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Analysis of sustainable architecture components in Fujian architecture

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ABSTRACT

One of the most tangible aspects of Southern Fujianese culture is its traditional architecture, known for its vibrant colors, ornate designs, and exaggerated forms. Despite its cultural significance, appreciation for heritage architecture has declined over the decades. In Malaysia, many Hokkien heritage buildings reflect a blend of traditional Chinese, colonial, and local Malay architectural influences. However, there is limited research on how Hokkien architectural components contribute to sustainability. This paper addresses this gap by examining sustainable elements in Hokkien architecture, particularly in the Peranakan-style Blue Mansion (Cheong Fatt Tze). The study analyses architectural features such as the gable roof structure, ridge beasts, and decorative "Chien Nien" and "Chai Hui" on the façade to understand their role in achieving sustainability. Data collected through case studies and site observations at the Blue Mansion are discussed, highlighting how these components contribute to architectural sustainability. This research is crucial as it delves into the sustainable aspects of Hokkien architecture within a Peranakan context, providing insights into Fujian's cultural heritage and its application in sustainable design.

Introduction

The influx of Southern Fujian culture into Malaysia

The province of Fujian, which is on China's southeast coast, features a long coastline that is suitable for maritime trade. There are three important harbors were set up for trading in the Golden Triangle of Quanzhou, Zhangzhou, and Xiamen (figure 1). Southern Fujianese, also known as "Minnan" Chinese, are renowned for their expertise in commerce and navigation. The significant emigration of Southern Fujianese in the 17th century can be attributed to their advantageous geographic position, advanced maritime infrastructure and technology, and active involvement in international trade. This international commerce facilitated the spread of Southern Fujian culture to other countries (Koh and Lim 2022).

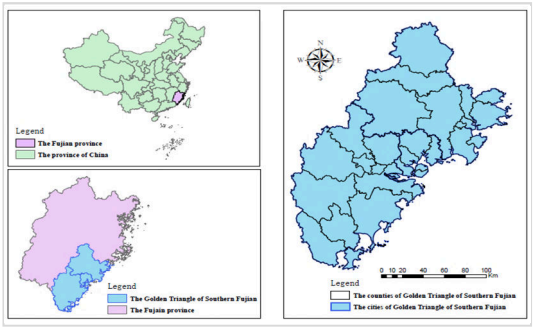

Figure 1. The golden triangle in Fujian, China

The first Chinese immigrants to establish colonies in Malaya were the Southern Fujianese, also known as Hokkien. The traditional Chinese

architecture in Malaya, particularly in clan houses and shophouses, shows the cultural tradition and architectural style of southeast China, the region where the Southern Fujianese originated (Armani and Arbi 2014). Immigrants built temples and shophouses based on the designs of their homeland, replicating the architectural shapes and styles of Southern Fujian in their Malaysian settlements (Widodo 2018).

Sustainable architectural components

To achieve architectural sustainability, the passive design approach incorporates environmental elements like wind, sunlight, humidity, and heat into the early stages of housing design. Certain traditional Hokkien residential buildings consist of extensive ancestral knowledge on adapting to specific climates (Sun, Wang, and Zheng 2022). Passive design and green buildings share similarities with ancient Hokkien architecture as they primarily rely on building components and focus on the shape, materials, colours, and construction details to enhance the building's interaction with natural conditions (Huang et al. 2024).

Problem statement

Living in a diverse culture, people often fail to appreciate the historical significance of ancient architecture, colonial structures, and artifacts. Malaysian Hokkien culture, originating from southern Fujian, China, has notably influenced local architectural styles, blending traditional Chinese, colonial, and Malay elements. However, there is a lack of studies on how Hokkien architectural components achieve sustainable goals in Malaysia. Previous studies have focused mainly on the temple and Kongsi's roof structures, neglecting other building elements like shape, color, materials, and sustainability. This paper addresses this gap by examining sustainable components of Hokkien architecture, particularly the Minnan red-brick residential buildings in Fujian, and their influence on Peranakan architecture, to develop a new conceptual framework for understanding sustainable Hokkien architecture in The Blue Mansion. The main objective of the study is to examine the architectural components in southern Fujian ancient red-brick residential buildings in China, and analyse the architectural components and the Hokkien influences in The Blue Mansion, Penang.

