution building. By 1872 Borsig was the largest producer of locomotives in Europe, with works at Zabrze in Silesia and at Dortmund, as well as those in Berlin. It entered a period of relative decline after the death of August Borsig's son Albert in 1878, and went through many mergers in the 20th century. It continued nevertheless to produce notable locomotives, including the three class 05 streamlined 4-6-4s of 1935-37, which set various speed records. One of them is preserved at Nuremberg.

3.2 Structural Finding on Building A, production hall

The structural frameworks of industrial buildings during the 1930s in Thailand was characterized by a blend of functionality and emerging modernist aesthetics. These structures typically featured robust materials such as steel and reinforced concrete, which allowed for larger spans and open interior space conducive to manufacturing process. Additionally, the incorporation of assembly lines and mechanized systems within these building underscored the era's industrial advancements, while the exterior often showcased a utilitarian style that emphasized simplicity and durability, marking a significant evolution in industrial architecture in Thailand. The structural frame of this production hall building was characterized by the prominent use of reinforcement columns and beams, which played a crucial role in supporting the overall architecture (**Figure 7**).

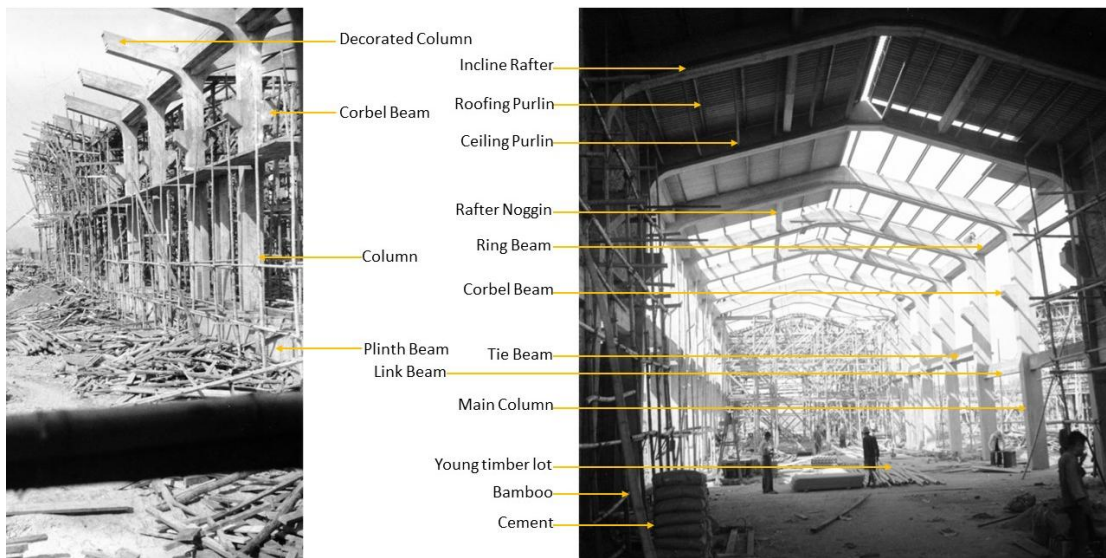


Figure 7: Elements of Building A, production hall in 1937

Source by Pendleton, Robert Larimore, 1890-1975, photo taken on (21/02/1937).

Source: <https://collections.lib.uwm.edu/digital/collection/agsphoto/id/17431/rec/2>

There are three distinct types of reinforced concrete beams constructed above the floor level: the ring beams constructed at the upper sections, corbel beam and the tie beams positioned in the middle of floor and ring beam. The straight reinforced main column transitions into an incline rafter at the center of the roof, simultaneously serving as a decorative column in the external façade elements. This design is notably uncommon for the era in Thailand, reflecting the boldness of European engineers who possessed extensive expertise in structural engineering. Additionally, these elements were typically designed to bear heavy loads, allowing for expansive open spaces within the interiors, a significant departure from the more compartmentalized designs of earlier periods in Thailand in 1937s. The columns were often arranged in a grid pattern, providing both stability and flexibility in the layout of the building, while the columns and beams spanned large distances, facilitating the construction of high-rise ceiling structures. This innovative use of reinforced concrete type not only enhanced the durability of the buildings but also constructed to the aesthetic appeal, as the exposed reinforced concrete elements become a defining feature of the industrial style that emerged during era.

There are many reasons to understand why this modern architecture initiated by westerner for this industrial building constructed with reinforce concrete instead of steel imported from Europe. In 1913, the Siam Cement Company was established and began operation in 1915. In 1917, the company increased its capital by there million bath and imported modern machinery from abroad to expand its production capacity. The company's success was due to partly to serval construction project in Bangkok, especially shophouse along main road and partly to other infrastructure project along waterways for long haul transport since Thai economy was till depending on river express. The change from an absolute monarchy to a constitutional monarchy on 24 June 1932 but the expansion of capitalism under the leadership of Field Marshall Phibun Songkran have strong relationship and support to national established industrial companies, especially the Siam Paper Company Limited own by ministry of defense. The paper mill was located just beside the river, and most construction materials are brought to the project site in most economic and reliable method. Numerous raw materials are readily accessible in the local environment, including *young timber logs, bamboo, plywood, and various types of wood*, all of which are regarded as fundamental components in the construction industry. Therefore, the modern paper mill building was heavily correlated with a set of social-political philosophies including the idea that buildings could be the answers to deep-rooted social inequalities.

3.4 Underground Compartment, Building A, production hall

The design of Building A features a T-shaped layout that incorporates an underground compartment situated beneath the area designated for heavy-duty machinery. This underground space is intended to facilitate convenient access during the installation of heavy machinery, while also serving as a crucial component for routine maintenance activities (**Figure 9**).

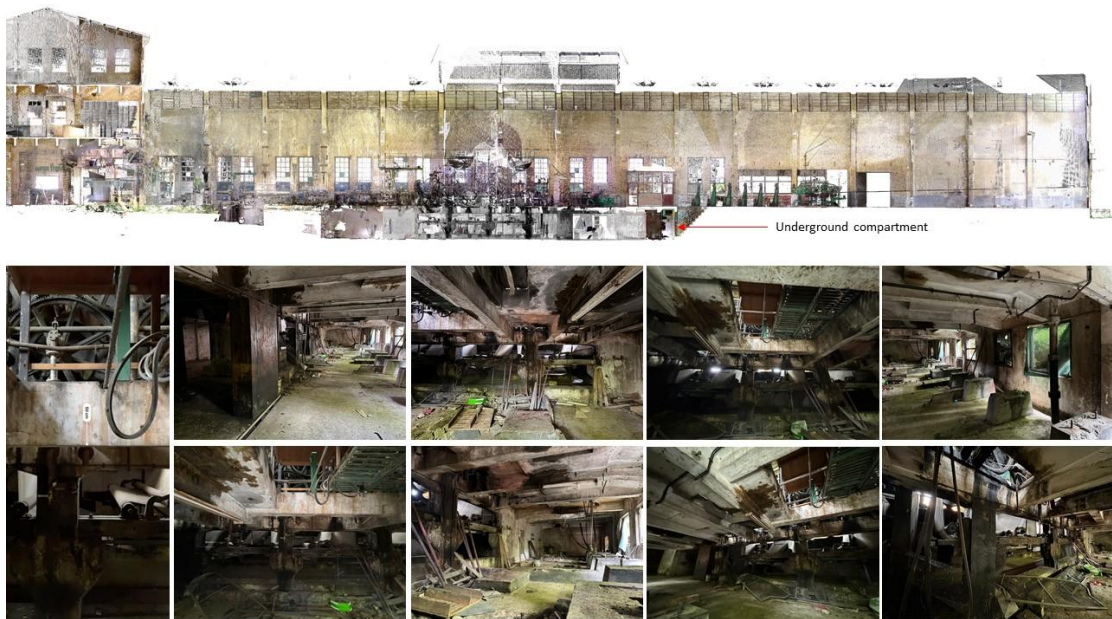


Figure 9: 3D section of underground compartment and photos at Building A
3D scanning by professor Isarachai Buranaut and photos by Zay Myo Lin (2024).

The machinery supplier, J.M. Voith Heidenheim, may impose specific structural requirements to ensure the availability of a complete set of structural components, including beams and columns, which are relatively uncommon in mills during the 1937s, both regionally and nationally. The dimensions, connection points, and placements of construction beams and columns vary significantly, necessitating the expertise of structural engineers and soil technologists to address these complexities effectively. The specifics regarding the design and steel components cannot be determined due to the fact that all remaining columns and beams are in satisfactory condition without defects, and none available for visual inspection. Additionally, the quantities and nominal diameter of rebar and stirrups rings are remained ambiguous. Furthermore, several sets of plinths are also noted to be in good condition. The architectural features large windows on both sides, facilitating cross ventilation and the influx of natural light; however, the condition of the window frames and panels is suboptimal due to their wooden composition. The exterior wall that accommodate the windows are constructed from concrete with a thickness of 250 millimeters. Although the steel components remain unidentifiable, they have been observed to be in satisfactory condition. Additionally,

the building is equipped with cast-iron rainwater downpipes that extend from the roof gutters to an underground compartment, a design choice that is relatively unusual.

3.5 Floor Slab, Building A, production hall

The first floor is the only one level at Building A, the floor, wall, column, beam and joists at roof are all made of concrete. The thickness of the reinforced concrete slab is specified to be 200 millimeters, utilizing reinforcement bars of sizes 16 millimeters and 10 millimeters (**Figure 10**). The composition of the concrete mix consists of cement, sand, and 4-20 mm sub base aggregate river gravel. The total estimated tonnage of aggregate, cement, and sand required for construction of 1 floor slab is 735.52 tons. The delivery capacity is facilitated by standard tipper trucks, which can carry loads ranging from 15 to 20 tons. Reinforce concrete slabs are structural elements that incorporated steel reinforcement to enhance the load-bearing capacity and durability. This combination of concrete and steel allows the slab to withstand tensile forces, with concrete alone cannot effectively manage. The design and implementation of reinforcement of reinforced concrete slabs are critical in paper mill construction application, providing a robust foundation for building and other structures. By integrating reinforcement within the concrete matrix, the engineer who designed has optimize the performance of the slab, ensuring it meets the necessary safety and performance standards specially to host heavy machinery imported from *J.M. Voith Heidenheim*, Germany.



Figure 10: Building A, floor slab of level 1, ceiling of basement compartment
 Photo by Zay Myo Lin, (2024)

3.6 Wall, Building A, production hall

The walls are constructed with reinforced concrete, measuring 275 mm in thickness, extending from the floor to the level of ring beam. This concrete mixture comprises cement, rebar, river gravel and more ration of sand, serving as an alternative to traditional brick walls (**Figure10**). Additionally, there may be particular specification for a wall height of 3.3 meters, which is intended to function as a shear wall. Concrete shear walls are structural elements designed to resist lateral forces, primarily those induced by wind or seismic activity. These walls are typically constructed from reinforced concrete and serve to provide stability and strength of buildings, particularly in high-rise structural wall mill equipped with heavy machinery. By effectively transferring lateral loads to the foundation, concrete shear walls play a crucial role in maintaining the integrity of a building's overall design. The implementation not only enhances the structural performance but also contributes to the safety and durability of the edifice in the face of dynamic environmental forces. The concrete shear walls have been meticulously designed and calculated to work in conjunction with corbel columns, ensuring effective

collaboration not only during the installation phase of heavy machinery but also for future maintenance requirements.



