Welsh School of Architecture
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Ecological Design of Lighting and Ventilation in Traditional Shophouses in Urban Southeast Asia

Thesis for the degree of Doctor of Philosophy

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Dedicated to my lovely parents

ABSTRACT

Including a courtyard open to the sky is an interesting design feature in most old town shophouses. It has been found that the courtyard shophouses in this urban fabric were always good examples for the bioclimatic typologies where their residents could enjoy the outdoor daylight and fresh air with a minimum of energy use while not being separated from their climate and culture. However, such courtyards in Taiwan have gradually disappeared while more have been retained in urban Southeast Asia. This thesis intends to determine what kinds of factors influence the application, outcomes, and changes over time of early shophouses for its dwellers.

The principal aim of this thesis is to evaluate the potential of the retention of traditional shophouse courtyards in urban Southeast Asia, especially in Taiwan, with a focus on the preservation of continuity rather than the preservation of the past.

The work presented in this thesis consists of three main research activities, all focusing on the use of simulation tools and the logic of reasonable inferences to support the continuance of traditional shophouses: analysis of current traditional shophouses; development of an approach for well-founded selection of ecological design in lighting and ventilation; analysis of the suitability of existing practices and experiences to support the selection process; and development of a strategy as well as a proof-of-concept prototype that provides support for the selection of ecological issues and that demonstrates the viability of the proposed changes.

It should be noted that the research is exploratory in nature and has only begun to address the many issues that are important in the preservation of urban heritages, but the questions addressed – what quality needs are important for shophouse occupant satisfaction and what quality dimensions are important for public attitudes – are arguably among the most important in quality maintenance.

LIST OF PUBLICATIONS

Conference Papers

Li, S.F., 2017. *Rethinking the Daylighting Conditions of Traditional Shophouse Building with a Focus on the Courtyard Model.* The 13th Technology and Society conference, 3 June 2017, Hsinchu, Taiwan.

Li, S.F., 2016. *Thinking a Smart Cover on Top of the Shophouse Courtyards.* The 12th Technology and Society conference, 4 June 2016, Hsinchu, Taiwan.

Li, S.F., Gwilliam, J.A. & Fedeski, M.H., 2015. *Lighting Environment Simulation of Traditional Courtyard Shophouse.* The 11st Technology and Society conference, 6 June 2015, Hsinchu, Taiwan.

Li, S.F., Gwilliam, J.A. & Fedeski, M.H., 2014. *Internal Ventilation in Vernacular Dwellings: Rethink, Reuse, and Remodel.* The Conference on Indoor Environmental Quality and Health in Taiwan, Mainland China, Hong Kong and East Asia 2014, 14-15 July 2014, Taipei, Taiwan.

Li, S.F., Gwilliam, J.A. & Fedeski, M.H., 2013. *Expectations of an Inner Shophouse Atmosphere: The Influence of Courtyard on Air Flow Comfort.* The 20th National Computational Fluid Dynamics Conference in Taiwan, 21-23 August 2013, Nantou, Taiwan.

Li, S.F., Gwilliam, J.A. & Fedeski, M.H., 2011. *Taking Action on Conserving Local Distinctiveness: The Issue of Historic Streets in Taiwan.* The 7th Technology and Society Conference, 25 June 2011, Hsinchu, Taiwan.

Li, S.F., 2009. *Understanding of Courtyards Preservation Studies: Preliminary Survey of Spatial Use in Traditional Shophouses*. The 5th Technology and Society Conference, 6 June 2009, Hsinchu, Taiwan.

Conference Posters

Li, S.F., Gwilliam, J.A. & Fedeski, M.H., 2013. *Saving Courtyards, Saving Energy in Vernacular Shophouses.* Poster presented at the LOLO Energy Demand in Buildings Conference 2013, 22 November 2013, London, U.K.

Li, S.F., Gwilliam, J.A. & Fedeski, M.H., 2013. *Expectations of an Inner Shophouse Atmosphere: The Influence of Courtyard on Air Flow Comfort.* Poster presented the 20th National Computational Fluid Dynamics Conference in Taiwan, 21-23 August 2013, Nantou, Taiwan.

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1. Introduction

This thesis intends to develop a closer insight on the concept of heritage preservation and management in the urban development context, in order to re-establish the vernacular values that lie between the micro and macro urban sphere and then evaluate them in the context of a newly proposed model. To date the majority of the recent research that considers the value of traditional shophouses are focused on a macro-urban scale, which is at the centre of many questions from different sectors including the ecology one. In this context the fact that traditional shophouses derive from the courtyard concept is frequently overlooked and at the root of these problems is a lack of awareness. This work investigates and compares the question of traditional shophouses in Southeast Asia and Taiwan.

The shophouse can serve for both business and habitation: with the ground floor used for commerce while upper floors are used for residence. As they are typically built as a continuous terrace along the road, in blocks, problems associated with access to the inner property, poor planning and development of these buildings have led to complications such as disorganization, poor ventilation, and inadequate daylight. At the same time, problems that relate to the destruction of the early shophouses include the lack in legislation, lack of control within the local governments, lack of funds, conflicts of interest and lack of awareness with regards to the heritage values of buildings between the different categories of public interest (Chulasai 1985; Fels 2002). While, with so many types of shophouse found elsewhere in Southeast Asia, the focus is often on the beauty of the exteriors, while within these buildings, historic architecture is being torn away in favour of modern facilities and interiors. Apart from these aspects, the fact that the early shophouses are typically privately owned also plays a major role in their destruction.