Literature review

This section will discuss the building components of Southern Fujian (Minnan) architecture.

Architectural color

The Fujian historic buildings, despite their simplicity, possess a distinct and strong character, with walls painted in vibrant red, evoking a sense of elegance and grandeur. The ambiance closely resembles of an old palace. Such a warm red-orange tiled residential community is rarely seen in other buildings around the world (figure 2) (Jin 2016). There is limited research on the historical origin of Minnan architecture's red color. When the imperial legislation was issued, the people of Quanzhou mistakenly believed that the local government allow them to construct palace-style architecture. As a result, they began to build structures resembling palaces and painted their buildings red, thinking it was a simple symbol of status and wealth. The first instance of this misconception was uncovered when a replica of the "Palace" was constructed on the outskirts of Quanzhou in Nanan (Xia and Chiou 2015).

Figure 2. Red-brick wall and red roof tile of Quanzhou and Zhangzhou's ancient dwellings
Source: I3CSEE: International Conference on Civil, Structure, Environmental Engineering 2016

Local materials in architecture

From an architectural perspective, ancient dwellings demonstrate a pronounced focus on the embellishment and ornamentation of brick walls. The red brick walls in the southern region of Fujian exemplify a unique aesthetic characteristic of the area, contributing to the distinctive style of Southern Fujian. The Minnan regions have abundant natural resources, including minerals like limestone and kaolinite, and are surrounded by sea and mountains. Due to the subtropical climate, the soils in these regions consist mainly of red and clay soils (Cao 2008). The red bricks primarily used in Minnan's ancient buildings

originated from Shima, Zhangzhou, while white stone materials were sourced from Quanzhou (figure 3) (Ye and Tao 2022).

Figure 3. Red brick wall facade with white granite base
Source: ICHE: International Conference on Humanities and Education 2022 (Ye and Tao 2022)

The utilization of local materials in constructing ancient dwellings effectively reduced energy consumption and costs, thereby fostering sustainable architecture. Some ancient Minnan buildings featured striking and elegant exotic tiles on their façades. The Chang brothers introduced Southeast culture to architecture via their abroad business endeavors, which were represented by the Philippine tiles (figures 4) (Xia and Chiou 2015).

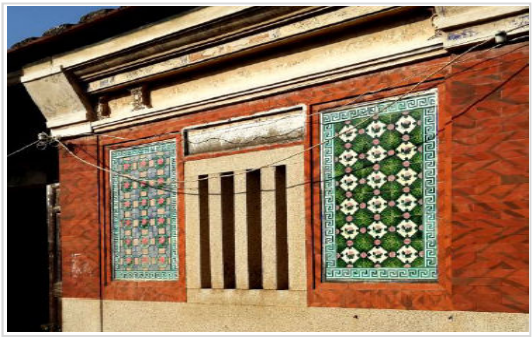

Figure 4. Exotic tiles from the Philippines
Source: ISPRS: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 2015

Research shows that traditional clay bricks are cheaper and more durable than modern cement bricks. Cement blocks are costly and heavy, prompting efforts to find affordable, long-lasting alternatives. Traditional clay bricks, made from red clay soil, animal dung, ash, and water, are fired to improve quality and reduce weight. Consequently, they are more energy-efficient and sustainable for construction (Mohammed et al. 2021).

Architectural components

(a) Dougong structure

The Dou-Gong bracket represents a distinctive masterpiece in Chinese wooden architecture. This element boasts an exquisite form and intricate tension. Its structure encompasses crucial load-bearing components that connect the beam and the column. Dou-Gong brackets play a pivotal role in mitigating the impact of earthquakes in both horizontal and vertical directions. From a mechanical perspective, Dou-Gong serves the dual purposes of power dispersion and shock absorption (figure 5) (Zhang and Gao 2020).

Figure 5. Simple wooden Dougong and stone Dougong as beams to support the extended roof
Source: People's Government of Fujian Province, 2023

However, sometimes Dou-Gong is employed by affluent families as a means of ostentatiously displaying their wealth, serving simultaneously as a significant decorative feature. These brackets are meticulously crafted, adorned with intricate paintings, and gilded with gold, thus possessing considerable artistic value (figure 6) (Tong 2021).