Figure 11: Walling work in progress in 1937 and onsite measurement conduct in 2024

Photo by Zay Myo Lin

3.7 Doors and Windows, Building A, production hall

It is common for doors and windows to be constructed from glass and locally sourced timber but design is unique modern architecture in their time 1937s. Modern architecture this paper mill emphasizes innovative design in doors and windows, reflecting a commitment to both aesthetics and functionality. The integration of large glass panels and minimalist frames allows for an abundance of natural light, creating a seamless connection between indoor and outdoor spaces. This approach not only enhances the visual appeal of structures but also promotes energy efficiency through the use of advanced materials and technologies. The design of doors and windows in this paper mill architecture often prioritizes clean lines and geometric shapes, contributing to a cohesive and sophisticated overall appearance. The concepts of doors and walls of this building's architecture can be understood as fundamental elements that define spatial organization and functionality within structures. Doors serve not only as entry points but also as symbols of

transition between different environments, while walls act as both physical barriers and aesthetic components that shape the overall design. Together, they reflect the principles of modernism, emphasizing simplicity, utility, and the integration of form and function in architectural practice (**Figure 12**).



Figure 12: Façade and Window of Building A, Production Hall

Photo by Zay Myo Lin (2024).

3.8 Roofing, Elements and Materials, Building A, production hall

The primary frameworks for the roofing system consist of inclined rafters, which are derived from the main columns and interconnected by noggins arranged in linear formations, constructed from reinforced concrete. The purlins that support the roofing, along with the ceiling joists, are established using **steel C channels**. The roofing is composed of **fiber cement sheets**, providing durability and structural integrity (**Figure 13**).



Figure 13: Roofing of Building A, Production Hall

Photo by Zay Myo Lin (2024)

3.9 Overall Condition Assessment, Building A, production hall

The current state of Building A is characterized by a T-shaped layout of the production hall, which stands out as the most favorable condition among the various structures within the complex. All structural components are intact and exhibit no defects, including the shear walls, which are constructed from reinforced concrete and show no signs of cracking. In contrast, if the walls had been made of brick, one could expect numerous creaks and defects both externally and internally. The existing concrete flooring has largely retained its original form; however, certain metal sheets and wooden flooring over access points and underground channels are in poor and unsafe condition. Additionally, the doors and windows are not functioning optimally, primarily due to a lack of regular maintenance over the past several decades. While the main entrance door remains in satisfactory condition, it still required repair and restoration efforts to ensure proper functionality. The roofing of the building is generally in good shape, although there are noticeable signs of water leakage, evidenced by water stains on the ceiling panels. Furthermore, the built-in gutters, rainwater downpipes, and the drainage system at ground level are not operating effectively, which may exacerbate the issues related to water management within the facility (**Figure 14**).

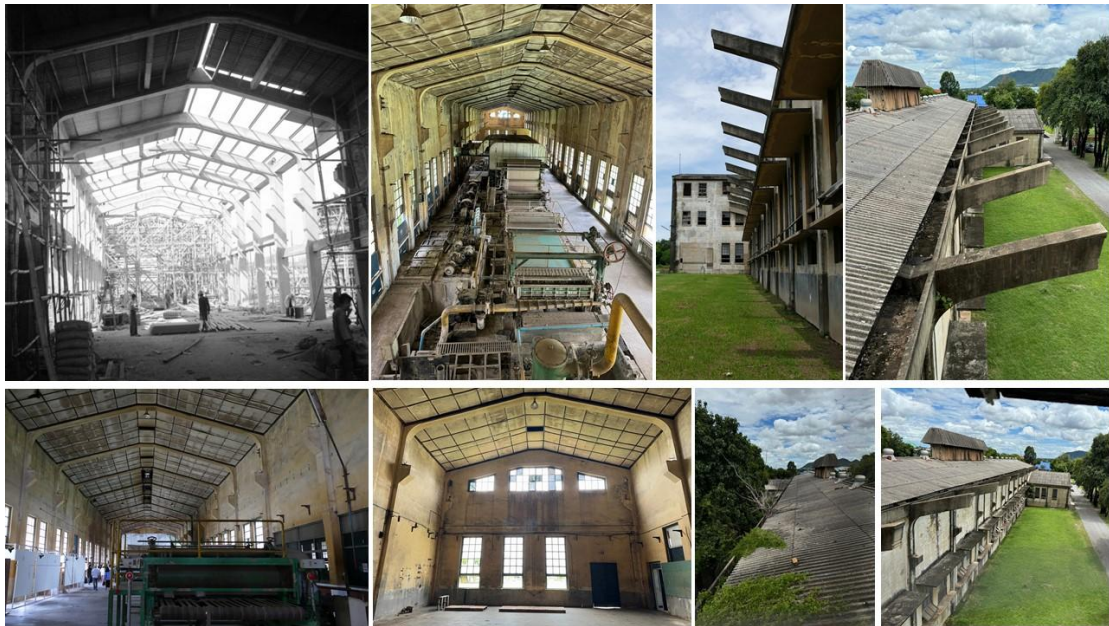


Figure 14: Interior and exterior of Building A, production hall

Photo by Zay Myo Lin, 2024

3.10 Recommendation on Building A, production hall

Recommendation for emergency response involves the restoration of the roofing, doors, windows, and the inserted floor on level one. The roofing is crucial for the preservation of heritage buildings, as it prevents water leakage and rainwater intrusion, which can cause significant damage throughout the structure. In this case, all machinery and equipment remain intact on-site, making the maintenance of the roof directly linked to the protection of these assets. The integrity of the building is compromised if the roof fails. It is essential to clean all gutters, downspouts, and drainage systems to eliminate any debris that could obstruct proper water flow. Additionally, restoring the functionality of doors and windows is necessary to re-establish security, pest control, lighting, and ventilation. The inserted floor within the interior also requires repair and proper fitting, as the building accommodates over 700 visitors on weekends, some of whom attempt to access the interior by opening unsecured windows and doors. Furthermore, the installation of a fire-fighting system is being considered, with mobile fire extinguishers recommended as emergency fire protection equipment.

CHAPTER 4

UNDERSTANDING ON BUILDING B, PREPARATION PROCESS BUILDING

The processing hall complex comprises four structures designated as B1, B2, B3, and B4 (**Figure 15**). Building **B1** features three stories with high ceiling, the first level extending from the production hall and lacking walls. The second level is equipped with a large glass panel that provides an aerial view of the production hall. The third level is linked to Building B2 via a pathway that continues to Building B4.

The **B2** building features a multi-story structure with partitioned walls, meticulously designed by industrial architects and engineers to meet specific operational needs. The façade of the building incorporates four distinct types of windows, which facilitate natural light and ventilation on each level, aligning with the operational requirements.

The **B3** building features three stories characterized by high ceilings and expansive window panels. Each level includes access doors to the B2 and B4 buildings; however, strategically placed brick walls have been designed to minimize noise, dust, and to meet various operational safety standards.

The **B4** building features a double-height volume on the first level, which is necessary for operational purposes due to the presence of a large steel container cylinder that extends through a hole in the second-level slab. The second level has a lower ceiling and is linked to building B3 through an access door. In contrast, the third level boasts a high ceiling that connects directly to building B1 via an access pathway. Additionally, there is a small structure situated atop the third floor served as observation room, providing a panoramic view of the entire paper mill complex, the surrounding landscape, and the river.



Figure 15: Section of Building B consist of 4 building 3D scanning by professor Isarachai Buranaut.

Operational usage of Building B is mostly for chemical process with 70% of its area dedicated to a series of processing plants machinery, as well as mixing tanks constructed from reinforced concrete structure. The remaining 30% of the space is designated as an observation, working space and mini channel and drainage system. External walls are reinforced concrete walls that are identical to those of the third floor, ensuring uniformity in design other building's façade. The wall of which are constructed from the floor up to the roofing structure elements, utilizing reinforced inclined rafters and rafter noggins. The roofing is constructed using the same materials and elements as those utilized in the production hall, Building A, thereby maintaining a cohesive architectural style across the facilities. This design choice not only enhances the aesthetic style across the facilities but also structural integrity of the buildings. The integration with the processing floor and hall reflects a strategic approach to space utilization within the preparation group. In summary, the configuration of the chemical processing group, particularly the design and construction, illustrates a deliberate effort to create functional and visually harmonious spaces. Layout plan provides several access points, including direct entry to the production hall above the same floor, external doors leading to the

outside of the building, and both a staircase and an elevator that facilitate movement to the upper levels.

The wall adjacent to B1 and Building A may have been built in a subsequent phase, occurring only after the installation of equipment on the first floor. It is likely that the construction of **B1** began with the establishment of both superstructure and substructure, followed by the construction of the floors slab and roof. Furthermore, certain sections of the floor and wall were intentionally left without slab and walling to facilitate vertical access during the installation of machinery, as evidenced by the presence of a wooden plank floor at the fourth level. The final stage of B1's construction involved the erection of walls through bricklaying, which accounts for the existence of two separate walls through bricklaying, which accounts for **the existence of two separate walls** positioned closely together between B1 and Building A (**Figure 16**).



Figure 16: The two separate walls through bricklaying, which accounts for the existence of two separate walls

Photo by Zay Myo Lin, 2024

4.2 Architecture finding of Building B, preparation process building

The overall architecture of buildings B groups witnessed a significant evolution in the design of industrial buildings, characterized by a modernist approach that emphasized functionality and simplicity. This buildings group marked a departure from ornate styles, as architects began to prioritize the efficient use of space and materials, reflecting the technological advancements of the time. The integration of large windows, open floor plans, and the use of high story walls not only enhanced the aesthetic appeal but also improved the operational efficiency of these structures. This modern architecture not only served the practical needs of industry but also symbolized a broader cultural shift towards embracing innovation and progress in the face of revolution challenges. This building is a modern architecture showcased window designs that emphasized expansive, often geometric openings characterized by a lack of decorative elements. This approach mirrored the streamlined aesthetic of the time, which prioritized functionality and simplicity. Common features included casement windows, flush designs, and large glass panels arranged in geometric configurations, all contributing to a clean and efficient look. The modernist movement placed a strong emphasis on practicality and clarity, resulting in the incorporation of large, unobstructed windows that enhanced the influx of natural light and offered unobstructed views of the surroundings. This focus on functionality was evident in the design choices, which favored simplicity and a seamless integration with the overall architectural vision. Various window styles emerged during this period, including flush casement windows that opened outward and often featured multiple small panes arranged in geometric patterns. Additionally, large picture windows became popular for their ability to frame expansive outdoor views, while double-hung windows, which slide vertically, were favored for their ventilation capabilities. Throughout these designs, ornamentation was minimal, reflecting the minimalist ethos of the era, influenced by both Art Deco and Streamline Modern styles, which celebrated sleek lines and geometric forms.

4.3 Structure finding of Building B, preparation process building

Reinforced concrete **floor slab** design rebar are different from Building A, because building B group are supporting more to dead load, which is 70% of its area dedicated to a series of processing plants machinery, as well as mixing tanks constructed from reinforced concrete structure. The floor, wall, column, beam and joists at roofing structure are all made of concrete. The thickness of the reinforced concrete **slabs** is specified to be 250 millimeters, utilizing reinforcement bars of sizes 16 millimeters as main bar and 14 millimeters as secondary bar, the spacing is 100mm x 160mm (**Figure 17**). This floor rebar design is complying to all floor slab constructed at Building B. The concrete mix is composed of cement, sand, and river gravel aggregates ranging from 10 to 32 mm in size. Reinforced concrete slabs are structural components that incorporate steel reinforcement to improve their load-bearing capacity and overall durability. This synergy between concrete and steel enables the slab to effectively resist tensile forces, which concrete alone is unable to manage efficiently. The design and execution of reinforcement in reinforced concrete slabs are essential in the context of paper mill construction, as they provide a solid foundation for buildings and other structures. By embedding reinforcement within the concrete matrix, the engineer enhances the slab's performance, ensuring compliance with the required safety and performance standards, particularly for accommodating heavy machinery imported from Germany.