However, the courtyard found inside such building typologies is an interesting design feature; as while most buildings designed in the modern day lack openings designed to promote environmental performance factors like ventilation, thermal comfort, wind flow; the openings in shophouses, surrounding the courtyards, play a major role in maintaining comfort in the residence in terms of lighting, ventilation and thermal comfort. In addition the courtyard would also have played a key cultural role, providing a place for family members in a residence to gather to relax and enjoy some fresh air after sundown without being seen in public. Therefore, this thesis aims to:

I. Investigate how traditional shophouses in Southeast Asia benefit from their courtyards in maintaining comfort in terms of natural lighting and ventilation,

II. Establish why traditional shophouse courtyards in Taiwan have gradually disappeared while those across much of urban Southeast Asia have been retained, and

III. evaluate the feasibility of the retention of shophouse courtyards in Taiwan.

The scientific relevance of the development of this strategy lies in its contribution towards assessing the different approaches used to harness and control daylight and ventilation in the context of modern mechanical equipment being widely implemented in existing shophouse. The secondary aim is to establish from this analysis, whether there are any over-riding factors in determining the success of controlling lighting and ventilation in this context.

The public relevance of the development of this strategy is a contribution that enhances decision-making during the design of ecological shophouse buildings. In a general sense this contributes to increased attention to building performance and in particular focuses design teams on the importance of making well-founded choices regarding the selection of appropriate business reuse functions for traditional shophouses. With a specific focus on the question of research, this work aims to explore the hypothesis that courtyards are the most important feature of early shophouses; where any changes to these open-to-sky spaces must be given careful consideration.

1.1. Brief background

A shophouse is typically an urban dwelling found across Southeast Asia, which includes a small shop or meeting space that opens up to the street, together with two or three internal courtyards that break up the house into various sections. Early shophouses were significantly influenced by the building traditions of early Chinese immigrants, especially those from the southern Chinese provinces of Fujian and Guangzhou, from which most of these Chinese immigrants had emigrated. The long and narrow floor plans and the courtyards which this study typically associates with an early shophouse can be traced back to Southern China (Authority 1995). Other aspects of shophouses in southern China include high ceilings and ventilation features, such as air vents and louvered shutters, which are essential in their warm climate and are also used in Southeast Asia to respond to the same weather considerations.

Simon and Emrick (1979) argue that the idea of the old shophouses could have originated from the various types of old shophouse design in Batavia (Indonesia), as well as Calcutta and Madras (India). However, that only refers to the building type that combines shop and dwelling in a single unit without involving the five-foot-way corridor – covered pedestrian walkways (Ismail and Shamsuddin 2005). Sir Stamford Raffles was the one who probably brought the idea to Singapore. As an agent of the East India Company, Raffles travelled widely in India and Southeast Asia and observed the development of colonial cities and their planning and organization. However, the regular façade and five-foot-ways, was owed to him. It was Raffles' instructions in 1822 to the Town Planning Committee of Singapore that resulted in the emergence of the prototype.

The design of early shophouses in the old town centres today is unique to Southeast Asia, particularly in Malaysia, Singapore, Thailand, and also Taiwan. Even though part of the built form can be traced back to Southern China and European countries, the corridor or five-foot-way added after the 1880s, gives its unique character. It must be clarified that buildings used as shops on the ground floor and accommodations on the upper floor can also be found in other parts of the world, such as in England. However, these don't include the five-foot-way (Ismail and Shamsuddin 2005). Yeang (1987) considers traditional old shophouses as an important urban archetype in early Malaysian towns. He argues that a linear arrangement of old shophouses of specified widths, linked by the five-foot-way, a covered passageway, was introduced 'for the sake of regularity'. He suggests that an understanding of its spatial morphology can provide ideas for contemporary use in the making of the Asian city's identifiable angles and land subdivision into lots and public spaces. Miao (2001) considers the five-foot-way as helping to create a continuity and sense of unity in an urban ensemble. It is responsive to the hot humid climate and the drenching rain. Apart from the physical form of early shophouses, related activities also contributed to urban quality.

The early masonry shophouses built in the 19th century were usually around six to seven meters wide and thirty metres deep, sometimes extending to sixty metres. The narrow frontage, particularity in Malacca, was due to the paying of taxes according to the width of the façade facing the street during the Dutch period (AlSayyad 2001). The plans of early shophouses were basically divided into several segments that included the courtyard. The number of courtyards related to the length of the early shophouses, whereby the longer it was, the higher the number of courtyards were incorporated; which helped to maintain a rigid boundary between the interior and exterior. Their windows and doors did not seal off the interior space, which flowed into the outdoor space – the courtyard or the street. The permeability or openness of the Chinese house, as Ronald Knapp (2003) argues, was one aspect of a remarkable continuity of form throughout history.

1.2. Problem statement

In spite of all efforts and achievements so far in designing early shophouse buildings, as well as contribution to the urban form and its spatial and physical aspects, there are both opportunities in and need for further improvements. Opportunities arise from the installation of modern and powerful mechanical facilities and the ongoing development of ecological technologies. The needs are created by ever-increasing urbanization problems, which represent economic interest in the replacement of old shophouses with new buildings. Therefore, early shophouses are under threat of extinction.