Figure 6. Gold crafted Dougong at Khoo Kongsi, Penang, the largest Hokkien clan house in Malaysia

(b) Roof structure

Southern Fujian (Minnan) architecture is normally designed in three types of roofs which are Yingshan (a), Xieshan (b), or Xuanshan (c) styles, where the Yingshan roof is the most prominent (figure 7) (Zhou et al. 2020).

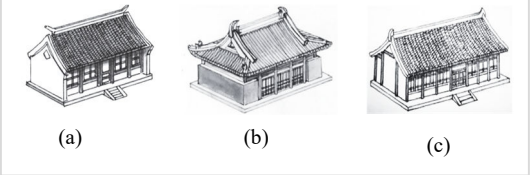

Figure 7. 3 Common roof types used in Fujian architecture
Source: CAA: Conference in Computer Applications and Quantitative Methods in Archaeology 2011

However, these roof shapes alone do not sufficiently represent the Southern Fujian architectural style. One of the most iconic features is the upwardly curving roof crest, known as a "swallow-tail ridge," present at both ends of the ridge. Typically, the swallow-tail roof is at the main hall, while the horseback or saddle gable roof is at the supporting hall, which is commonly constructed adjacent to the main hall to accommodate the extension of family members (figure 8 and figure 9) (Li and Ying 2021).

Figure 8. Swallowtail roof and horseback ridge gable roof (water and metal elements) can be found in most of the Southern Fujian architecture
Source: People's Government of Fujian Province 2020

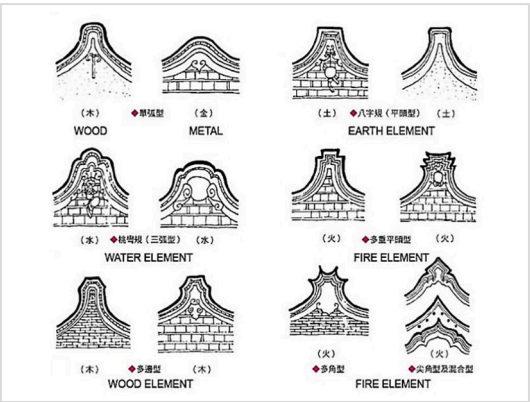

Figure 9. Five elements of the gable roof based on Chinese Fengshui

Decorative elements

(a) Hokkien "Chien Nien"

Chien Nien also means "cut and paste" which refers to the skill of applying colourful porcelain shards to create vibrant motifs, forms, and figures on architectural facades, roofs, and gables, especially on temples, palaces, and wealthy dwellings (figure 10) (Dass 2021).

Figure 10. Chien Nien technique, a Fujian style colorful porcelain artwork on the facade, roof ridge, and gable
Source: Online web: Huitu.com

In southern Fujian, architectural decorative patterns include floral designs such as flowers, peonies, lotuses, and curled grass, as well as motifs featuring tigers and phoenixes. Additionally, natural patterns like clouds, thunder, and drip motifs, as well as animal patterns like fish, dragons, and animal faces, are frequently used (figure 11) (Dass 2021; Zhou et al. 2020).

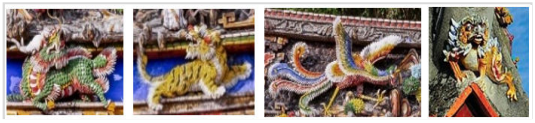

Figure 11. Chien Nien motif, sequence from the left, dragon, lions, phoenix, and beast
Source: Online web: Huitu.com

(b) Hokkien "Chai Hui" wall frescoes

"Chai Hui" paintings are normally on some of the walls, roof ridges, and gables of Fujian architecture. These depict scenes from traditional Chinese literature. Traditional Fujian architecture exhibits a distinctive use of art on anything from a building's complete façade to a single beam. Many structural components in traditional Fujian or Taiwanese architecture are artistically embellished in

addition to the architectonic and symbolic ornamentation (figure 12) (Fu 2005).