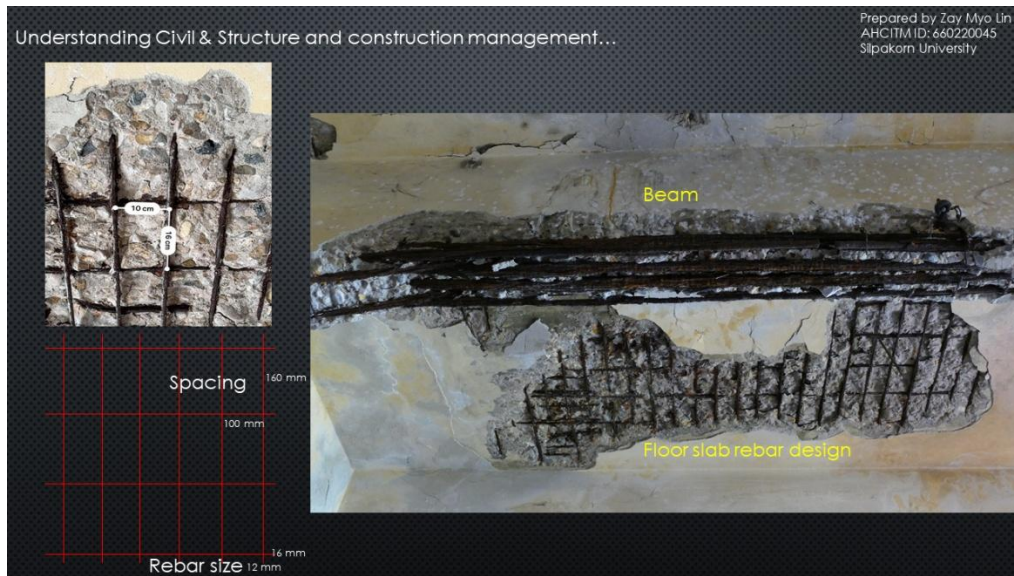


Figure 17: Floor slab rebar design of Building B, process group of building
 Photo by Zay Myo Lin, 2024.

Super structure and sub-structure such as main column, secondary column, short columns, and beams are also reinforced concrete method by using Rebar, mixture of cement, gravel and sand. There are various of column sizes and designs due to particular requirement based on particular floor area (**Figure 18 & 19**).

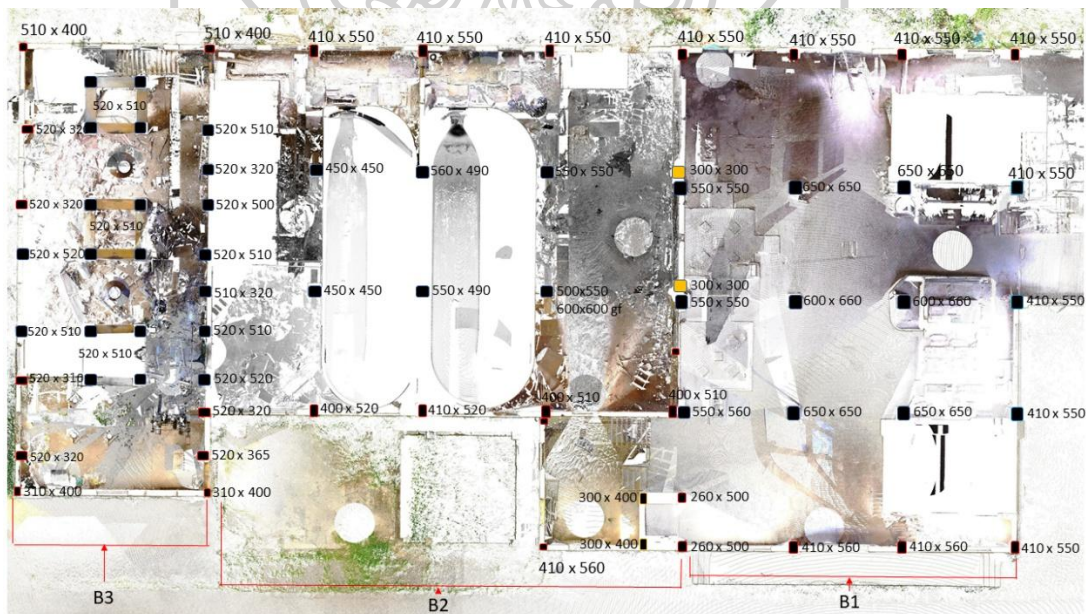


Figure 18: Column plan of Building B, group of building
 3D scanning by professor Isarachai Buranaut.

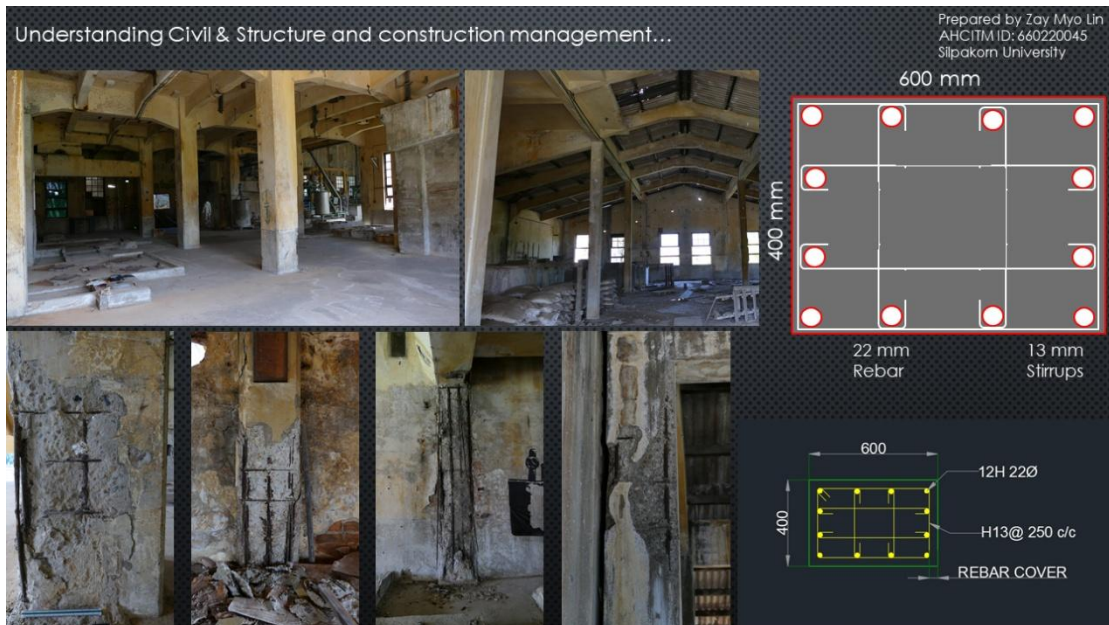


Figure 19: Columns and rebar design from 1937s

Photo and drawing by Zay Myo Lin (2024).

The integration of beams in reinforced concrete structures is essential due to their fundamental function in ensuring the support and stability of the entire building framework. Within a span of three meters, three concrete beams have been constructed, each featuring various rebar designs and sizes tailored to meet the specific operational requirements dictated by the nature of the building. Notably, Building B is recognized as the most extensively constructed beam structure, not only within the Paper Mill complex but potentially throughout Thailand's construction industry during the 1930s (**Figure 20**).



Figure 20: Building reinforced beam overall plan
3D scanning by professor Isarachai Buranaut

Structural beams are stiffened concrete beam constructed from reinforced concrete, which incorporates materials such as rebar, cement, gravel, and a small amount of sand. The primary rebar used in these beams typically ranges in diameter from 20mm to 32mm, while stirrups are generally sized between 12mm and 14mm. Although various types of beams exist, they can primarily be categorized into four major types, as depicted in **(Figure 21)**. In reinforced concrete applications, a "stiffened concrete beam" denotes a beam configuration that integrates supplementary structural components, such as internal or edge beams, to enhance its stiffness and load-bearing capacity, particularly in scenarios involving stiffened raft slabs. Stiffened raft slabs exemplify a prevalent use of stiffened beams, characterized by their incorporation of edge and internal beams that significantly improve structural integrity. The primary objectives of stiffening a concrete beam include increasing its stiffness, which provides enhanced resistance to deflection and deformation under applied loads; augmenting its load-carrying capacity through more effective load distribution; and bolstering the overall stability of the structure, particularly in contexts susceptible to uneven settlement or ground movement. Stiffening can be achieved through the use of edge beams, which are positioned along the periphery of

a slab or structure to offer additional support and rigidity, and internal beams, which are situated within the slab to further reinforce the structure and facilitate load distribution. Additionally, the concept of tension stiffening is relevant in reinforced concrete, where the concrete between cracks can still sustain some tensile stress due to its bond with the reinforcement, thereby contributing to the overall stiffness of the structure (**Figure 22**).



Figure 21: 4 type of beam founded as major group in Building B
Photo and drawing by Zay Myo Lin, (2024)



Figure 22: Stiffened concrete beam founded in Building B
Photo and drawing by Zay Myo Lin, (2024)

4.4 The Inaugural Elevator

Building B1 and B2 was connected by adjacent building built for elevator and staircase, a reinforce concrete staircase could access to both building and an elevator shaft have been integrated; however, the elevator access door face B1. Notably, this elevator represents **the inaugural elevator in Thailand** marked a significant advancement in the country's architectural and engineering landscape. This innovation not only facilitated vertical transformation within buildings but also symbolized the modernization of urban infrastructure. The introduction of the elevator played a crucial role in shaping the design and functionality of high-rise structures, ultimately contributing to the evolution of Thailand's urban environment, especially at the Kanchanaburi paper mill, where it was installed concurrently with the completion of the preparation process building **since 1937**. A significant investment of 12.9 million bath was made in this Paper Mill to acquire a comprehensive set of machinery from Germany, which notably included an electric motorized elevator designed to facilitate transportation within a prospective four-story building (**Figure 23**). This acquisition marked a pivotal moment in the industrial history of Thailand, reflecting the country's evolving capabilities in manufacturing and infrastructure development. It is widely recognized that the inaugural elevator for human transportation in Thailand was introduced in 1958 within the Garden Wing of the Mandarin Oriental, Bangkok, but in fact, it was the second. The presence of an elevator in the pulp paper mill situated in Kanchanaburi may be perceived by many as a standard feature of a building. However, it holds considerable significance that distinguishes it from other industrial structures in Thailand. This elevator represents a unique value and marks an important development in Thailand's industrial landscape during the 1930s.

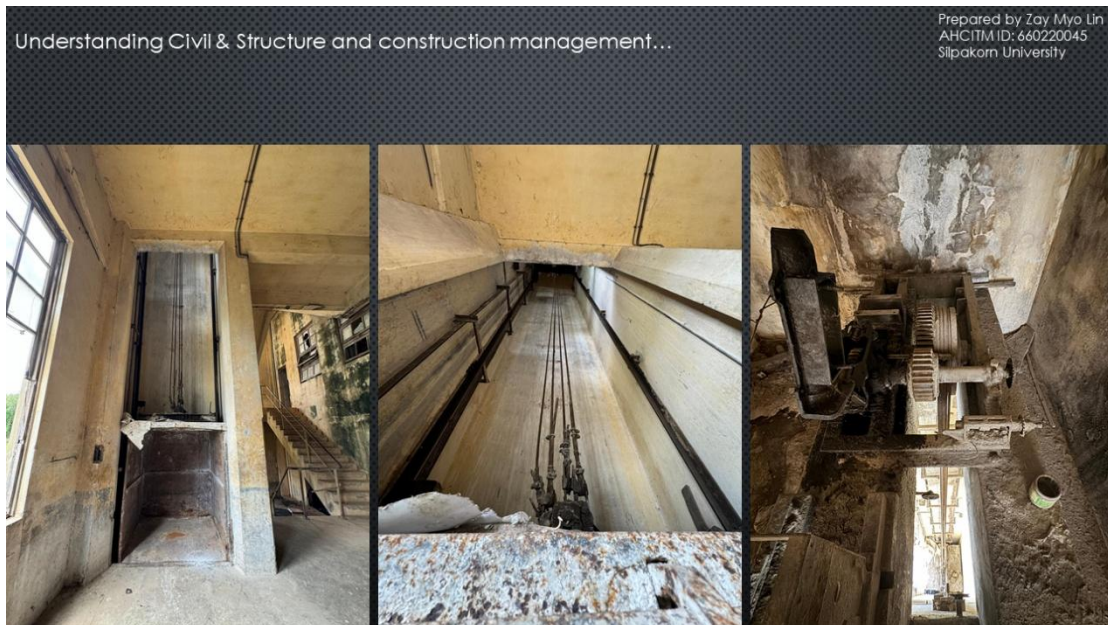


Figure 23: Elevated lift car, lift shelf and mortar room located above 4 story building
 Photo by Zay Myo Lin (2024).