The integration of traditional building performance (evaluations of natural lighting and ventilation) and the building design process (continuity of early shophouses) becomes a next process for reconsideration and redesign into what might be termed 'historic green buildings'. Although the evaluation of building performance can be expected to be an essential part of the building design process, the original advantages of spatial planning to provide concepts to support future shophouse design processes does not live up to this expectation. Old buildings can be seen as an historic districts' biggest sustainability challenge. However, while preserving heritage is key, construction methods would have changed dramatically while energy efficiency is often paramount, so architects and/or designers are looking at ways to make these buildings more sustainable. A lot of demolition does not make sense. The most sustainable thing we can do is to *not* build new; as everything can be considered as an asset until we prove it otherwise (Sebag-Montefiore 2016).

Current technologies do not seem to accommodate the range of facility types and do not particularly provide an integrated approach to vernacular buildings. Generally speaking, the environmentally designed building must meet much higher comfort and performance levels than vernacular architecture was designed to achieve, the model for a less energy-hungry building. If the modern artificial conditions were not properly applicable to the vernacular cultures, it would become an energy-hungry architecture again (Hagan 2003). Thus, this project aims to study the process of overcoming the challenges of facility discovery, access, and management in the eco-environments. This could be achieved by integrating ecological design into the vernacular or aged buildings.

Vernacular, or aged buildings, which focus on the well-done renovation of spatially disparate modern facilities, allow dwellers to enjoy raw modern power with the aims of efficiently utilizing this power and providing on demand high-performance comfort to users (Turan 1990). At the same time, the underlying challenge of the renovation of vernacular buildings is the coordinated sharing of modern facilities across lightweight structural organizations. This sharing goes beyond the traditional interior spaces to encompass direct access to the building envelope and the partitions, with precise levels of control over how shared facilities are to be used. Further challenges are presented by the dynamic nature of sharing relationships between these facilities (Cañas and Martín 2004). The mechanisms must be flexible and lightweight so that the facility sharing arrangements can be established and changed quickly.

On the other hand, economic disparities and the challenges of basic survival in many developing countries lead to situations whereby development pressure has resulted in the loss of traditional buildings. Economic factors are another reason for modernization: where sometimes the cost of maintaining historic sites is so high that governments see heritage building as an unaffordable luxury, so buildings are torn down in favour of new construction that will bring about more economic benefits (Hermawan *et al.* 2013).

Many of the shophouses in Taiwan built since the 1950s were very much simpler than those of the pre-war period. Construction was more often in concrete rather than the original timber, and simple rectangular windows lacked plaster decoration, making the overall result much less attractive than the earlier shophouses.

The earlier shophouses were first built along the high street of old towns, often by merchants who had no legal rights. The early buildings were therefore not architectural masterpieces, but they did represent a marriage of East and West. Their unique charm and character came from their early styles, which meant that while some were elaborate, others were very simple, and each exist within the same street block, thus reflecting different influences over a period of time.

Moreover, the importance of culture and heritage is becoming more and more obvious, both for regionalists and for regional development. Cultural factors are important because they directly affect economic performance and development, and therefore the competitiveness of the region. Thus, if the 200-year-old early shophouses can be identified as heritage shophouses, this may present a good opportunity to pursue heritage based tourism. Heritage tourism has proven to be an economic shot in the arm for many regions, particularly those with an industrial history but no industrial present. Attracting heritage tourism is linked to historic preservation, and there is a great deal of funding and technical assistance available from government and non-profit sources to support it.

1.3. Method of investigation

The bottom-up approach of understanding the case of traditional shophouses, studied using the descriptive case study model, will be interpreted in a top-down manner with surveying and mapping, digital simulations of courtyard lighting and ventilation, will be undertaken in order to explain the problems traditional shophouses are facing today in Taiwan. The research presented in this thesis concerns the fields of ecological design and building simulation; these fields underlie all research activities reported here. The aim is to improve their integration. The outline of this thesis is based on the following three issues:

i. Discussion of the context and starting points for the research, based on a review of existing research on the integration of ecological design concept and building simulation;
ii. Analysis of the current situation, through a review of fieldworks and surveys in selected case studies; and
iii. Innovation and realization, through the investigation of ecological design and development of a prototype that demonstrates this improved integration.

We will begin by introducing the structure of this thesis. In Chapter 2, a description is given of the relevant concepts and driving forces for this study as well as the phases of research. This chapter provides the structure/content for the whole study based on literature and personal experience.

1.4. Outcomes of the study

The main research aim of this study is *'to evaluate the potential of the retention of traditional shophouse courtyards in Taiwan, with a focus on the preservation of continuity rather than the preservation of the past'*.

Architectural design is diverse in nature and application-oriented, and it is difficult to only discuss it abstractly. The case study allows us to specify the decision processes, as well as multi-faceted and holistic problems, and focus in detail and depth on the domain problem without losing applicability (Belton and Stewart 2002). As far as this study is concerned, it will be difficult to respond to this problem related to the exploration of examples on the island of Taiwan only.

Therefore, according to the typical and simple form of traditional shophouses, the actual example of reference to the Southeast Asian region becomes both appropriate and necessary. In addition to the differences in geographical climate, other aspects of the local conditions are similar such as their social, economic, and cultural background. One of the most interesting points is that these old towns across the Malay Peninsula and Taiwan all experienced colonial rule.

Based on these goals, a series of major research objectives have been set to guide this investigation:

1. To establish a theoretical empirical understanding of environment performance of shophouses courtyards. Following by reviewing the spatial and physical characteristics of traditional shophouses, in terms of the vernacular design strategies employed in shophouse courtyards. (Refer to Aim I.)

