



Rehabilitation of the Elephant Heads Bridge with Preservation Best Practices Aiming to Revive Its Historical Significance

Bhatraradej Witchayangkoon^{1,2}, Pisit Thongjub^{1*}, Kritsada Anantakarn³,
Yasser Arab⁴, Ahmad Sanusi Hassan⁵, Koltouch Anantakarn^{1*}

¹Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, Rangsit, THAILAND.

²Thammasat University Research Unit in Climate Change and Sustainability, Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, THAILAND.

³Faculty of Engineering and Architecture, Rajamangala University of Technology Tawan-ok, Uthenthawai Campus, THAILAND.

⁴Department of Architectural Engineering, Dhofar University, Salalah, SULTANATE of OMAN.

⁵School of Housing, Building & Planning, Universities Sains Malaysia, MALAYSIA.

*Corresponding Author (Email: tpisit@engr.tu.ac.th,).

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Abstract

Chaloemla 56 Bridge, popularly known as the Elephant Head Bridge, is a RC bridge that was constructed over a century ago in the heart of Bangkok, Thailand. This historic bridge features a unique vertical curve. One of its distinctive features is the presence of four-column statues, each adorned with four white elephant heads on every side of the square column. These statues are positioned in pairs on both sides of the bridge. Initially accommodated two-way traffic with a total of six lanes, the bridge was later expanded to eight lanes after its reconstruction. This study focused on reviewing and understanding the construction and preservation techniques employed during the bridge's expansion to cater to the demands of modern heavy traffic. The construction contractor was entrusted with the responsibility of ensuring the preservation of the four statues with white elephant heads, and their reinstatement was an integral part of the project. The rehabilitation process followed the principles of the Preservation Best Practice (PBP) concept, emphasizing the importance of maintaining historical elements while incorporating modern infrastructure requirements.

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1 Introduction

A bridge is a constructed structure designed to traverse a physical obstacle, such as a body of water, valley, road, or railway, without obstructing the paths beneath it. The lifespan of a bridge typically ranges from 25 to 80 years or more, depending on factors such as location, materials used, and environmental conditions (Wikipedia, 2024a). Traffic bridges are subjected to dynamic loadings caused by moving vehicles and their speeds, which can lead to vibrations. Over time, bridges deteriorate gradually, necessitating the monitoring of their structural health to assess their conditions and determine the extent of maintenance required, including potential rehabilitation through repair or reconstruction.

According to NPS (2024), rehabilitation refers to the process or actions taken to enable a property to be used in a compatible manner through repairs, modifications, and enhancements, while preserving its historical, cultural, or architectural significance. Preservation, on the other hand, involves protecting properties to prevent further damage or destruction, such as safeguarding them from exploitation.

In this study, the Chaloemla 56 Bridge (also known as the Elephant Head Bridge) was chosen as a case study for rehabilitation using preservation best practices (PBP). This bridge holds historical significance related to His Majesty King Chulalongkorn (King Rama V) and is an arch-road reinforced concrete bridge. Despite being built a century ago in central Bangkok, Thailand, the Chaloemla 56 Bridge still maintains its aesthetic appeal. However, as traffic in Bangkok has steadily increased over time due to the city's expansion, the bridge now serves a growing number of vehicles on a daily basis.

The Bangkok Metropolitan Administration (BMA) commissioned a study, evaluation, and assessment of the Chaloemla 56 Bridge. Given that the bridge has exceeded its intended lifespan and is deteriorating at an accelerated rate, rehabilitation is crucial to ensure its continued functionality.

2 Literature Review

US-DoT (2009) pointed that the conservation of historic bridges plays a crucial role in the maintenance and protection of the country's transportation infrastructure, which is intertwined with the roots of our society. Leshko & Tunstall (2004) studied the Eklutna River Bridge in north of Anchorage, Alaska, a historic three-span structure with two multiple I-beam approaches and a unique arched deck truss main span. The main span features a complex geometry with three truss lines, canted exterior trusses, and an arched bottom chord. The study delves into the finite element modeling and structural analysis conducted, as well as outlines the primary rehabilitation tasks carried out. These tasks encompassed repairing existing deterioration, widening the deck to accommodate both vehicle and bicycle traffic with new bridge railings, enhancing the live load capacity to HS20, and fortifying the structure against seismic loads. Throughout the rehabilitation process, utmost care was taken to preserve the historical significance of this structure.