4.5 Overall condition assessment, building B

I have conducted condition assessment for buildings B that involve a systematic evaluation of the structure's current state to identify any deficiencies or areas requiring maintenance. This process typically includes a thorough inspection of various components, such as the super structure, sub-structure, roofing, walls, and mechanical systems. The goal is to ascertain the building's overall integrity and functionality, ensuring it meets safety standards and operational requirements. The assessment method employs a combination of visual inspections, non-destructive testing methods, and performance evaluations. By utilizing these techniques, and collect data on the building's materials, structural stability, and potential hazards. This information is crucial for developing a comprehensive maintenance plan and prioritizing repairs, ultimately extending the lifespan of the facility. Furthermore, condition assessments can serve as a valuable tool for decision-making regarding renovations or upgrades. By understanding the current condition of the building, stakeholders can make informed choices about resource allocation and investment strategies. This proactive approach not only enhances the safety and efficiency of

industrial operations but also contributes to long-term sustainability and cost-effectiveness.

The roofing structure has suffered significant damage, with roofing sheets exhibiting breakage attributed to insufficient maintenance. Additionally, numerous windows, doors, panels, and louvers are non-functional, also due to a lack of proper upkeep. Many glass panels are either broken, missing, or malfunctioning, which poses a risk of water leakage and subsequent corrosion. Evidence of monitor lizards has been observed on the ground floor, while traces of pigeons are present on every level. The presence of non-organic bird waste further exacerbates the potential for corrosion. There are remnants of lime, limestone, and unidentified chemical substances found within open tanks and on the flooring. The B3 area is heavily cluttered with debris, resulting in a complete coverage of the floor. Furthermore, there are significant vegetation issues affecting the roofing, walls, and extending down to the base of the building's exterior (**Figure 24**).

The structural components of the building, including the floor slab, walls, columns, beams, joists, and roofing elements, have remained intact since their construction in 1937. There are no significant damages or functional failures attributable to earthquakes or other natural disasters. Overall, Building B is in satisfactory condition; however, some walls, columns, and beams exhibit exposed rebar, likely resulting from a destructive testing process that involved the hacking away of concrete. The exposed rebar has suffered considerable corrosion due to prolonged exposure to the elements and moisture, exacerbated by inadequate ventilation within the building's interior. This deterioration poses a risk of structural failure if immediate protective measures are not implemented. It is crucial to address these issues promptly to ensure the integrity and safety of the structure.

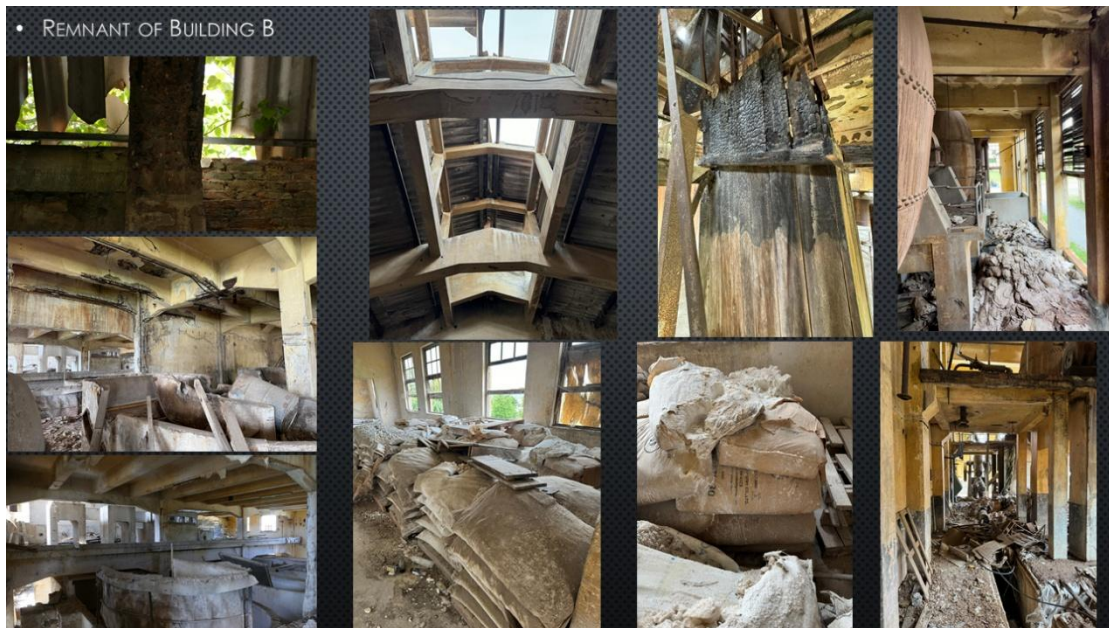


Figure 24: Remnant of Building B

Photo by Zay Myo Lin, (2024)

4.6 Recommendation for building B

1. The management of housekeeping and debris removal is essential to prevent fire incidents and implement effective pest control measures. Notably, there are signs of burn damage on the upper section of Building B3, where rafters and joists have suffered significant charring due to elevated temperatures, indicating a potential fire outbreak. The restoration of doors and windows is the next priority, as this will aid in pest control and enhance security measures.

2. The immediate replacement of damaged roofing is crucial, followed by the clearing of debris and vegetation from the gutters. It is also necessary to restore the rainwater downspouts to ensure the proper functioning of the drainage system. Additionally, the removal of limestone bags should be considered to prevent any chemical reactions that could affect exposed metal and steel components.

3. Most critically, there is an urgent need to protect exposed steel and rebar elements within the columns, beams, and walls. Applying anti-corrosion paint as an initial protective measure is essential, and it may also be necessary to use epoxy paint for structural reinforcement purposes. This proactive approach will help safeguard the integrity of the building's structural components.

CHAPTER 5

ARCHITECTURAL AND STRUCTURAL FINDINGS OF BUILDING C

Building C is a single-story structure characterized by its high ceilings, likely designed for use as a warehouse or an area for receiving raw materials that require weighing for tonnage purposes. The architectural design features central pillars and supplementary columns at the entrance, which support its intended function (**Figure 25**). Evidence of metal hooks can be observed on the additional columns and beams, indicating previous usage or modifications made to accommodate specific operational needs. These remnants suggest that the building was equipped for handling heavy materials or equipment, reinforcing its role in logistics or storage. Overall, the design elements and remaining fixtures of Building C highlight its practical purpose, emphasizing its suitability for industrial activities related to material handling and storage. The structural features not only support the building's functionality but also reflect its historical use in a commercial context.

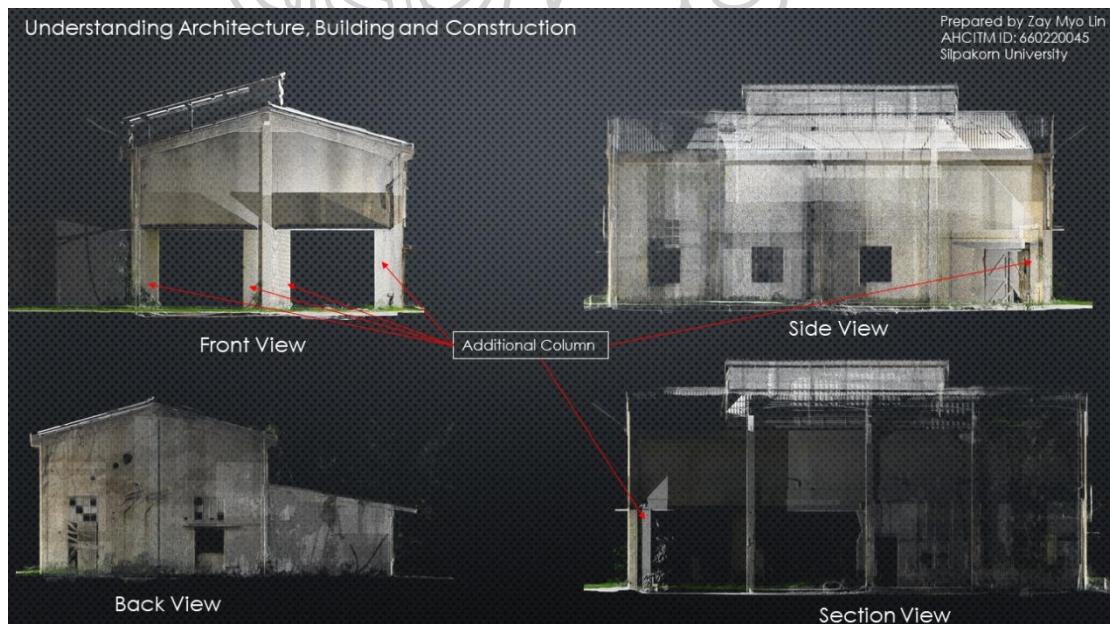


Figure 25: Images from 3D scanning conducted by Professor Isarachai Buranaut (2024).

Architecture of this industrial warehouses reflects a significant evolution in design principles and functionality. This architectural style emphasizes efficiency, adaptability, and sustainability, catering to the needs of contemporary industrial operations, allows for expansive open spaces, maximizing utility while minimizing unnecessary structural elements. The design of this warehouses often incorporates windows and open floor plans, promoting natural light and enhancing the working environment. This approach not only improves energy efficiency but also fosters a more pleasant atmosphere for employees. Furthermore, modern industrial warehouse architecture often prioritizes flexibility, allowing spaces to be easily reconfigured to accommodate changing operational requirements. This adaptability is crucial in a rapidly evolving pulp paper manufacturing, where the supply chain must respond swiftly to new challenges and opportunities. Overall, the modern architectural approach to industrial warehouses represents a harmonious blend of functionality, sustainability, and aesthetic appeal (**Figure 26**).



Figure 26: Structural elements and interior of Building C

Photo by Zay Myo Lin (2024)

5.1 Overall Condition Assessment, building C

The foundation and floor slab, along with the pitch and channels, remain intact as originally constructed. The walls, columns, beams, and all structural components are in satisfactory condition, reflecting their initial state. Additionally, roofing elements, including joists, purlins, ventilation panels, and natural light panels, continue to be in good condition. However, the doors and windows have suffered damage and are not functioning properly, primarily due to a lack of maintenance. The roofing sheets have also sustained damage, leading to water leakage from the roof to the ground floor, which has been observed. Furthermore, remnants of electrical wiring and lighting do not adhere to proper cabling standards, and there is some vegetation present around the building.