2. To understand occupants' perceptions of comfort and environment conditions in shophouses and their courtyards; and to evaluate visitors' attitude toward the retention of inner courtyards. (Refer to Aim II.)

3. To establish and evaluate design strategies that provide remedial responses to occupant and empirical understanding of shophouse performance in order to provide strategies for environmental enhancement of their courtyard and adjacent spaces. (Refer to Aim III.)

Shophouse preservation is not the only measure that has been adopted to create a lively historic district that is true to its original form, yet reliable in its engineering structures and housing activities suited to a modern age. This study gives an overview of relevant literature, aiming to introduce the complex relations between physical environment, culture, heritage, tourism, and experience economy. Furthermore, it offers a clear definition of each specific term, and defines the newest forms and trends in cultural tourism and experience economy.

2. Thesis Structure

Following the introduction, this chapter aims to provide a conceptual and philosophical framework for interpreting the occupants' use and organization of living spaces in traditional shophouses so that existing shophouse buildings can be repurposed and redesigned for their occupants. The framework is established and based on an investigation of relevant philosophies including critical regionalism and Eastern philosophy, and as well as a critique of architectural design research. In fact, it will also encompass a critical view of natural lighting and ventilation in understanding the ways in which traditional shophouse spaces are holistically organized in adaptation to regional climates and cultures (Figure 2.1). The overarching goal is to determine what kind of hidden factors influence the applications, outcomes, and changes over time of the use of shophouses and the manner in which people currently live and work in them. This is the background to the main research.

As will be discussed later, it is these *changes* that are driving this work. For the changes that are significant to the main study, the background could itself be the subject of research to:

- find evidence that the changes are real, and to establish the pace of change;
- find the reasons for the changes, that is the factors that are driving the changes, as these have to be responded to by any resulting proposals;
- establish the interrelationships between the changes; for example, the lifestyle changes may be influencing the climate-control changes;
- understand the new demands that these changes have on shophouses, which designers must try to meet.

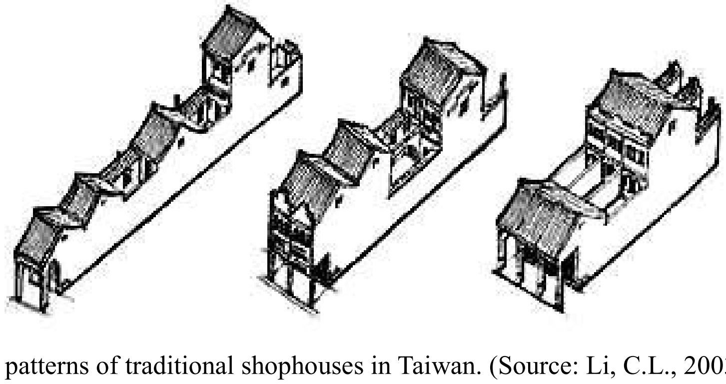


Figure 2.1: Spatial patterns of traditional shophouses in Taiwan. (Source: Li, C.L., 2003)

2.1. Research concepts

In this chapter, as the first part of the methodology, the conceptual framework will be developed to address and answer the research subjects by integrating a range of approaches including statistics, ethnomethodology or semiotics (Greene *et al.* 1989; Mason 2002). This chapter theoretically examines how to study the substantive topic of traditional shophouse design through an exploration of appropriate theories in the literature, establishing the phases of research, as well as establishing a process of data collection and analysis of current shophouses. Later on, the second part of methodology, presented in Chapter 6, will establish approaches to evaluate change responses.

2.1.1. Conceptual basis and scope of framework

As reviewed in the literature, Southeast Asia has had a long history influenced by Chinese culture; where Chinese norms and philosophies have been one of the perspectives guiding the way in which Southeast Asians behave and interact with each other. One of the most influential philosophies in this cultural context is the concept of Yin-Yang, which has its roots in Chinese Daoism; where Yin-Yang plays an important role in Chinese cultural practices, including the fields of building design and spatial organization.

Yin-Yang itself contains an explicit view of oppositions; where Yang represents the force whose characteristics are vast, strong, powerful, mobile, lit, and solid; while Yin symbolizes being meek, weak, passive, still, dark, and void (Mitchell and Wu 1998). Yin and Yang can be transformed together following a principle of complementarity, with the transformation providing a new development or adjustment in order to achieve a balance between things and events in the environment. In light of the above, a range of binary oppositions are established to explain the structure of the social world. For example, Tran (2001) argues that Feng-Shui is conceived on the basis of the integrity of two elements of *Feng*, which means wind, and *Shui*, which means water. Wind is dominated by a Yang force because it is motive and dynamic, while water is dominated by Yin for its stillness.

The combination of *Feng* and *Shui* in building design helps to achieve a harmonious relationship between the two elements of dynamic a Yang and a stable Yin in a building (Wong 1996). In this study, the concept of Yin-Yang will be utilized in order to understand the structure of spaces that people designed for their long-term interactions. The organization of living spaces will be holistically investigated in a harmonious relationship with nature and community, because, in Southeast Asia, spaces are unconsciously structured with the influence of the eastern concept of Yin-Yang.

2.1.2. Language of space: light well versus air well

As a social product, architecture or buildings can be seen as establishing their language and can be deciphered in terms of rules of space. In the context of this work, the 'courtyard' in a building is typically located centrally and the terms 'air well' and 'light well' are used in everyday discourse to distinguish and manifest these particular spaces. There are words or syntax to construct spatial code that reflect this paradigm and give the space a meaning. Lefebvre (2001) confirms that a produced space may be read and decoded by the notions of message, code, information, and others. And he argues that because a space expresses a 'process of significance', it contains not a general code but a specific one which may have been challenged through a specific historical time through trial and error.