According to Walker (2009), in Texas 384 historic bridges have been identified for preservation. Due to the increasing demands on transportation infrastructure, many of these bridges are at risk of abandonment or destruction as efforts are made to remove structurally deficient and functionally obsolete bridges. In the 1990s, The Texas Department of Transportation (TxDOT) launched a proactive program to protect historic bridges. Through interdisciplinary teams and consensus-based objectives, preservation strategies were developed for three main outcomes: maintaining full vehicular service, reducing vehicular service, or adapting for non-vehicular use. With these strategies, TxDOT has successfully restored and prolonged the life of numerous historic bridges in Texas over the past decade. Walker (2009) highlighted some achievements to showcase the effective implementation of preservation strategies.

Puls (2013) presented a framework for bridge planning and management strategies in the face of limited funding. Effective management of historic bridges requires the inclusion of crucial elements such as timely identification of flaws, proactive maintenance, assessment of conditions beyond routine inspections, modification of evaluation techniques, and the application of engineering expertise when utilizing numerical evaluation methods.

Bowman & Moran (2015) discussed the importance of bridge preservation treatments and best practices within a strategic preventive maintenance program. This program aimed to preserve and prolong the service life of bridges while reducing costs. It involved regularly conducting cost-effective preventive maintenance tasks.

Sirimontree et al. (2016) conducted a study on a contemporary continuous segmental prestressed concrete bridge, focusing on the measurement of tendon natural frequency and its impact on tendon forces. After the bridge was inaugurated, it was observed that cracks and spalling of concrete occurred at the dry joints of precast segments after six months. Moreover, there was a noticeable increase in bridge deflection. Visible joint openings were also evident, especially when heavy vehicles passed by. However, it is important to note that the opposite side of the bridge span remained in good condition. The primary concern is whether these issues affect the strength and functionality of the bridge. To address this concern, a comprehensive study was initiated, involving visual inspection and measurement of tendon natural frequency. Data was collected for further analysis and potential retrofitting measures.

Ruiz et al. (2018) discussed the curricula of civil engineering institutions need to emphasize the territorial aspect of public works by incorporating educational programs that raise awareness among engineering students about the historical significance and cultural heritage of transportation networks and infrastructure. This can be achieved through teaching methods that focus on the history and aesthetics of civil engineering. In line with the principles of project-based learning (PBL), students engage in research, mapping exercises, and on-site investigations to formulate a plan for recognizing, evaluating, and preserving a contemporary road with historical importance.

Ismail (2021) delineated the variations in traditional house typology in Negeri Sembilan in Malaysia. These design differences reflect specific purposes that are closely tied to the culture and customs practiced by the local community. The research encompassed multiple villages in Negeri Sembilan, Malaysia. Data was gathered through observation, interviews, surveys, and photography. This study aims to educate and serve as a point of reference for the younger generation, enabling them to develop a deeper understanding of their traditional architectural heritage in Malaysia, particularly in Negeri Sembilan. Preserving and upholding the identity and uniqueness of Negeri Sembilan traditional houses is becoming increasingly challenging, and it is our responsibility to ensure their preservation and prevent their disappearance.

MnDOT (2024) emphasized the significance of bridge rehabilitation in preserving historic structures to ensure their continued use by vehicles, bicyclists, and pedestrians. Rehabilitation involves repairing and improving the structural and mechanical components of the bridge. By implementing regular rehabilitation efforts and consistent maintenance, a historic bridge can remain in service for a century or more. In the United States, the rehabilitation work on historic bridges must adhere to the federal requirements outlined in "the Secretary of the Interior's Standards for the Treatment of Historic Properties (the Secretary's Standards)".