5.2 Recommendation for building C

The primary focus is to resume roofing work to ensure complete protection against rain and adverse weather conditions. Following this, the restoration of doors and windows will be prioritized to address issues related to pests, weather damage, and security concerns. Additionally, it is essential to implement proper cabling for lighting and power sources in accordance with established building codes. Maintaining cleanliness and removing debris from within the building is also crucial to mitigate the risk of fire hazards. In conjunction with these efforts, the removal of vegetation surrounding the building will be addressed as part of the final maintenance activities. This step is important for enhancing the overall safety of the premises. Furthermore, it is advisable to install fire extinguishers and safety signage, particularly since the building remains accessible to visitors. These measures will help prevent accidents such as trips and falls. Overall, a systematic approach to these maintenance tasks will not only improve the building's structural integrity but also enhance safety for all individuals who enter the premises. By prioritizing roofing, restoring entry points, ensuring compliance with electrical standards, and maintaining a clean environment, the building can be made safer and more secure.

CHAPTER 6

ARCHITECTURAL AND STRUCTURAL FINDINGS OF BUILDING D, WATER STORAGE AREA

The Building D group comprises an overhead water tank system, a series of water tanks situated above ground, and a facility dedicated to water distribution management. The primary function of the overhead water tanks is to provide domestic water supply, while the additional above-ground tanks may serve purposes such as supplementary storage and potentially wastewater treatment (**Figure 27**).



Figure 27: Building D group

Aerial photo by professor Isarachai Buranaut, (2024)

An old photograph captured by [Pendleton, Robert Larimore, 1890-1957](#) who involved as soil specialist in construction of pulp paper mill project. The image indicates that the overhead water tank was constructed on earlier state of entire project. This footprint of sequence & series also stating that consumable domestic water supply is important even during in construction stage of projects, although construction site is quite near to the river. Construction site need a clean water supply

not only for domestic usage but also for construction purpose such as mixing of cement concrete, conducting water testing and cleaning activities etc. Consequently, the project's management opted to prioritize the construction of water storage facilities at the outset. The main purpose of overhead water storage tanks is to achieve an even distribution and it maintains constant pressure and flows, at the time of discharge when the water comes down from a certain height it has a sufficient increase in pressure that makes it serves at a constant rate in almost every outlet. The significance of overhead water tanks during the 1930s cannot be overstated. The overhead water tank, built between 1914 and 1925 in Maen Sri, is the sole remaining structure of its kind under the Bangkok Metropolitan Water Authority (MWA) and has been designated as a national heritage site. The architectural and structural design of overhead water played a crucial role in the management and distribution of water, particularly in an area that out of Bangkok. Their design allowed for the efficient storage and gravity-fed delivery of water, which was essential for both before and after of construction stages. In an era marked by significant industrial growth and urbanization, overhead water tanks provided a reliable solution to the challenges of water supply. The implementation of these tanks represented a pivotal advancement in infrastructure, contributing to the overall development of industry out of Bangkok. Moreover, the use of overhead water tanks reflected a broader trend towards improved engineering practices and public utility management. As industry expanded, the need for effective water distribution systems became increasingly apparent, and overhead tanks emerged as a practical response to this necessity.

6.1 Overall Condition Assessment, Building D

The overhead water tanks, the water distribution control facility, and all associated water storage units remain in excellent condition, exhibiting no defects or damage. However, there is some debris and vegetation present on the concrete surfaces. The architectural and structural integrity of these buildings has been assessed and found to be satisfactory when compared to other structures in the vicinity. This indicates that they maintain their original design and functionality effectively. Overall, the condition of the water infrastructure is commendable, with

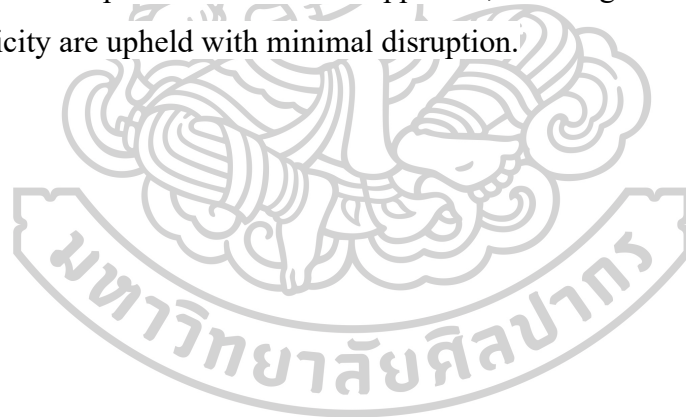
only minor issues related to surface debris and plant growth, which do not compromise the overall performance or safety of the facilities.

6.2 Recommendation on Building D

1. The overhead water tanks may represent the oldest, tallest, and largest structures of their kind in the region. Their restoration could be achieved swiftly and efficiently, requiring minimal intervention and incurring low costs while preserving their integrity and authenticity.

2. These water tanks, notable for their age, height, and size, stand out as significant historical structures in Kanchanaburi. The process of restoring them could be both cost-effective and straightforward, allowing for the maintenance of their original character with limited alterations.

3. In Kanchanaburi, these overhead water tanks are potentially the most ancient, tallest, and largest examples of their type. Their restoration presents an opportunity for a rapid and economical approach, ensuring that their historical value and authenticity are upheld with minimal disruption.



CHAPTER 7

UNDERSTANDING BUILDING E, LOCOMOTIVE AND ELECTRICAL POWER DISTRIBUTION BUILDING

Building E encompasses three distinct functional areas under a single roof. One section houses two BORSIG wood-fueled locomotive engines along with a chimney, while the adjacent area serves as an electrical power distribution station located on the mezzanine level. The remaining portion of the L-shaped structure is designated for warehouse purposes (**Figure 28**). Numerous concrete pits and plinths are located beneath the locomotive section, under the mezzanine floors in the electrical distribution panel area, as well as in the warehouse spaces; however, their specific purposes remain unclear. A steam locomotive operates by utilizing a boiler to heat water, resulting in the production of steam. This steam is harnessed to drive pistons, which subsequently rotate the locomotive's wheels, enabling movement. The generation of steam through the combustion of wood is fundamentally a mechanical operation. For an extended period, steam locomotives were the primary form of locomotion, depending on fuels such as coal or wood for steam production, rather than relying on electricity.

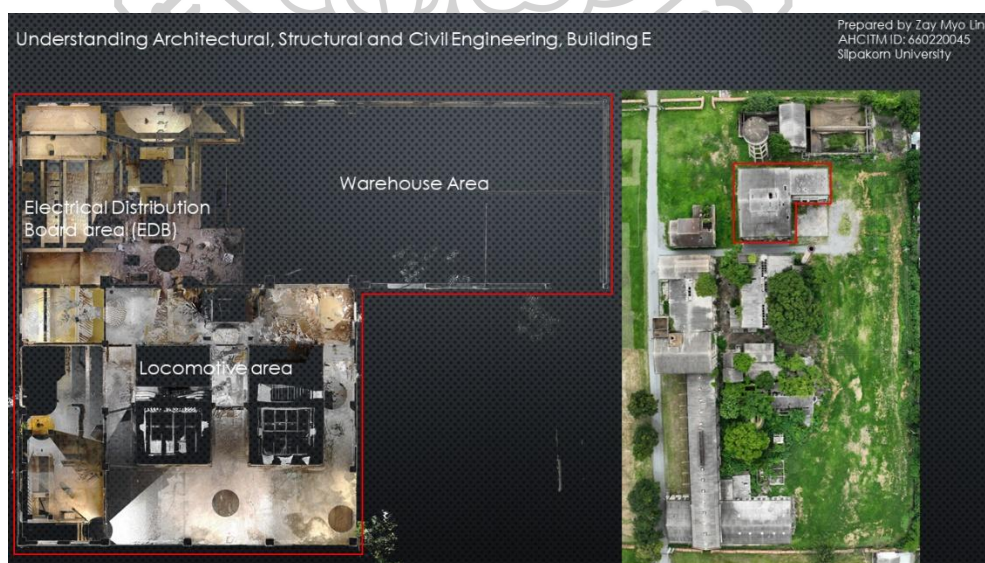


Figure 28: Overall Plan of Building

Drone and 3D scanning by Professor Isarachai Buranaut, (2024)

7.1 Architectural findings of building E, locomotive section

The Architecture of building E is thoughtfully designed to accommodate locomotive engines, emphasizing open floor plans that characterize industrial buildings. These designs typically incorporate expansive, unobstructed areas to enhance production efficiency and streamline workflow. Additionally, the incorporation of high ceilings not only permits the installation of machinery and equipment but also ensures sufficient vertical space for the workforce. The use of robust materials such as concrete, brick, and metal contributes to an impression of strength and resilience, while simultaneously embodying the essence of industrial architecture. The locomotive sector emphasizes the creation of structures that support the safe and effective manufacturing, upkeep, and storage of locomotives and their associated equipment. Extensive buildings are typically defined by expansive, unobstructed areas, durable construction materials, and practical layouts that enhance operational efficiency. The design of locomotive workshops and factories necessitates spacious interiors to accommodate the substantial dimensions of locomotives and the heavy machinery involved in their assembly and repair, and highlighting the industrial aesthetic and functional purpose of the buildings. Furthermore, the design prioritizes the safe movement of materials, personnel, and vehicles, thereby optimizing production and maintenance workflows. This building may be the sole remaining edifice from 1937 within Thailand's industrial landscape, showcasing a careful blend of functionality and aesthetic appeal. The period during which this building was constructed signifies a pivotal shift in engineering methodologies, as designers aimed to improve locomotive performance and efficiency while also prioritizing the visual characteristics of the buildings. Consequently, locomotive buildings not only functioned as operational centers but also embodied the industrial progress and artistic values of the era, thereby playing a significant role in the historical narrative of the regional industry. The walls are constructed using bricks with a thickness of 45 mm. The roofing features a triple-height volume, utilizing roofing sheets that are consistent with those used elsewhere, specifically compressed concrete sheets. However, the roofing structure employs a steel bracing technique, which offers greater flexibility for the building's movement and allows for significant cross ventilation (**Figure 29**).



Figure 29: Architectural and overview of Building E, locomotive area

Photo by Zay Myo Lin (2024).

7.2 Structural findings of building E, locomotive section

In 1937, the integration of architectural and structural elements in industrial buildings marked a significant evolution in design and functionality. This period saw a harmonious blend of aesthetic considerations with engineering principles, resulting in structures that were not only visually appealing but also optimized for their intended industrial purposes. The collaboration between architects and engineers facilitated the creation of spaces that effectively accommodated machinery and workflows while ensuring safety and durability. This approach laid the groundwork for modern industrial architecture, emphasizing the importance of both form and function in the built environment. There are additional steel structural components specifically designed to accommodate locomotive equipment and chimneys, playing a vital role in locomotive construction. These components, which consist of beams, columns, and frames, are engineered to deliver the necessary strength and stability to endure the various stresses experienced during operation. The advantages of using steel are significant, as its high tensile strength and durability facilitate the development of lightweight yet sturdy structures. Furthermore, the manufacturing process of these steel elements can be meticulously regulated, ensuring they align

with the precise specifications of locomotive design. In summary, the incorporation of steel structural components is crucial for improving both the performance and durability of locomotives.

The structural design of this locomotive facilities involves the careful planning and engineering of buildings that house and maintain locomotives. The management of planning, design calculations, and material supply can be directly handled by BORSIG based in Berlin, Germany. This process encompasses various considerations, including the load-bearing capacity of materials, spatial requirements for equipment and personnel, and adherence to safety regulations. Effective structural design ensures that these buildings can withstand the operational demands placed upon them while providing a functional and efficient environment for locomotive operations. In building E, a range of column and beam sizes and designs can be observed, akin to those in other structures. However, it is noteworthy that the largest beam, identified as a ring beam, stands out with dimensions of 300 mm by 1200 mm. The reinforcement bars used in this beam include a main bar of 25 mm and stirrups measuring 12 mm, as illustrated in **Figure 30 & 31**.