In general, a courtyard is often applied as a method of providing the natural aspects of climate control to building occupants. It is usually considered to be a space that is bound on all sides by buildings. The size and degree of the enclosure have a significant impact on its performance and on the performance of the building or spaces adjacent to the courtyard (Hyde 2013). 'Light well' and 'air well' are similar terms for a mechanism that introduces natural lighting and ventilation, but a distinction should be made between these two terms.

In a temperate climate zone like several found across Europe, we can easily find light wells or courtyards in many buildings. An unroofed external space is provided within the space of a larger building, primarily to allow light, and secondarily air, to reach what would otherwise be a dark or unventilated area. Light wells serve primarily to reduce the necessity for electric lighting, add a central space within buildings, and provide an internal open space for windows to enable cross ventilation as well as provide an illusion of having an outside view. In relative terms, it is like an open shaft passing through the floors of a building for lighting and ventilation.

While, in countries such as Malaysia (a tropical climate zone), the focus for such open spaces is no longer on the penetration of light into deep plan buildings but to promote air movement, thus the purpose of air wells. These are common features of terraced housing in this context, where the deep plan nature of the building necessitates the integration of methods to improve ventilation (Hyde 2013). This is particularly important in tropical areas where ventilation is primarily achieved, promoted, and enhanced through air pressure differentials.

2.1.3. Comparative concepts: lighting versus ventilation

Certainly, all of the terms introduced above may provide a place to bask in the sun or a shady and airy place to be cool in environment where the houses are either stuffy, overheated by the afternoon sun, or too cool from the previous night (Heschong 1979). However, in this context of the dual primary functions of ventilation and light for the spaces of interest for this study, it is necessary to outline a theoretical approach to comparative concepts and on the theory of gradable concepts. In this context, comparative concepts such as *greener than* or *higher than* are ways of ordering objects. They are fundamental to our grasp of gradable concepts, that is, the type of meaning expressed by gradable general terms, such as ‘is green’ or ‘is high’, which are embeddable in comparative constructions in natural language (Dietz 2013). To make an inference, the spaces of courtyards or the types of ‘wells’ could be considered to be gradable in terms of their expected delivered levels of lighting and ventilation.

Givoni (1969) suggests that in hot humid climates, such as those found in Taiwan, the design of the building fabric in urban areas should provide optimum ventilation and shading. The main problem in achieving this, is that the high density of buildings serves to reduce the airflow on the ground plane as compared to that of an open rural area. In general, in urban areas the wind is divided into an area of free-running air above the average building height, while, restricted airflow is found at the ground plain. In this way, ‘wind shadow’ occurs where wind is forced over buildings. The negative pressures behind buildings and their differential heights can draw air from the free-running zone to the ground plane (Figure 2.2). This can be an advantage in providing additional ventilation and higher velocity to the ground plane.

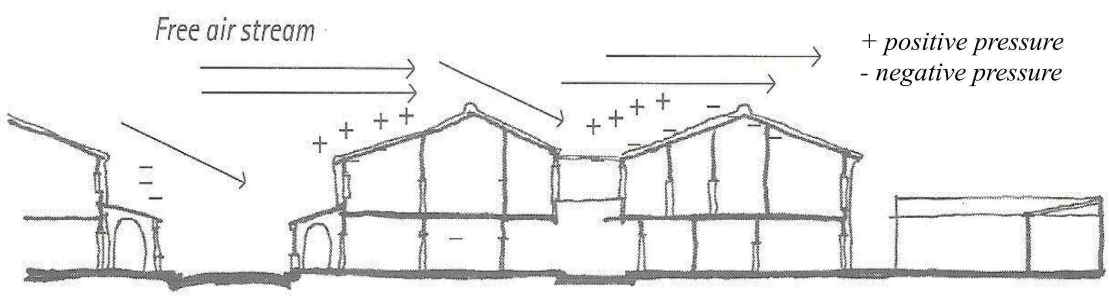


Figure 2.2: Ventilation to the courtyard in the merchant’s house, Melacca. (Source: Hyde 2013)

As can be seen, the architectural strategy behind using courtyards or air wells can play a significant role in design for the promotion of air flow adaptation, where the provision of cross-ventilation has been found to provide up to twice the velocity of internal air movement than those found in non-cross-ventilated spaces (Hyde 2013). Therefore, it is necessary for the designer to absorb and understand the implication of such spatial issues as well as the physical climate when designing a shophouse in a given region. Tracing back to the concept of Yin-Yang, the roof types and spatial forms of these types of traditional shophouses could provide the wind, a yang force with a motive and dynamic nature. In addition, the light into the courtyard is seen to be reflected light from side walls into the adjacent spaces. The reflected light is diffused, thus reducing heat gain resulting from the light penetration.

The daylight issue that is most unique to the context of shophouses courtyards is that of controllability. Even for spaces which are not going to be primarily used for activities of daily living, openings still have the potential to provide natural ventilation benefits to adjacent spaces. For living spaces, there is still the issue of providing a tempered environment through the control of solar heat gain whilst at the same time providing enough light for the space to remain usable. A notable benefit of controlling daylight in traditional shophouses is that there is a real potential to increase dweller satisfaction and dwelling functionality whilst at the same time cutting down on energy expenditure. To do this effectively, the builders and/or designers need to carefully plan how daylight is going to interact with artificial luminaires and ventilation systems.