Numerous road infrastructure bridges are currently undergoing inspections in Thailand to assess any potential damage. For instance, Tipagornwong et al. (2022) conducted a study on the structural evaluation and rehabilitation of a balanced cantilever bridge equipped with center hinges. On the other hand, Heritage Strategies (LLC) (2024) has developed a comprehensive guideline for the preservation of historic sites, specifically focusing on the town of Wellesley, Massachusetts, USA. This guideline encompasses various aspects, including design principles for historic preservation, preservation techniques for historic building materials, and the treatment of historical building features. Additionally, the guideline also addresses the topic of additions, new construction, and site features.

3 Historical Context of the Chalermkla 56 Bridge

Chalermkla 56 Bridge, commonly known as Saphān Hua Chang (in the Thai language), remains in existence. The Bangkok Government (BMA) has made diligent efforts to maintain the bridge's original appearance. Despite the expansion of the road, the bridge requires rehabilitation to cater to the nation's progress and the growing congestion in transportation.

3.1 Significant Historical Attributes of the Chalermkla 56 Bridge

The Chalermkla 56 Bridge holds significant historical value as it was commissioned by His Majesty King Chulalongkorn to commemorate his 56th birthday. Constructed using reinforced concrete, the bridge showcases exquisite craftsmanship with its curved concrete beams and intricate details. Notably, the bridge features four statues of elephant heads, one on each corner, adorned on all four sides. Additionally, the bars of the bridge are designed in the fashion of a

western balustrade. Adding to its regal charm, the bridge proudly displays the royal monogram Jor Por Ror in Thai royal script letters at its center.



Figure 1: The original Chaloemla 56 Bridge.
Geocoordinates (13.749189, 100.531187).

Sources: The image is used under the Creative Commons license, which can be accessed on <http://commons.wikimedia.org/w/index.php?curid=129233>

PBS (2023) provided an explanation regarding the significance of white elephants in Thailand. Thailand has a deep admiration and reverence for elephants, which can be observed in various aspects of Thai culture such as old Thai coins, national flags, beer bottles, and architecture. Among these elephants, the white elephants hold a special place. Despite their name, white elephants are actually light brown or beige in color. They are considered sacred animals, symbolizing Thailand's distinct culture and beliefs, and are utilized in important Royal ceremonies. Presently, there are only 10 white elephants remaining in Thailand, residing at the Thai Elephant Conservation Center in Lumpang province.

His Majesty King Chulalongkorn (King Rama V) oversaw the inauguration of the bridge on 15 November 1909, coinciding with the age His Majesty King Buddha Lertla Napalai (King Rama II) reached during that year. In honor of this, a royal ceremony was held by His Majesty to commemorate the auspicious birthday of King Rama II and to pay tribute to Wat Arun Ratchawararam. Due to His Majesty King Rama II possessing four white elephants, the Chaloemla 56 Bridge was named after His Majesty King Rama II (King Buddha Lertla Napalai), with the bridge's pillars being adorned with designs of four white elephant heads.

3.2 Characteristic Feature of the Chaloemla 56 Bridge

The Chaloemla 56 Bridge, also known as Hua Chang Bridge or Elephant Heads Bridge, has stood for more than a hundred years. Situated on Phaya Thai Road in central Bangkok, it is in close proximity to Saphum Palace and key business areas like Siam Square, Siam Discovery, Siam Center, and Siam Paragon. This reinforced concrete bridge runs north-south over the Saen Saeb Canal. Prior to its renovation, the bridge spanned 28 meters in length and accommodated five lanes of traffic, with a width of 14 meters.