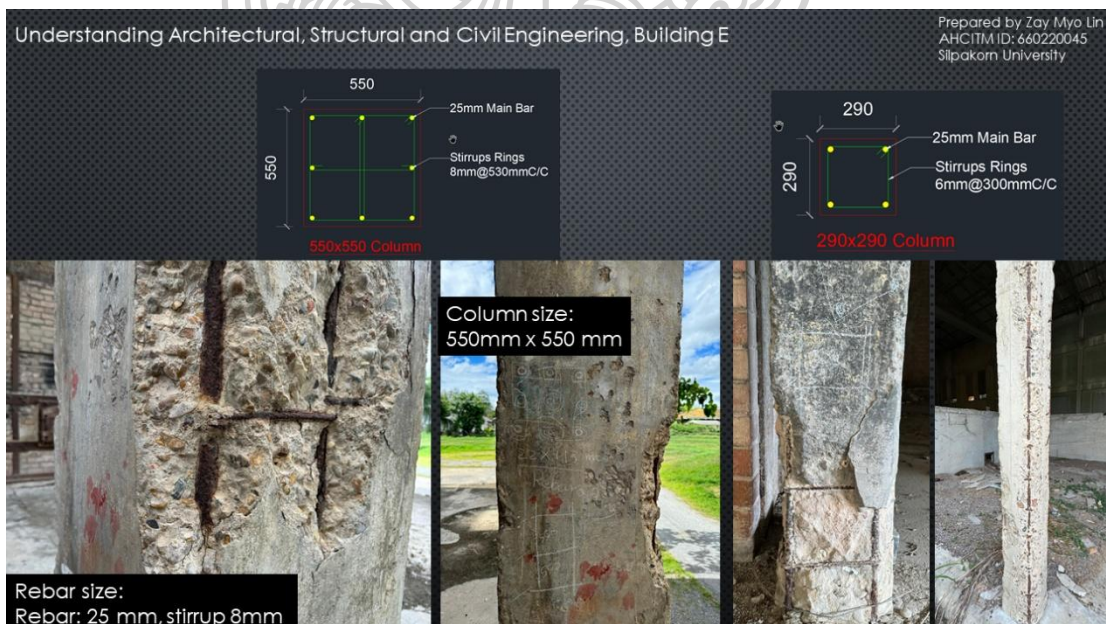


Figure 30: Columns size of Building E

Photo and drawing by Zay Myo Lin (2024)

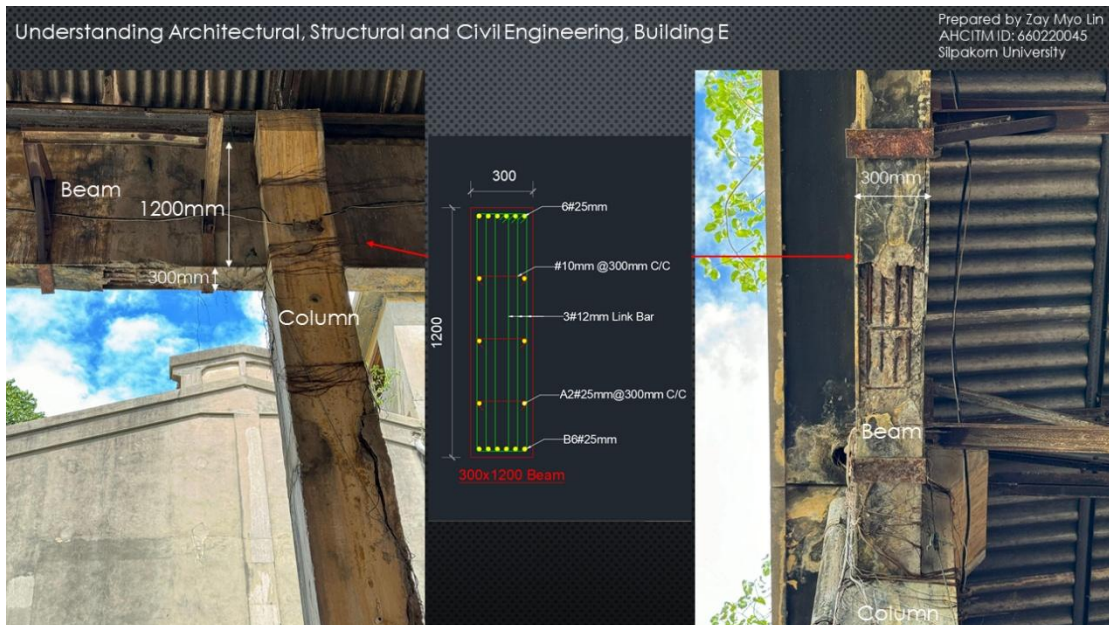


Figure 31: Beam size of Building E, locomotive section

Photo and drawing by Zay Myo Lin (2024)

7.3 Role of locomotive

Steam locomotives emerged as the dominant form of railway transportation from the late 19th century to the mid-20th century, significantly contributing to the expansion of rail networks in Thailand. Over time, steam locomotives underwent advancements in boiler design, cylinder construction, and overall operational efficiency. At the Kanchanaburi Paper Mill, steam locomotives were utilized, with wood serving as a convenient and often the most feasible fuel option, particularly in regions rich in forest resources. The implementation of wood fuel locomotives at paper mills can be attributed to several factors. The use of wood as a fuel source was driven by the need for sustainable and cost-effective energy solutions during a time when traditional fossil fuels were either scarce or expensive. Additionally, the paper industry, which relies heavily on the transportation of raw materials and finished products, benefited from the availability of locally sourced wood, reducing transportation costs and enhancing operational efficiency. The adoption of wood fuel locomotives also aligned with the growing emphasis on environmental sustainability, as utilizing renewable resources helped to minimize the ecological impact of industrial operations. Two heat generator houses have been constructed using fire-

rated bricks and a steel framework. Each house features three accessible openings that can be opened or closed, and a cylinder is mounted at the rear, functioning as part of the engine system. This locomotive is designed not only to power the equipment installed in the processing sector building but also to facilitate the transportation of raw materials from the riverside to the factory's warehouse area (**Figure 32**).

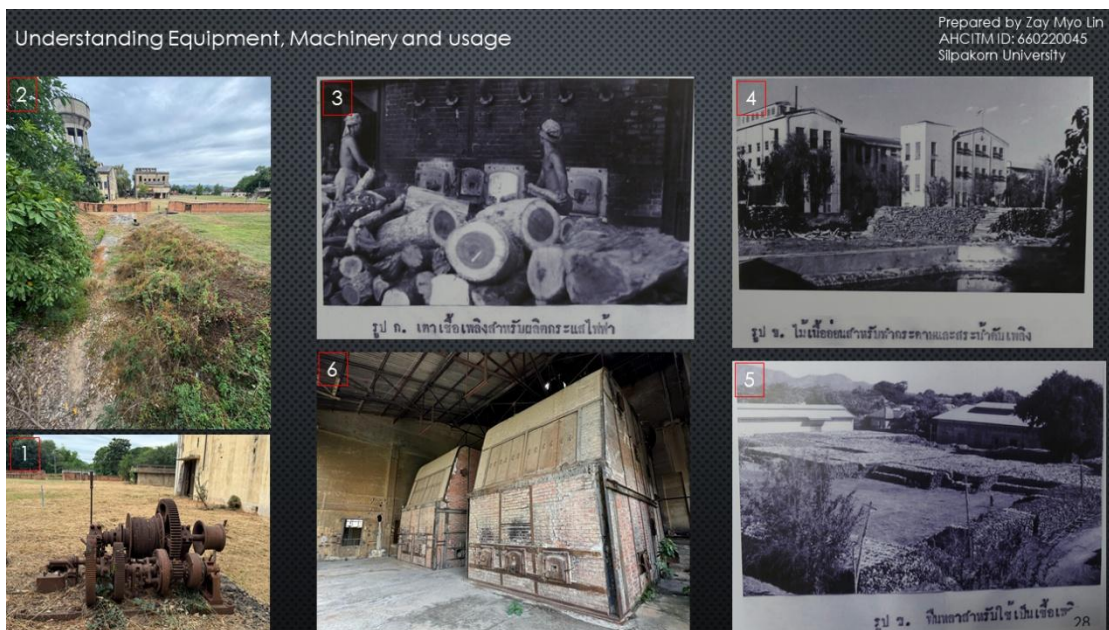


Figure 32: Wood fuel locomotive, usage and warehouse

New photos 1, 2, and 6 are taken by Zay Myo Lin (2024), old pictures 3, 4 and 5 are from photo booth conducted photo show in 2024.

The historical context of Borsig locomotives and their connection to Siam during the 1930s is a fascinating subject. This period marked significant developments in railway technology and international relations, particularly as Borsig, a prominent German locomotive manufacturer, played a crucial role in advancing locomotive design and production. Siam, now known as Thailand, was undergoing its own modernization efforts, which included the expansion of its railway infrastructure. The collaboration between Borsig and Siam during this decade highlights the intersection of industrial progress and geopolitical dynamics, reflecting broader trends in transportation and economic development in the region. The utilization of Borsig Locomotives in paper mills in Thailand is essential due to several compelling reasons.

Firstly, these locomotives are renowned for their reliability and efficiency, which are critical in the demanding environment of paper production. Their robust design ensures they can handle the heavy loads associated with transporting raw materials and finished products within the mill. Additionally, Borsig Locomotives are equipped with advanced technology that enhances operational performance, leading to reduced downtime and maintenance costs. Furthermore, their adaptability to various operational requirements makes them an ideal choice for the diverse needs of paper mills in Thailand, ultimately contributing to increased productivity and cost-effectiveness in the industry.

7.4 Understanding electrical power distribution section

A significant electrical power distribution panel is situated on the mezzanine level of Building E, next to the Locomotive section (**Figure 33**). However, its construction and installation may occur at a later stage, likely following the installation of a diesel locomotive capable of generating electricity. In contrast, a wood-fueled steam locomotive engine, in its conventional design, does not generate electricity directly; instead, it harnesses the heat produced from burning wood to create steam, which subsequently powers pistons to produce mechanical motion rather than electrical energy. The electrical power supply sector plays a crucial role in the functioning of modern society by generating, transmitting, and distributing electricity to various consumers, including residential, commercial, and industrial users. This sector ensures the availability of reliable and efficient energy, which is essential for powering homes, businesses, and essential services. Additionally, it supports economic growth and development by facilitating technological advancements and improving the quality of life. The sector also faces challenges such as the need for sustainable energy sources and the integration of renewable technologies, which are vital for addressing environmental concerns and ensuring long-term energy security.



Figure 33: Electrical Power Distribution Sector at Building E
Photo by Zay Myo Lin, (2024).

7.5 Architectural and structural findings of building E, electrical power distribution section

The Electrical Power Supply section shares an identical architectural and structural design with the locomotive section and may potentially be constructed during the same phase. Both sections are encompassed by the same roofing, maintain a uniform ceiling height, and exhibit a consistent facade design. However, the arrangement of columns and beams differs due to the relatively low load requirements that need to be supported or distributed through these structural elements.

7.6 Architectural and Structural findings of building E, warehouse section

The warehouse space in Building E appears to be an extension constructed in a later phase, as evidenced by a visual inspection of its physical characteristics. Although the ground floor levels are consistent, the flooring features pits and plinths to accommodate operational needs. The architectural and structural designs exhibit minor variations compared to the other buildings, particularly in wall dimensions, while the ceiling and roofing heights remain uniform. This building is presumed to

serve as a warehouse for the storage of organic fuel and raw materials utilized in pulp and paper manufacturing. The primary function of an industrial warehouse is to serve as a storage facility for goods and materials used in various manufacturing and distribution processes. These warehouses are designed to efficiently manage inventory, facilitate the organization of products, and streamline the supply chain by providing a centralized location for the receipt, storage, and dispatch of items. By optimizing space and ensuring proper handling of goods, industrial warehouses play a crucial role in enhancing operational efficiency and meeting the demands of businesses in a timely manner.