2.2. Research framework

The aim of this study is the preservation of continuity, but not the preservation of the past.

Simply put, this research does not attempt to freeze the shophouse type into a museum display, but instead it as an effort to push this building typology to a new level - making it a reasonable and vital element of future cities, while maintaining the valuable characteristics which it has embodied until now. It is therefore argued that the principle of ‘Growth’, as defined by Fathy (2010), is central to this work, as this embraces progressive change through thoughtful and well-balanced design.

Figure 2.3a explains the driving force for this study, where current practices, ‘the conventional design trend’ are responding to environmental comfort requirements through a practice of overdesign. It is argued here that this is problematic and does not learn from the environmental responsiveness of the vernacular design that has informed the evolution of shophouses to date. This has resulted in the hypothesis that a change from overdesign to necessary design informed by Yin-Yang and Feng-Shui as guiding principles would be less problematic and that this is supported by an ecological design response to the need for evolution in the delivery of comfort, both thermal and lighting, in these spaces.

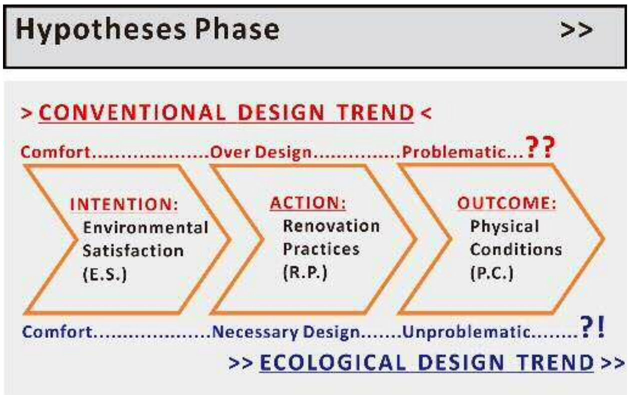


Figure 2.3a: Hypothesis Phase

Second, buildings in hot and humid climates have been traditionally cooled by ventilation (Laar and Grimme 2002). Internal airflows in such naturally ventilated buildings can be pressure-driven, resulting from the external wind pressure field, and buoyancy-driven, resulting from the temperature differences between the building interior and exterior. This research therefore proposes the concepts of the 'retention of courtyards', which is carried out through the whole of this study. This is described in the figure below (Figure 2.3b), where the three phases of the research are presented: 1. Literature review, 2. Learning & Finding (Surveys) and 3. Strategy and Prototype (Chapter 6 onwards).

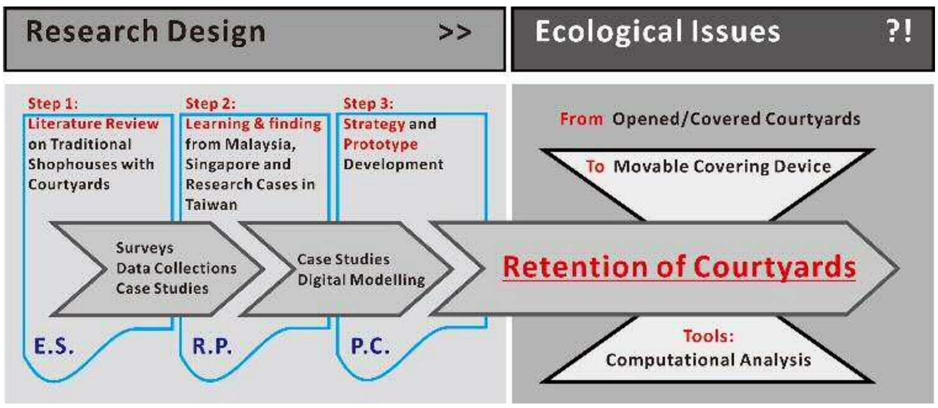


Figure 2.3b: Research Design

And then, we note that the vernacular architecture provides an art of construction to application functionality, over and above standard or contemporary architecture. However, the vernacular has been modified by technological and cultural changes for centuries (Aranha 1994). For example, in Southeast Asia, zinc and clay tiles are used as substitutes for roofs made of leaves; brick and cement columns as replacements for timber stilts and ladders; glass for windows which were formerly open; and nails as alternatives to rattan and tree roots that were used to tie joints together. Each of these have had a profound impact on the evolution of vernacular architecture.

Vernacular architecture is a major part of our daily experience (Jones and Shaw 2006), and thus it reflects a quality or ‘sense of place’ that comes about through the interaction of our physical environments and cultural myths (Chen 1998; Laar and Grimme 2002). Vernacular architecture therefore represents a continuity of architectural evolution. However, it is argued here that the current trend towards the enclosure of courtyards in shophouses and the application of distributed artificial conditioning systems is of concern. This approach appears not to respect the evolution of shophouse design and this work aims to support the continued preservation of continuity rather than the preservation of the past.