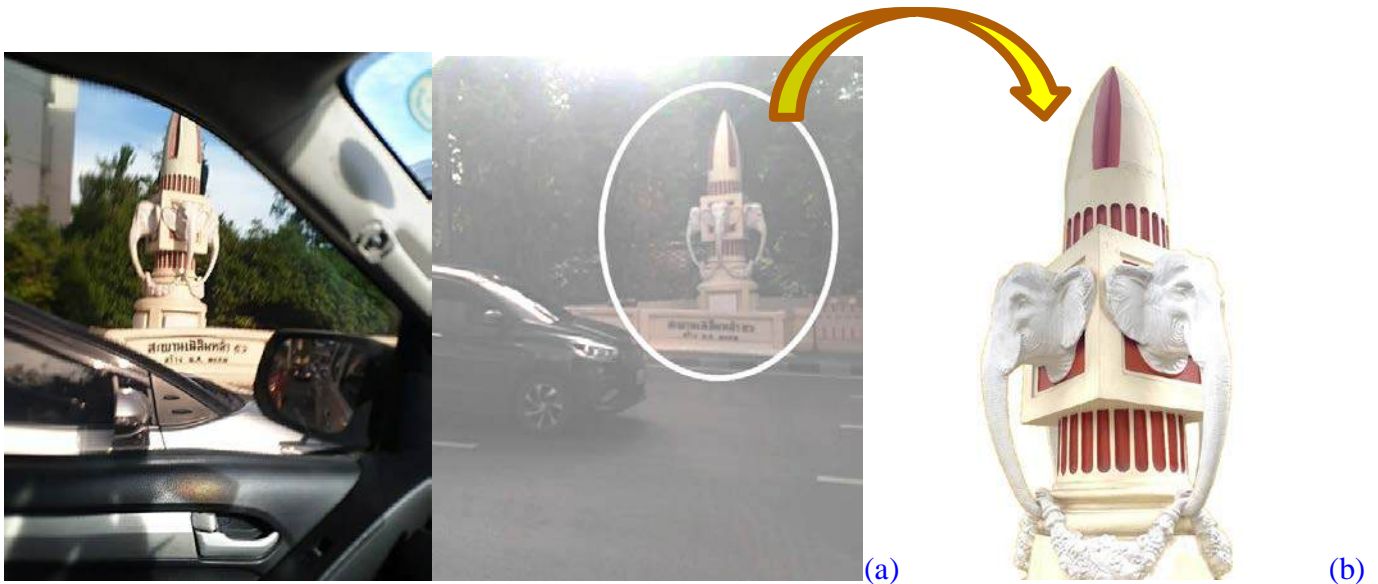


Figure 2: Elephant heads available from the Chaloemla 56 Bridge.
(photo (b) is licensed under the Creative Commons, accessible from [wikimedia.org](https://www.wikimedia.org))

4 Preservation Best Practices (PBP) for Historic Structures

Various conservation methods are necessary for the proper upkeep of historic buildings, sites, and landscapes, as they contribute to the long-term development of cities and neighborhoods. Implementing preservation best practices (PBP) involves a wide spectrum of approaches, from meticulously restoring the original historic elements of a building/structure at a micro-level to fostering community growth and revitalization at a macro-level through strategic reinvestment (HS, 2024). To maintain the original historic and architectural character, it is important to make sound choices before and during the renovation project. WHS (2024) provides best practices to guide toward genuine preservation, i.e., preserve the original architectural style, adhere to the authentic design, abide by preservation principles when conducting maintenance and repairs, and substituting with materials that match if repair is not feasible.

To preserving historic structures, LE (2024) recommended key strategies such as to perform a comprehensive evaluation by cooperating with specialists in preservation, to integrate the old and new elements flawlessly, involve the local community, and safeguard the distinctive characteristics of the building

Figure 3 shows Standards for Rehabilitation (NPS, 2024). This study adopted the guild line given in Figure 3.