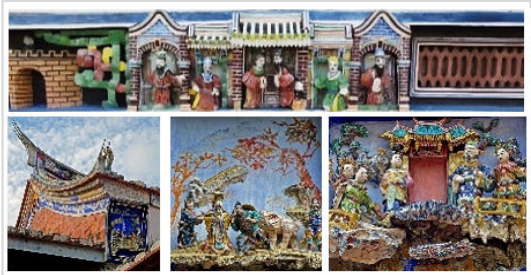

Figure 12. Painted Chai Hui on porcelain artwork on the building facade
Source: online Web: Huitu.com

Architectural layout

The Minnan ancient building plan is characterized by axial symmetry. The layout features bright halls and dim rooms, with the primary hall serving as a spacious, well-lit area for honoring ancestors, and gods, and hosting visitors. The residential space is organized into two levels. Minnan's traditional residences follow the "one bright and two dark" form, with three rooms per sector. The courtyard house is a traditional property comprising multiple buildings and exterior spaces, also adhering to the "one bright and two dark" layout (figure 13) (Xia and Chiou 2015). "East jutou" and "west jutou," or "east wing room" and "west wing room," are the terms typically used to describe the rooms on both the east and west sides of the courtyard.

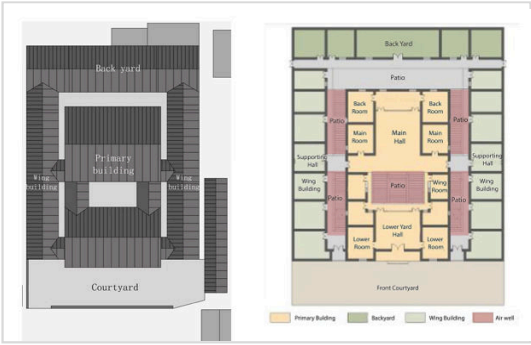

Figure 13. left picture is the general layout, right is floor plan with 5 patio or courtyard
Source: ICHE: International Conference on Humanities and Education 2022 and by author

The central patio or courtyard provides ventilation, lighting, and rainwater collection, thereby creating a comfortable environment during hot and humid summers. Consequently, the courtyard serves as a critical component in achieving sustainability in Minnan ancient architecture by reducing energy consumption and improving indoor air ventilation (Wang et al. 2018).

Methods

This research approach incorporates qualitative research analysis methodologies, specifically using case study data to analyze the obtained outcomes. The research has been split into three phases. The first phase was consolidating the existing literature to evaluate the current studies that align with the focus of this research. Based on the research and literature collection related to Southern Fujian (Minnan) architecture mainly in China, secondary data on important building components in Minnan architecture have been identified in Table 1. The second phase involved a case study and site observation at The Blue Mansion, Penang to collect primary data as in Table 1 and compare which Hokkien influences were found in this Peranakan Building. The third phase is to gather and analyse all the data collected on how the Hokkien influences building components to achieve sustainable architecture.

Case study

The Blue Mansion, popularly referred to as Cheong Fatt Tze Mansion, in Penang, has been chosen as the case study for this paper for two reasons: (a) the mansion's architectural features, particularly the gable roof façade design reflects some of Hokkien architecture. (b) known for its impeccable restoration projects which make the mansion achieve sustainability.

Location and site

The Blue Mansion also known as Cheong Fatt Tze is located in the center of Penang, next to Muntri Street and at the intersection of Leith Street. The most remarkable aspect of the complex is that the Mansion and its neighbors do not follow the alignment of Leith Street, which goes from northeast to southwest. The complex also contains a row of five terrace houses across the street. At this end of the street, every home is oriented from southeast to northwest, thus creating a garden with a rhombus form (figures 14 and 15) (Loh-Lim 2001).

Figure 14. Rhombus-shaped Garden in the Blue Mansion
Source: Google Earth and International Transaction Journal of Engineering, Management, Applied Sciences and Technologies 2017 (Soon and Bahauddin 2017)