Finally and on the basis of this research, conclusions will be drawn from the findings and recommendations made. It’s worth noting that in step 3: strategy, of the research design – Strategy & Prototype Development, as well as ‘Ecological Issues’, the process might be understood as one of ongoing planning, searching, discovery, reflection, synthesis, revision, and learning, as shown in figure 2.4 below:

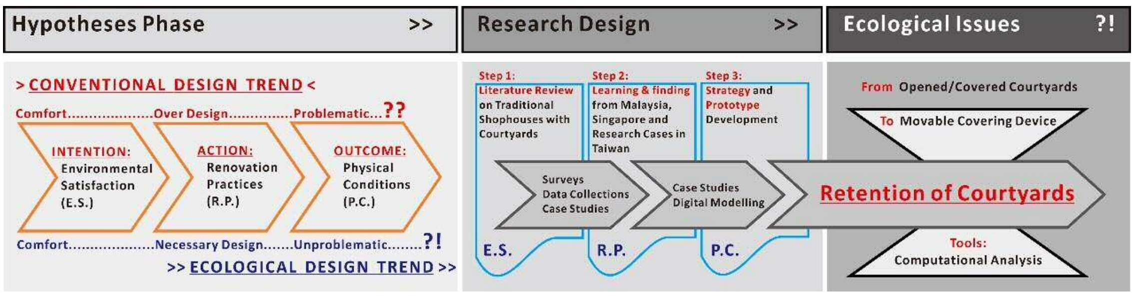


Figure 2.4: Combined Research Framework

2.3. Approach

As shown above, research is composed of certain phases and/or steps. Step order may vary depending on the subject matter and researcher (Kothari 2004). Taking into account different guidelines, one can distinguish different numbers of phases/steps in the research process. Frequently, those phases/steps can have different names, and it seems rational to reduce the number of research phases to three, and each of the phases can be divided into specific steps (Hanacek 2010). The following three phases and Figure 2.5 try to outline a simple and effective strategy for conducting this research:

I. The conceptual phase

This phase of research involved activities with a strong conceptual element – retention of courtyards. The activities include thinking, rethinking, theorizing, making decision, and reviewing ideas with supervisors. It can be divided into 4 steps as follows:

1) formulation of the research problem on traditional shophouses
2) search and review of the literature relating to the reasons for the changes
3) development of the theoretical construction of ecological thinking
4) creation of hypothesis which should be verified in future research

II. Empirical and analytic phases

The first step, the empirical phase, is the most time-consuming part of the investigation – collecting the data. The data include a physical survey of existing courtyards, an occupant survey of the selected shophouse users, and a visitor survey of the on-street visitors in tourist districts. And then, the next step is to systematically organize the findings so that they can be summarized and subjected to the following types of analysis:

1) shophouse environment by physical survey
2) spatial use of shophouse informed by occupant surveys
3) environment attitudes of both occupants and visitors surveys
4) satisfaction from living and travelling in old shophouses

III. Disseminative phase

Once the above phases/steps have yielded sufficient and relevant data, in order to be meaningful, the results obtained from data analysis require further interpretation. It is time to propose a high feasibility study – ecological design strategies. This job is not completed, however, until the author communicates the result of the study to others who may find it useful.

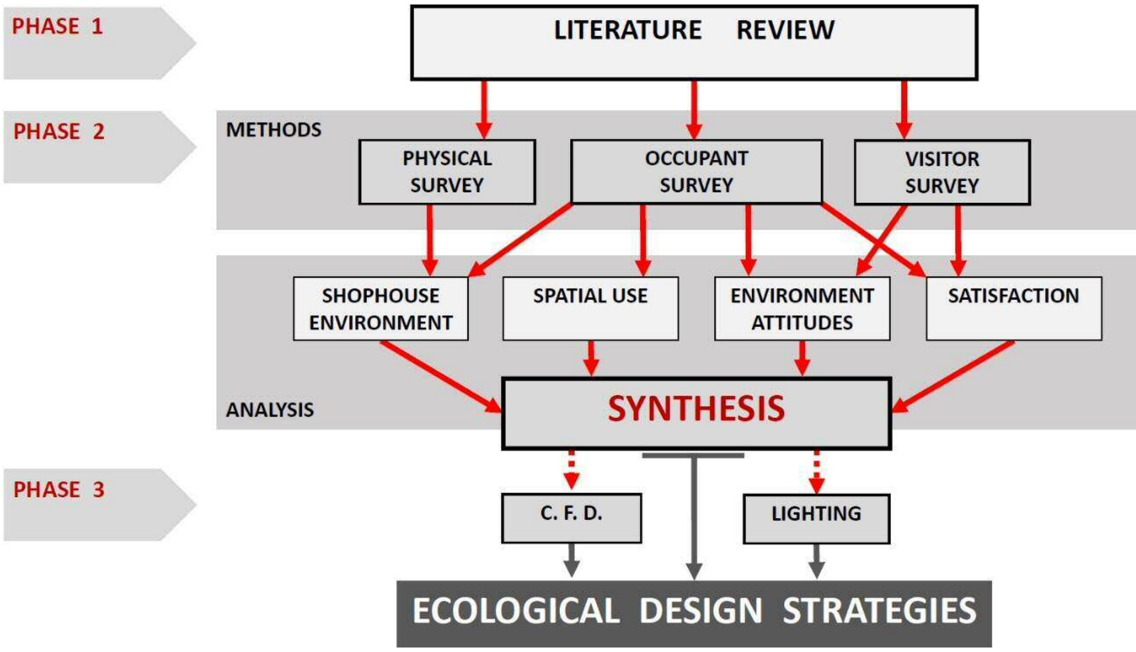


Figure 2.5: Phases and steps of research process

As this research is confined to the analysis and investigation of the origins of *change* responses, the review of the literature indicates that there are a wide range of issues that might have some impact on *change* responses. These include a plethora of macro issues such as cultural differences, regional economics, and modern technical issues as likely exogenous factors. While, in relation to the shophouses themselves, these focus on the exploration of the occupants' perceptions on the relationship with the *change* in the courtyards, rather than considering all perspectives of the shophouse buildings; and this, through the use of questionnaires. In order to enable further interpretation of the occupants' perceptions of thermal and lighting conditions in the courtyards, physical conditions might have been measured. However, due to both the stated theoretical focus of the work and time and resources constraints, this was not undertaken.