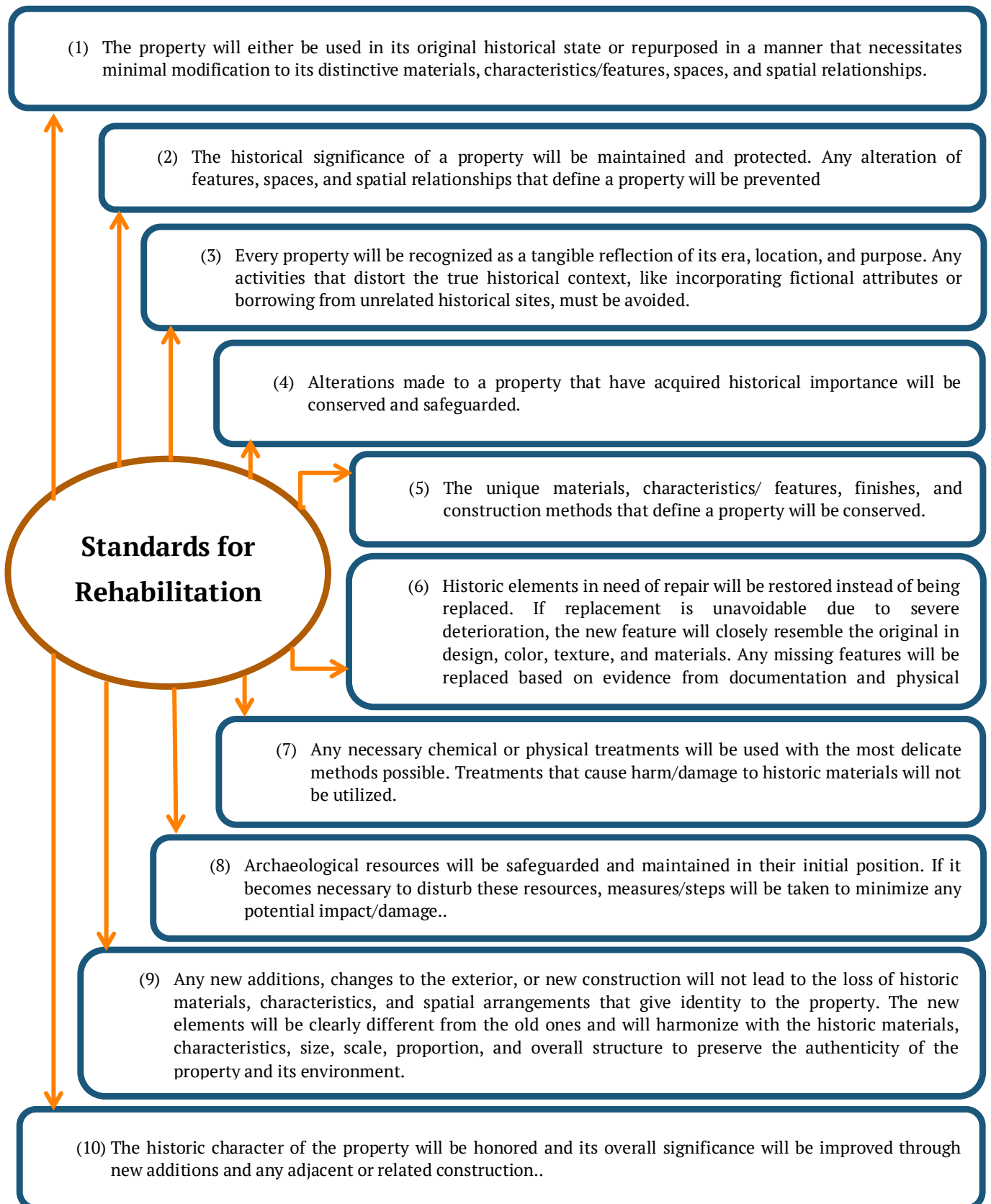


Figure 3: The PBP-based US Secretary of the Interior's Standards for the Treatment of Historic Properties: Rehabilitation as a Treatment and Standards for Rehabilitation (NPS, 2024).

5 Method

5.1 Community Opinion Survey

BMA conducted the Community Opinion Survey (COS) with a sample size of 100 respondents. This randomized and scientifically reliable survey allowed residents to share their feedback on their satisfaction with BMA services and activities.

The COS survey findings revealed that an overwhelming majority of Bangkok residents, nine out of ten (92%), expressed great satisfaction with the BMA's rehabilitation project for the Chaloemla 56 Bridge, particularly appreciating the preservation of the symbolic elephant heads. The key takeaways from the survey highlight that residents highly prioritize culture (92%), lifestyle (93%), and safety (95%). Therefore, the Chaloemla 56 Bridge rehabilitation project may proceed.