7.7 Overall Condition Assessment of Building E

The roofing sheets in the majority of the area are damaged, with indications of water leakage affecting approximately 60% of the roofing surface. However, there are no visible signs of failure or defects in critical roofing components, including fascia, flashing, soffit, eaves, gutters, underlayment, decking, valleys, and rafters. While the walls show no significant damage, the window panels and ventilation access panels have suffered deterioration due to insufficient maintenance. The flooring remains largely intact, although some pits and channels are obstructed by debris. Additionally, there are signs of destructive testing performed on the columns and beams by an individual or organization. Overall, the architectural and structural integrity of the building is assessed to be 95% in good condition, with 5% requiring urgent attention.

7.8 Recommendation on Building E

It is essential to prioritize the repair or replacement of roofing using materials that are similar to the original. This approach is crucial for safeguarding the roofing components, which in turn helps to protect the underlying steel structure and other roofing elements. Ensuring that roofing repairs or replacements utilize like-for-like materials is vital for maintaining the integrity of the roofing system. This practice not only preserves the functionality of the roofing members but also contributes to the overall protection of the steel framework and associated roofing elements. The significance of roofing in industrial warehouses cannot be overstated. A well-

constructed roof plays a crucial role in protecting the building's contents, ensuring the safety of personnel, and maintaining operational efficiency. Moreover, the roofing system contributes to energy efficiency and sustainability in industrial settings. Proper insulation and ventilation can reduce energy costs and enhance the overall working environment. Therefore, investing in high-quality roofing solutions is essential for the longevity of the warehouse and building E.

Restoration of doors, windows, lighting, and ventilation systems is essential for the resumption of the building's operational functions, ensuring the safety of both employees and visitors. Additionally, these measures are crucial for maintaining security, implementing control systems, and addressing pest management. Furthermore, the building's facade will regain its architectural significance and uphold the structural integrity of the property. The roles of doors and windows in industrial buildings are multifaceted and essential for the overall functionality of the structure. Doors serve as critical access points, facilitating the movement of personnel, equipment, and materials in and out of the facility. They also contribute to security and safety by controlling entry and exit. Windows, on the other hand, play a vital role in providing natural light and ventilation, which are crucial for maintaining a comfortable and productive working environment. Additionally, they can enhance visibility for monitoring operations and ensuring safety within the industrial space. Together, doors and windows are integral components that support operational efficiency and contribute to the well-being of the building.

The ground floor, mezzanine, and first level are cluttered with various debris and discarded items that require immediate removal. This action is essential to mitigate risks associated with corrosion, ensure human safety, and address fire safety concerns. The significance of housekeeping within industrial heritage structures is multifaceted. It encompasses not only the maintenance and preservation of these historical sites but also the enhancement of their aesthetic appeal and functionality. Effective housekeeping practices ensure that the integrity of the building is upheld, allowing for the safe and sustainable use of these spaces. Furthermore, it plays a crucial role in educating visitors about the historical context and cultural value of the industrial heritage, thereby fostering a deeper appreciation for these important landmarks.

It is crucial to apply epoxy or a protective coating to the exposed rebar of the columns and beams that have undergone destructive testing previously.



CHAPTER 8

ARCHITECTURAL FINDINGS ON BUILDING F

The Building F area comprises three structures divided into four sections, featuring two levels, which are essential for the functioning of the pulp paper mill. Adjacent to the main building stands a towering concrete chimney, recognized as the tallest in Thailand. The ground level is designated for the processing of raw materials necessary for daily operations, as well as for maintenance access. The first floor primarily serves as a workspace for monitoring and observing daily activities. This building is noted for its exceptional architectural beauty, characterized by its lofty ceilings and its status as the largest structure within the Pulp Paper Mill complex. This building, located in Kanchanaburi, outside of Bangkok, exemplifies Modern Industrial Architecture from the 1930s, a design movement that emphasized the incorporation of industrial materials and methods into architectural practices. During this era, there was a notable transition towards functionalism, prioritizing utility and efficiency in building design, often employing materials such as steel, glass, and concrete. The visual characteristics of this architectural style featured clean lines, expansive spaces, and minimal ornamentation, mirroring the technological advancements of the period. Architects aimed to construct edifices that fulfilled practical needs while also capturing the essence of modernity and progress, reflecting the wider cultural and economic transformations of the time. Modern Industrial Architecture in Thailand during the 1937s represents a significant evolution in the country's architectural landscape. This period marked a transition towards incorporating industrial materials and techniques into building designs, reflecting broader global trends. The architectural style of this era was characterized by the use of concrete, steel, and glass, which facilitated the creation of functional and aesthetically appealing structures (**Figure 34**). This movement not only showcased the technological advancements of the time but also symbolized Thailand's growing engagement with modernity and urbanization. The primary function of pulp and paper mills during the 1930s was the production of paper products through the processing of wood pulp. This involved several key operations, including the mechanical and chemical breakdown of wood

into pulp, followed by the formation, pressing, and drying of the pulp into sheets of paper. The mills played a crucial role in meeting the growing demand for paper in various sectors, including publishing, packaging, and stationery, reflecting the industrial advancements of the time. The emergence of modern industrial architecture in Thailand during the 1937s marked a significant development in the country's architectural landscape.



Figure 34: Layout plan, elevation and section of Building F 3D picture by Professor Isarachai Buranaut, (2024).

8.1 Structural findings on Building F

The evaluation of the building's condition suggests that the same structural engineer could be responsible for the design of Building F, considering the specifications of rebar, including its dimensions and configuration, as well as the proposed methodology. Although the building features various sizes of columns and beams, this discussion will specifically address the notable examples illustrated in **Figure 35**.

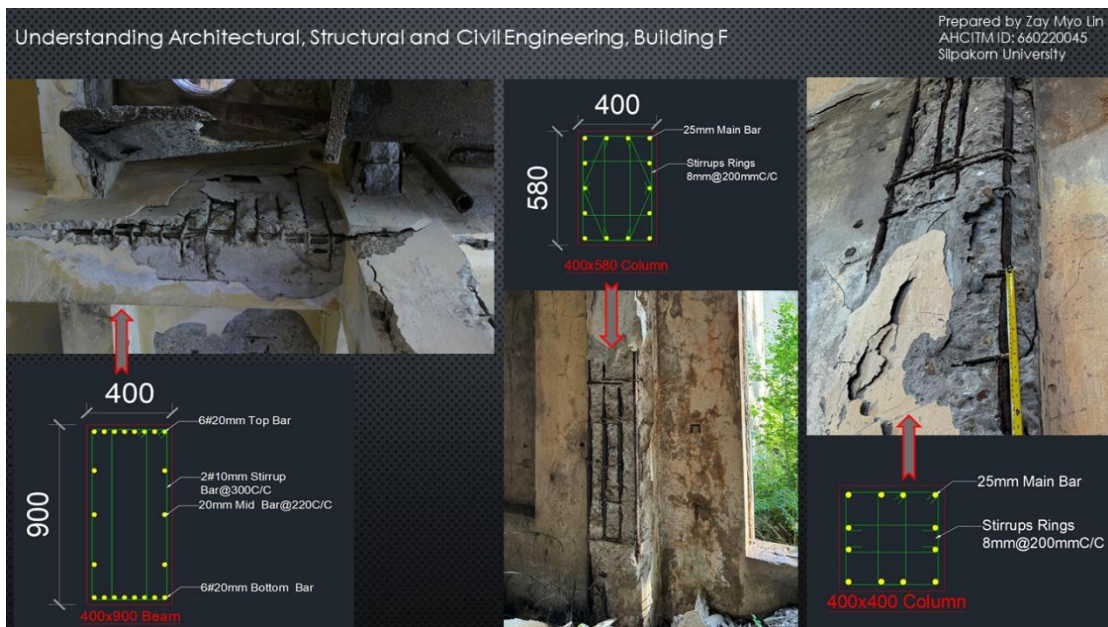


Figure 35: Column, Beam sizes and rebar design most founded at Building F

Photo by Zay Myo Lin (2024)

During the 1930s, the principles of reinforced concrete design were centered on comprehending the synergistic behavior of concrete and steel. Engineers of that era devised techniques to address issues of continuity and refined plate theory for practical use, while also highlighting the significance of grasping equilibrium and the deflected shapes of structural components. The primary role of high Reinforced Concrete columns is to provide structural support and stability to buildings and other constructions. These columns are designed to bear significant loads, ensuring that the weight of the structure is effectively distributed. Additionally, high RC columns contribute to the overall durability and resilience of the building, enabling it to withstand various forces such as wind, seismic activity, and other environmental stresses. Their robust design not only enhances the safety of the structure but also allows for greater architectural flexibility in the design of high ceiling industrial buildings. The primary role of a beam in an industrial building with high ceilings is to provide structural support and stability. Beams are essential components that help distribute the weight of the roof and any overhead loads, ensuring that the building maintains its integrity and safety. They facilitate the transfer of loads to vertical supports, such as columns or walls, thereby allowing for open spaces within the

structure. Additionally, beams contribute to the overall architectural design by enabling the creation of expansive areas free from obstructions, which is particularly beneficial in industrial settings where large machinery and equipment may be utilized.

For this particular building within the compound, reinforced concrete design principles emerged as a significant advancement in construction technology, combining the tensile strength of steel with the compressive strength of concrete. This innovative approach allowed for the creation of structures that were not only more durable but also capable of spanning greater distances without the need for excessive support. The integration of steel reinforcement within concrete elements enabled engineers to optimize material usage, leading to more efficient designs that could withstand various loads and environmental conditions. This period marked a pivotal shift in architectural practices, as the versatility and resilience of reinforced concrete opened new possibilities for modern construction of Thailand and Kanchanaburi.

8.2 Findings on chimney

A chimney, measuring 50 meters in height and 2.8 meters in diameter, was constructed in the 1930s, specifically in 1937, and is likely the tallest industrial chimney in the region. It may have also held the title of the tallest chimney in Thailand during that period. The structure was built using reinforced concrete techniques, and it is plausible that the design was executed by the same structural engineer responsible for Building F (**Figure 36**). The industrial chimney serves a critical function in the realm of manufacturing and energy production by facilitating the safe and efficient expulsion of exhaust gases generated during various processes. Its primary role is to elevate these emissions to a height that allows for their dispersion into the atmosphere, thereby minimizing the concentration of pollutants at ground level and reducing their potential impact on human health and the environment. The design and structure of industrial chimneys are engineered to optimize airflow and enhance the overall efficiency of the combustion process, contributing to improved operational performance and compliance with environmental regulations. Tall chimneys are engineered to emit waste gases and smoke into the upper atmosphere, allowing these emissions to blend with the air and disperse more efficiently. This process helps to diminish the concentration of

pollutants at ground level. Additionally, the residents of Kanchanaburi often remarked that the sight of smoke rising from the chimney of the pulp paper mill was an integral aspect of their daily lives during that period.



Figure 36: Reinforced concrete Industrial Chimney build in 1937
Photo by Zay Myo Lin (2024).