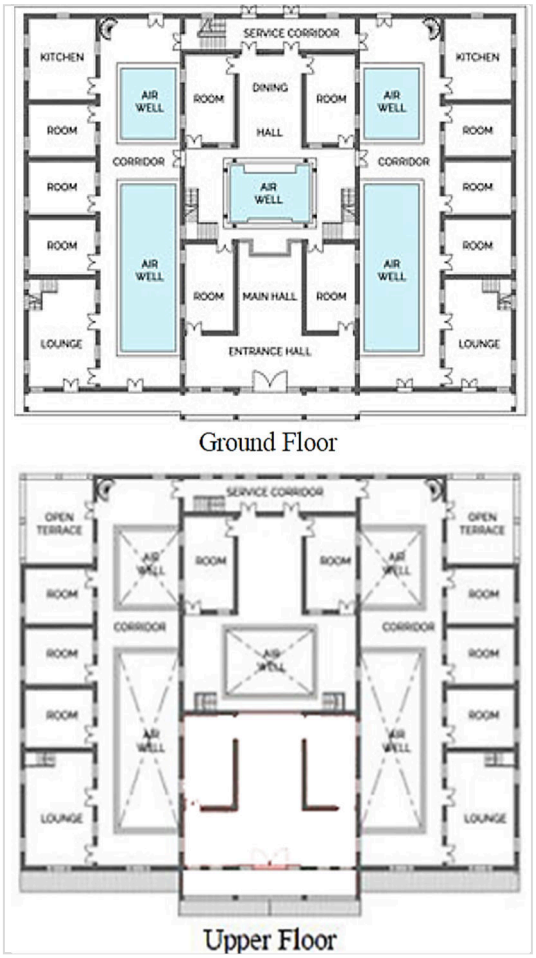

Figure 15. Floor Plan of the Blue Mansion
Source: Google Earth and International Transaction Journal of Engineering, Management, and Applied Sciences and Technologies 2017 (Soon and Bahauddin 2017)

The center bay of the iconic two-story courtyard house was constructed at first, while the wings were extended later. The mansion is split into two sections: the main hall and the twin side halls. Two hallways link the two sides of the mansion to the back. It was inspired by the form of the main building in the Hakka-Teochew mansion style, identified by the main roof's gables. The mansion consists of traditional Chinese architectural elements which include an ornamental terracotta roof, and a courtyard inside the mansion enable sunlight, rain, and air flow into the living spaces to improve the quality of the air inside.

Architectural component

Despite having a very traditional design, the Blue Mansion is a superb example of 19th-century eclectic architecture. This is the period in Malay history when the grandeur of the British Empire meets the legends and enchantment of the Chinese Kingdom. The increasing reputation of Cheong Fatt Ze as a Chinese official and his enthusiasm for Western workmanship were also reflected in The Blue Mansion (Cheong Fatt Tze the Blue Mansion 2020). Upon closer inspection, an incredible architectural mosaic is revealed, with Chinese calligraphy against timber beams, English Art Nouveau-stained glass mixed with Hokkien porcelain Chien Nien pieces, and Scottish cast-iron balusters juxtaposed with Cantonese timber lattices. The Blue Mansion is where many cultures and styles come together tastefully and charmingly (figure 16) (Dass 2021).

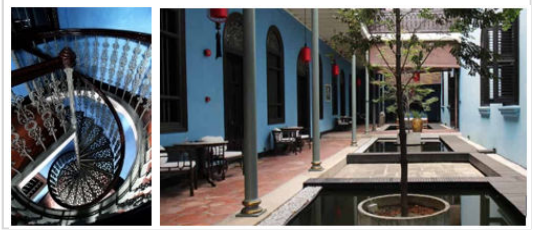

Figure 16. Interior of The Blue Mansion
Source: L'Plan Sdn.Bhd: The Blue Mansion 2001

Results and discussion

Comparison of the building components

This section will compare building components in both Southern Fujian architecture, especially in red-brick residential dwellings based on a literature collection, and The Blue Mansion through field observation in the aspects of architectural style, external façade, roof work,

gable wall design, air well, flooring, and decorating painting (table 1).

Table 1. Characteristics of typical Fujian red-brick dwellings and The Blue Mansion (Adapted from Teh and Bahauddin 2017)

Characteristic	Southern Fujian residential dwelling	The Blue Mansion
Architectural Style	Combination of Chinese and European elements	Combination of Chinese, Malay, Indian, and European elements
External Features	Symmetrical in spatial and layout design	Symmetrical in spatial and layout design
Roof works	Gable, swallowtail roof	Gable and pitch roof
Façade Design	Rouge brick, red bricks, granite, and green grass tone	Indigo blue lime-wash paint
Gable-end design	Saddle-shaped (water or metal element) is more favourable by Hokkien (Refer to figure 11)	Angle shaped (wood element) is more favourable by Teochew (Refer to figure 11)
Air Well	1 - 5 air wells	5 air wells
Flooring	Red-orange hexagonal and diagonal terracotta tiles, concrete, puzzle-style cut tiles	Staffordshire, England imported coloured tiles, and hexagonal terracotta from China
Decorating painting	Hokkien Chien Nien (decorative mosaic porcelain), 3D motif on roof ridge, gable roof, façade, and etc.	Hokkien Chien Nien (decorative mosaic porcelain), 3D motif on gable roof, façade, chi tou and etc.
	"Chai Hui" painting on the wall at both sides of the entrance	Hokkien painted "Chai hui" wall frescoes on the gable roof