5.2 Technical Factors

Preservation of the heritage bridge, specifically the four elephant head statues, is achievable through structural rehabilitation under the existing technology. Various design alternatives have been evaluated, focusing on determining the appropriate width and quantity of traffic lanes for the reconstructed bridge. The primary concern lies in safeguarding the four elephant head statues from harm while they are being disassembled and reassembled.

5.2.1 Span of the Rebuilt Bridge

The rebuilt Chaloemla 56 Bridge is longer than the original Chaloemla 56 Bridge bridge, see Figure 4. This produces no aesthetic effect on the neighborhood and the Sapathum Palace.

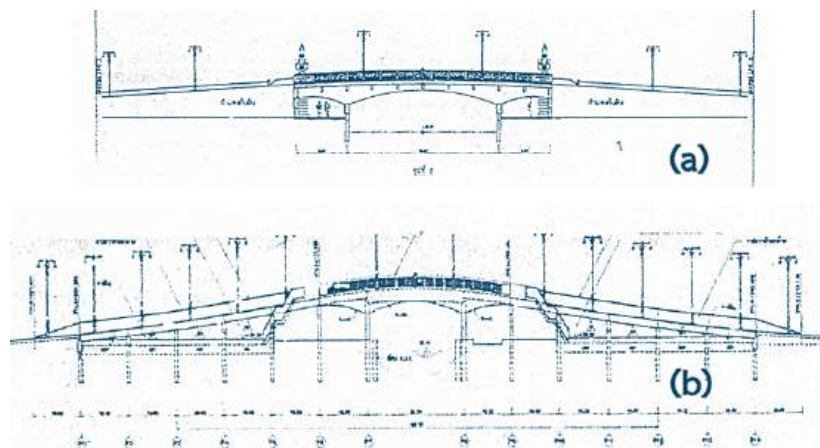


Figure 4: Chaloemla 56 Bridge (a) before and (b) after the rebuilt/rehabilitation.

5.2.2 Pedestrian Sidewalks & Increased Number of Traffic Lanes

The Chaloemla 56 Bridge has been reconstructed to allow for an 8-lane traffic flow, measuring 23m wide and 40m long. Pedestrian walkways, each 1.5m wide, are positioned on both sides of the bridge. With an increased number of lanes from five to eight, the widened bridge ensures a seamless driving experience for vehicles.

5.2.3 Cementitious Grout

The special cementitious grouting material utilized in this rehabilitation project is a cement-based, non-metallic, nonshrink grout that includes well-graded, natural, fine aggregate and other meticulously chosen components (quartz silica 70%, portland cement 20%, fly ash 10%). The commercial brand was IN-PAKT® (Sika, 2024). It is suitable for grouting base plates and column sole plates, as well as for grouting anchor bolts, dowels, handrails, and repairing pre-cast units. It is possible to mix and place the mixed materials with dry pack, plastic, and fluid consistencies by utilizing water:cement ratios that are relatively low. Prior to applying this grouting material, it is important to ensure that all surfaces are free from dust, oil, grease, or any other foreign substances that could affect the bond of the material. Then remove any delaminated or unsound concrete to create a roughened surface. After that, clean the repair area with potable water, ensuring the concrete is saturated but without standing water.

Table 1: Important properties of grouting cement used in the rehabilitation project.

Properties	Condition	Mixed state		
		Dry pack	Plastic	Fluid
Volumn of water	Per 25Kg grouting cement	2.45L	3.35L	3.7L
Working time (hr)		<0.5	1.0	1.0
Set time (hr)	Initial	0.6	3.0	4.0
	Final	1.0	4.5	6.5
Compressive strength (MPa)	1-day	34	24	20
	7-day	50	35	30
	28-day	65	40	35

Proper curing is crucial for enhancing the physical characteristics of concrete and reducing plastic shrinkage. The curing was done as soon as the material had achieved its initial set or as soon as the forms had been removed, following the guidelines outlined in ACI 308 "Guide to Curing Concrete". It was important to maintain a continuous moist curing process for a minimum of 7 days, with the utmost effectiveness lasting up to 28 days.