8.3 Overall condition assessment of building F and chimney

Condition assessment principles for an old industrial structure involve a systematic evaluation of its current state to determine its integrity and functionality. This process typically includes a thorough inspection of the building's structural components, such as the foundation, walls, and roof, as well as an analysis of the materials used in construction. Additionally, it encompasses the assessment of mechanical and electrical systems, identifying any signs of deterioration or failure. The goal is to establish a comprehensive understanding of the building's condition, which can inform maintenance strategies, renovation plans, or potential

decommissioning. By applying these principles, stakeholders can make informed decisions regarding the preservation and future use of the industrial facility. **Building F** has been identified as the most severely affected structure within the compound based on a comprehensive evaluation. The damage to the roofing sheets and structural components is primarily attributed to the presence of vegetation; however, the foremost concern arises from inadequate maintenance practices. Regular maintenance checks would have likely prevented the growth of vegetation. Currently, it is estimated that 60% of the roofing has sustained damage due to this vegetation, although the overall roofing failure should be regarded as complete, at 100%. The walls of the structure have been built using both brick and reinforced concrete techniques, with the majority remaining intact, including the facade wall. The internal and partition walls are also in satisfactory condition, with the exception of the external wall on the ground floor, which has been demolished for reasons that are unclear. The lighting, ventilation, and window panels installed on the external walls of the building are still present, although they are not in optimal condition. Conversely, the doors and windows on the internal walls are damaged and non-functional. The concrete flooring on the first level is generally in good shape, although some areas are obscured by debris and bricks. The ground floor's flooring is also largely intact, but approximately 40% of the area is difficult to assess due to safety concerns. Overall, the architectural condition of Building F is considered to be the poorest when compared to other buildings.

Condition assessment principles for an aging industrial structure involve a systematic evaluation of its current state to determine its integrity and functionality. This process typically includes a thorough inspection of the building's structural components, such as the foundation, walls, and roof, as well as an analysis of the materials used in construction. Additionally, it encompasses the assessment of mechanical and electrical systems, identifying any signs of deterioration or failure. The goal is to establish a comprehensive understanding of the building's condition, which can inform maintenance strategies, renovation plans, or potential decommissioning. By applying these principles, stakeholders can make informed decisions regarding the preservation and future use of the industrial facility. The exposed rebar on the columns and beams in the section of the building obscured by

vegetation presents challenges in determining whether the exposure is a result of damage from testing or simply due to the overgrowth. Nevertheless, despite the visible rebar, the columns and beams appear to be aligned correctly, showing no indications of bending or leaning upon visual inspection. Additionally, remnants of an internal brick structure on the ground floor and first level are found in a state of disrepair (**Figure 37**). The specific usage and function of each structural element remain difficult to ascertain due to insufficient documentation.

The chimney exhibits a section of exposed rebar, measuring approximately 1 meter by 0.3 meters, located about half a meter above ground level. Additionally, there is a noticeable crack line on the surface; however, its identification is complicated by potential damage from testing, weather conditions, or seismic activity, refer to (**Figure 36**).

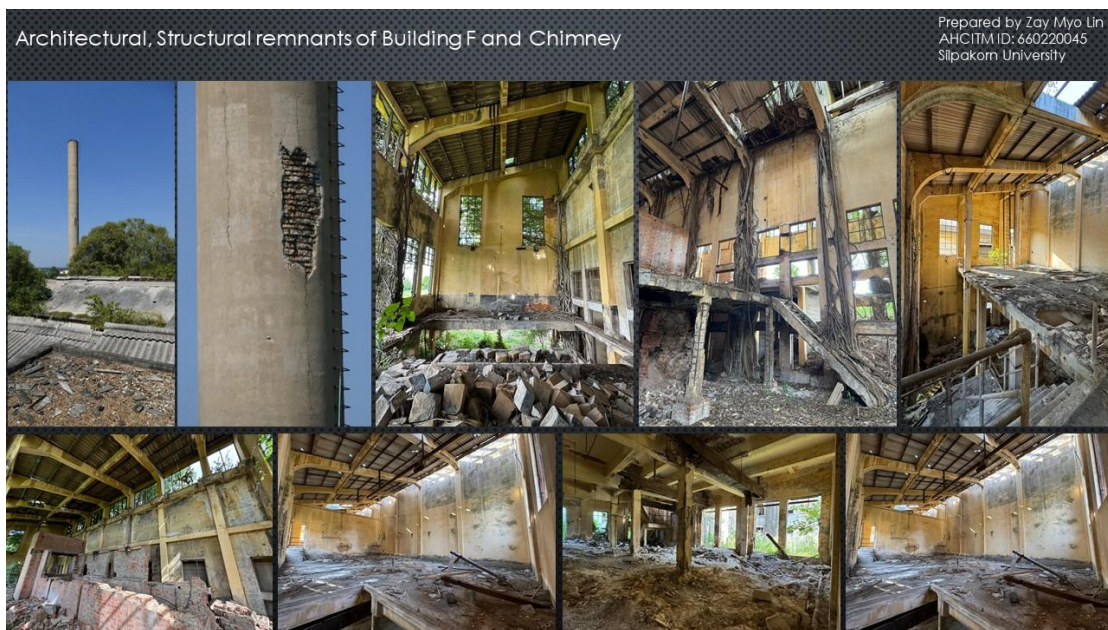


Figure 37: Architectural and structural remnants of Building and Chimney
Photo by Zay Myo Lin (2024).

8.4 Recommendation on building F

The immediate priority is to apply a protective coating, such as paint or epoxy, to the exposed rebars in the columns and beams. Epoxy or protective coatings serve as a vital solution for safeguarding corroded steel surfaces. These specialized

paints are formulated to create a robust barrier that prevents moisture and corrosive elements from further deteriorating the metal. By adhering firmly to the steel, epoxy coatings not only enhance the aesthetic appeal of the surface but also significantly extend the lifespan of the underlying material. Their chemical resistance and durability make them an ideal choice for various applications, particularly in environments prone to corrosion. This measure aims to prevent further corrosion while preserving the current state of the structure for future research and structural assessments. Additionally, showcasing the original dimensions and designs of the columns and rebars will serve to educate both the public and academic institutions about the construction techniques and methodologies employed in 1937. It is not essential to restore these elements with cement, which would obscure their original form. The primary goal is to ensure the preservation and conservation of the structure in its existing condition.

The second priority involves conducting thorough housekeeping on the site, which includes the removal of debris and the organization of leftover materials to facilitate the application of protective paint. Implementing effective housekeeping measures will enhance ventilation, improve air circulation, and promote air exchange within the building, thereby aiding in the prevention of corrosion on the exposed rebar in columns and beams. Housekeeping plays a crucial role in the maintenance and preservation of industrial heritage buildings. These structures, often rich in historical significance, require diligent care to ensure their longevity and integrity. Effective housekeeping practices not only help in safeguarding the physical condition of the building but also contribute to the overall visitor experience by creating a clean and organized environment. Furthermore, regular maintenance activities, such as cleaning and minor repairs, can prevent deterioration and damage, thereby protecting the cultural and historical value of these sites for future generations. In essence, proper housekeeping is integral to the stewardship of industrial heritage, ensuring that these important landmarks remain accessible and appreciated.

The third priority is restoration of roofing is a crucial aspect of preserving industrial heritage buildings. These structures often hold significant historical and cultural value, and maintaining their roofs is essential to protect them from deterioration caused by environmental factors. A well-preserved roof not only

safeguards the integrity of the building but also enhances its aesthetic appeal and ensures its longevity. By investing in the restoration of roofing, we contribute to the conservation of our industrial past, allowing future generations to appreciate and learn from these architectural landmarks.

The fourth priority is restoration of doors and windows in industrial heritage buildings is crucial for several reasons. Firstly, these elements are integral to the architectural integrity and historical significance of the structure, reflecting the design and craftsmanship of the era in which they were built. Preserving and restoring these features not only enhances the aesthetic appeal of the building but also contributes to its overall structural stability. Furthermore, maintaining original doors and windows can improve energy efficiency and ensure that the building meets modern safety standards while retaining its historical character. Ultimately, the careful restoration of these components plays a vital role in safeguarding the cultural heritage and identity associated with industrial architecture. The presence of multiple lighting panels, ventilation panels, and transparent glass window panels not only exemplifies the architectural advancements of 1937 but also underscores the building's functional mechanisms. These features facilitate essential functions such as lighting, ventilation, pest management, climate regulation, and access control, thereby enhancing the safety of both the structure and its occupants.

The 50-meter tall chimney has been discovered to have hairline cracks and exposed rebar, particularly in sections above 20 meters from the ground. This condition may necessitate the application of protective paint or epoxy to certain areas, or potentially to the entire structure.

8.5 Discussion on Vegetation at Building F

Vegetation-related challenges in industrial heritage structures refer to the various problems that arise from the growth of plants in and around these historical sites. Such issues can include the deterioration of building materials due to root penetration, moisture retention, and the accumulation of organic matter, which can lead to structural damage and compromise the integrity of the site. Additionally, uncontrolled vegetation can obscure architectural features, hinder accessibility, and pose risks to the preservation of the heritage value of these buildings. Addressing

these concerns is essential for maintaining the historical significance and physical stability of industrial heritage sites.

The vegetation present on Building F plays a crucial role in enhancing both the aesthetic and ecological significance of the structure. This plant life not only enriches the visual landscape but also provides a habitat for diverse species, thereby fostering biodiversity. Furthermore, the incorporation of greenery can alleviate environmental challenges, such as lowering urban heat and enhancing air quality. By integrating vegetation into the landscapes of industrial heritage sites, we can achieve a harmonious coexistence between nature and historical architecture, which deepens our appreciation for both the environment and our cultural heritage. Moreover, the roots that have developed on the building's walls and roof create unique natural artworks (**Figure 38**). Consequently, a thorough evaluation is necessary to determine whether these roots and plants should be preserved or removed.

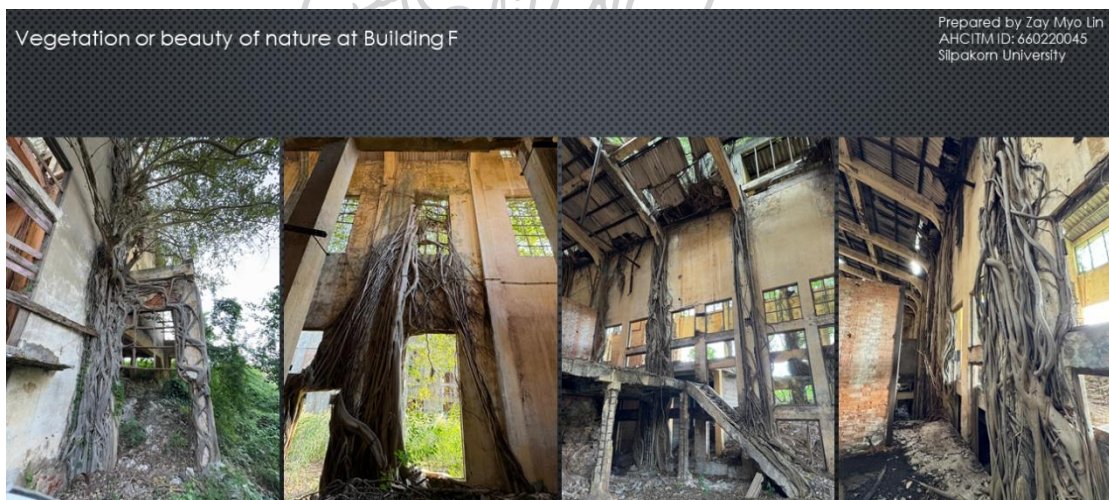


Figure 38: Vegetation at Building F

Photo by Zay Myo Lin (2024).

CHAPTER 9

OVERALL RECOMMENDATION

The Kanchanaburi paper mill stands as a significant industrial heritage site in Thailand, regardless of the identities of the architects and engineers involved in its creation. Established in 1937, it is recognized as the second paper mill in the history of Thai industry and the first fully integrated paper mill in Southeast Asia. The site retains its authenticity, with all industrial machinery, equipment, and accessories preserved in their original locations, and the building itself has remained largely unchanged since its construction. Architecturally, the mill represents a pioneering phase in modern architecture, showcasing innovative design principles. From an engineering perspective, it exemplifies exceptional civil and structural methods employed during its construction in 1937. The mill's historical significance is further underscored by its role in the production of pulp paper, which are vital to the functioning of a nation. To enhance its potential for recognition as a UNESCO World Heritage site, further research is essential to uncover the missing links and evidence related to the architects and engineers involved in this landmark project.



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