Source: Cheong Fatt Tze official website 2022

Hokkien influenced building components to achieve building sustainability

After comparing selected building components in both Fujian red-brick dwelling and The Blue Mansion, some of the components found in The Blue Mansion can be considered to have Hokkien influences which the most prominent features are the Hokkien Chien Nien and Chai Hui wall frescoes paintings. Hokkien Chien Nien which means "cut-and-paste-shard works". Specially made rice bowls from Fujian, China, were imported for the process. Lime putty was used to paste the tiny fragments of coloured porcelain that were carefully cut from the bowls using pliers to form intricate patterns of people, women, and animals, as well as scenes from various Gods and Chinese mythology, as well as scenes from an imagined heaven (figure 17 and 18).

Figure 17. left and middle pictures: the coloured bowl cut into pieces by using pliers; right picture: Artisan sorting through the bowl to select the required color bowl
Source: L'Plan Sdn.Bhd: The Blue Mansion 2001

Figure 18. the preparation and use of egg tempura paints (Ranquet, et al. 2023) and Chien Nien technique on the chi tou, facade, roof gable, and roof ridge of the mansion
Source: L'Plan Sdn.Bhd: The Blue Mansion 2001

During the on-site inspection, it was discovered that the front balcony has numerous ceramic shard decorations, 90% of which are made of imported cut porcelain from China. The decoration's key design features a dragon, which represents the community's superior prosperity and the king's honour (figures 19, 20, and 21).

Figure 19. Various opera character on different chitou of the beam. The puppet used Hokkien Chien Nien technique meanwhile some parts of the background

used Hokkien Chai Hui technique to create visual layering
Source: L'Plan Sdn.Bhd: The Blue Mansion 2001 and taken by the author

Figure 20. Ceramic shard decoration using the Hokkien Chien Nien technique on the gable facade
Source: THE Vibes 2022, and taken by the author

Figure 21. Closed-up of an external gable with Hokkien Chien Nien dragon, human figure, phoenix, and flora
Source: Pictures taken by the author

Once all the artwork is completed, a few layers of traditional "tung oil" as finishes applied over the external decorative tempera paintings help to protect the painting from the sun and rain, preventing them from fading over time (Loh-Lim 2001). Tung oil originates from the seeds of many species which included primarily Aleurites fordii, Aleurites spp., and a deciduous shade tree from China. Tung oil is one of the traditional oils that can be dried very fast when exposed to the air and polymerized into a glossy, hard, durable, and waterproof coating which is very suitable to be applied on the Hokkien Chien Nien porcelain surface to improve its sustainability and long-lasting (Liu, et al. 2015). Besides, there are few researches prove that tung oil is an eco-friendly, biodegradable coating as finishing (Yang, Zhang, and Li 2015), with high durability against a variety of weather conditions (Yoo and Youngblood 2017), and long-lasting coating (Samadzadeh et al. 2011).

Conclusions

Fujian culture is a combination of several civilizations, and its architectural ornamentation reflects the knowledge of many individuals. Both the research objectives have been achieved as the sustainable architectural component in Southern Fujian ancient architecture has been identified and categorized into a few aspects which were the architectural color, materials, structure in terms of roof and dougong, layout design, and decorative elements such as Hokkien Chien Nien and Chai Hui. Hokkien architectural influences in The Blue Mansion have also been determined and analyses in detail which is the Hokkien Chien Nien and Chai Hui on the façade, gable roof, column, and veranda. The materials used in porcelain art painting are tempera paint and tung oil is are applied over all the cut-and-paste ceramic work to promote long-lasting effects and create a sustainable architecture. Even though Hokkien architectural influences were very limited in the Peranakan mansion, however, it still can be beneficial to the researcher to conduct a further study in the field related to Hokkien architecture and Peranakan architecture.

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Author(s) contribution

Low Mei Jie contributed to the research concepts, preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Azizi Bahauddin contributed to research concepts, literature reviews, methodology, data analysis, supervision, and validation.