More information regarding the traffic management and construction phase during the rebuilt construction is available from Witchayangkoon et al. (2024).

5.2.4 Disassembly and Reinstallation of Statues of Elephant Heads

The process of dismantling and reinstalling the elephant head statues involves the use of a steel framework designed to safeguard each statue from potential damage during the disassembly phase, followed by their careful reinstallation. Figure 5 also shows details and dimensions.

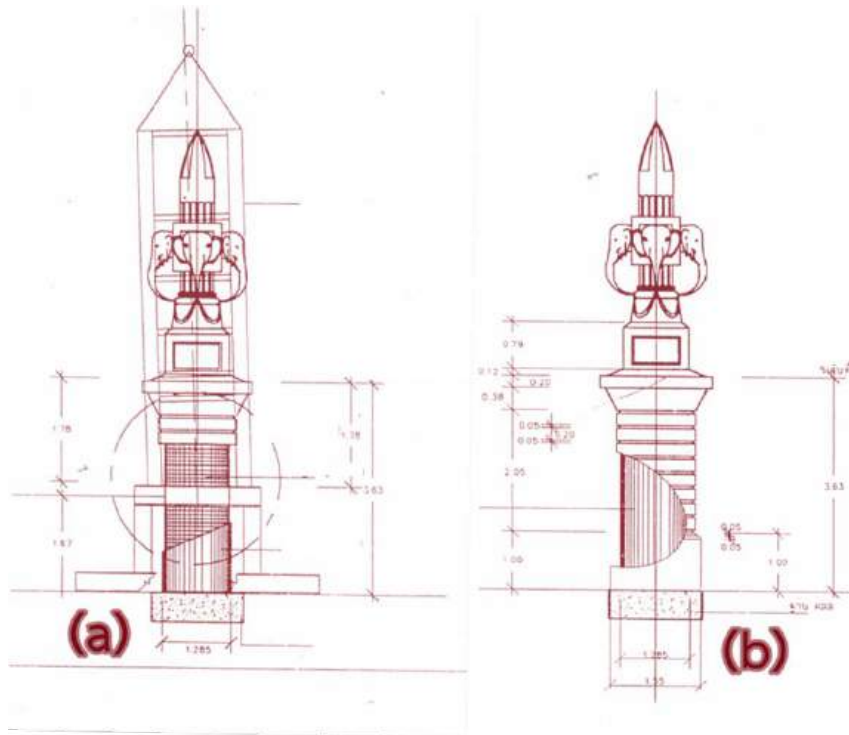


Figure 5: Steel framed elephant head statue before dismantlement (side view).

6 Results & Discussion

The successful execution of the Elephant Head Bridge, also known as the Chaloemla 56 Bridge, rehabilitation project has led to enhanced aesthetics, livability, and seamless integration with the nearby BTS Skytrain route.

6.1 Sustainable Transportation

Sustainable transportation involves modes of transportation that are socially and environmentally sustainable, evaluated based on the effectiveness and efficiency of the transportation system, as well as its environmental and climate impacts (Wikipedia, 2024b; Jeon and Amekudzi, 2005). The original Chaloemla 56 Bridge led to traffic congestion due to its narrow structure with only five lanes, causing bottlenecks and potential accidents. The reconstructed Chaloemla 56 Bridge has eight lanes, resulting in improved traffic flow and reduced emissions. This demonstrates that the system is now more effective, efficient, and environmentally friendly.

6.2 Strengthening the Community & Enhancing Social Sustainability

According to SocialLife Co. (2021), social sustainability involves the creation of thriving and enduring communities that prioritize the well-being of individuals. It entails comprehending the needs of people in the places they reside and work, and integrating the design of physical spaces with the design of social structures. This includes developing infrastructure that facilitates social and cultural activities, providing social amenities, establishing mechanisms for citizen participation, and allowing for the growth and development of both individuals and communities. According to the Western Australia Council of Social Services (WACOSS, 2020), social sustainability is achieved when both formal and informal processes, systems, structures, and relationships

actively contribute to the ability of present and future generations to establish vibrant and livable societies.

The restoration initiative of the esteemed Chaloemla 56 Bridge not only fosters stronger connections among the local community but also revitalizes the city of Bangkok with renewed vitality. By preserving this historical landmark, we pay homage to the past and acknowledge the graciousness of His Majesty King Rama V. This preservation effort allows Thai people to maintain a connection with their roots, thereby enriching their sense of identity and promoting a harmonious and resilient social fabric, characterized by social solidarity and cohesion. As a result, this bond nurtures psychological well-being and cultivates a heightened sense of unity within Thai communities.

7 Conclusion

Holding historical structures in development initiatives is a rewarding endeavor that allows for the preservation of local heritage while creating vibrant historical landmarks. By utilizing Preservation Best Practices (PBP) and working closely with preservation experts and the community, it is possible to incorporate historical structures into development projects, ensuring a lasting legacy for future generations. Each historical structure holds a piece of history that can be seamlessly integrated into modern times, enriching the built environment and fostering a sense of connection to our collective past. The rehabilitation of all four elephant head statues using PBP techniques has successfully revitalized the Elephant Head Bridge, improving its visual appeal, functionality, and integration with the BTS Skytrain route in the area.

8 Availability of Data and Material

All information is included in this work.

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Bhatraradej (Boonsap) Witchayangkoon is an Associate Professor of Department of Civil Engineering at Thammasat School of Engineering, Thammasat University. He received his B.Eng. from King Mongkut's University of Technology Thonburi with Honors. He continued his PhD study at University of Maine, USA, where he obtained his PhD in Spatial Information Science & Engineering. Dr. Witchayangkoon interests involve Applications of Emerging Technologies to Engineering.



Pisit Thongjub serves as a Laboratory Officer in the Department of Civil Engineering at Thammasat School of Engineering, Thammasat University, Thailand, where he also earned his Master's degree in Civil Engineering. His research interests include Civil Engineering, Management, and Technology.



Dr. Kritsada Anantakarn is an Assistant Professor at the Department of Civil Engineering Technology, Faculty of Engineering and Architectures, Rajamangala University of Technology Tawan-ok, Uthenthawai Campus, Thailand. He earned his Bachelor of Engineering (Civil Engineering) from Rajamangala Institute of Engineering, and a Master's degree in Urban and Environmental Planning from King Mongkut's Institute of Technology Ladkrabang, and a PhD from Thammasat University. He is interested in GPS/GNSS, Spatial Engineering & Technology.



Dr. Yasser Arab is an Assistant Professor at the Department of Architectural Engineering, College of Engineering, Dhofar University, Oman. He obtained his Bachelor of Architecture from Ittihad Private University, Aleppo, Syria. He obtained his Master's and PhD in Sustainable Architecture from Universiti Sains Malaysia (USM), Penang, Malaysia. His research focused on the Environment Performance of Residential High-Rise Buildings' Façade in Malaysia. He teaches Studio for first-year students and is involved in supervising student of Master of Architecture and Urban Design. He is a Registered Architect in the Syrian Engineers Union. He is very active in research and publication, he published over 50 journal papers, book chapters and conference proceedings.



Professor Dr Ahmad Sanusi Hassan is a Professor in the Architecture Programme at the School of Housing, Building and Planning, Universiti Sains Malaysia (USM), Penang, Malaysia. He obtained his Doctor of Philosophy (PhD) degree from the University of Nottingham, United Kingdom. His research focuses on sustainable architecture and urban design development for Southeast Asia, history and theory of architecture, daylighting and thermal comfort.



Koltouch Anantakarn is a student at Thammasat University. He received a Master of Engineering from Rajamangala University of Technology Tawan-ok, Uthenthawai Campus, Thailand and a Bachelor of Engineering in Civil Engineering from King Mongkut Institute of Technology Ladkrabang. His research focus on GPS/GNSS Surveying Engineering and Spatial Technology.