The work required for the completion of this thesis is discussed throughout a number of different chapters.

In Chapter 3, we will then review the traditional shophouses in general and specifically from the selected old towns in Taiwan, as a preliminary case study. This will provide a background on building history, development process, and then focus on the preservation of the early shophouses as part of urban heritage.

To outline the methodology for the first phase of this research, user surveys and field work are described in order to state and scope the problems, with the aim of the developing a tool for improvement, in Chapters 4 and 6. The first part of methodology, Chapter 4, establishes *change* requirements through the evaluation of the results of surveys.

To form a top-down view of the problem, in Chapter 5, I present an analysis of traditional shophouses from the perspective of occupants, and the role of building value both in architecture and urban planning. The research methods applied here are current shophouse case-studies, a field test, and a survey.

Chapter 6 details the second part of the methodology regarding the designing and evaluating *change* responses through the application of the computational modelling of natural lighting and ventilation to the courtyards area.

The next two chapters, 7 and 8, will describe the results of the simulation methodology steps from climate analysis and computer model set-up to validating the process decisions. They deal with the process of simulating daylight, glare effects, solar heat gain, thermal analysis, and airflow patterns in the context of the first courtyards (through three types of shophouse case-studies) using Radiance-based and DesignBuilder CFD software.

Informed by the findings from the public attitudes towards shophouses, the findings from the on-street visitor survey and the research and development work are presented in Chapters 7 (daylighting) and 8 (ventilation): Chapter 9 presented an analysis of the potential to improve the usability of traditional shophouses to better support the development of historic districts in the future. The strategy to provide computational support suggest the selection of ecological design that is the goal of the research, and then develops a prototype that demonstrates the feasibility of underlying ideas.

The conclusions for this study, its limitations, and suggestions and future challenges will be discussed in the final chapter, Chapter 10.

3. Literature Review

In the introduction, we pointed out that a courtyard open to the sky is an interesting design feature in most old town shophouses and that it is not an unusual topic for research in the Southeast Asian region to evaluate such traditional or aged buildings. In particular since the late 1970s, various scholars, from Southern Mainland China to Taiwan, have been continuously applying this as a pilot project: developing students at a postgraduate level in practical training and design thinking of spatial formation, typology, and utilization behaviour. As a result, there is a wide range of information regarding shophouses that can be found on the internet, such as personal or travel blogs, real estate market data, regional news, as well as a lot of cloud-based data regarding building renovations and re-use projects. Various relevant and similar building types are referred to in articles and/or websites such as Wikipedia, including: chophouse, townhouse, street house, shop office, terraced building, and tube house in Vietnam. All of these traditional styles of shophouses can be classified into the research fields of vernacular architecture (Knapp 2003; Fels 2002; Sujana 2002).

The following literature review is intended to lay the groundwork for the research questions considered here, which seek to understand how renovation programmes could be implemented in order to integrate natural ecological design within historic or aged buildings. This review provides a background to early or traditional shophouses in several coastal cities in Southeast Asia, analyses the literature pertaining to shophouse renovation in relation to both lighting and ventilation, and briefly outlines characteristics of shophouses that make vernacular cultures unique. This review is mainly based around the geographical focus of the island of Taiwan, the main location for this work, as well as research relevant to George Town in Penang, Malacca, and Singapore's Chinatown, for comparative analysis and case studies.

3.1. From definition to defining traditional shophouses

Initially, in terms of private and spatial scale levels, the changes in relation to architectural science in the shophouses are directly related to their history. Indeed this could be understood as the cultural history of such buildings and their value to people; and it is argued here that this, together with an approach that comes from a non-mechanical perspective, should be leading the approaches for rethinking the ongoing use of vernacular shophouses. For a comprehensive understanding, this chapter first discusses the concepts used in the study. Later on, 'Ecological Design' and its issues are reviewed. From relevant documents, the impacts on the development of shophouses and the design elements of traditional shophouses are also discussed.

3.1.1. Spatial pattern: Linear organization

In architecture, spatial organization is the way a series of spaces are arranged into one recognizable whole (Rapoport 1984). There are often different spaces with distinct demands in a typical building program. In terms of relationships between a series of spaces, according to Francis D. K. Ching (1979), 'The manner in which these spaces are arranged can clarify their relative importance and functional or symbolic role in the organization of a building'. The decision as to what type of organization to use in a specific situation will depend on the:

- demands of the building programme: such as functional proximities; dimensional requirements; hierarchical classification of spaces and; requirements for access, light, or view.
- exterior conditions of the site: that might limit the organization's form or growth; or that might encourage the organization to address certain features of its site and turn away from others.

In a house, space can be categorized into public-private, active-passive, and served-servant, based on the tasks accomplished in the rooms. The relationship and hierarchy between them in a shophouse is represented clearly through the spatial organization. According to Louis Khan (Papademetriou *et al.* 1998), served spaces are the main functional rooms, while servant spaces are those that support the served spaces. This research mainly addresses the category related to servant spaces: Courtyards.

In architecture, spatial organization and programmes have a close relationship. Often, the initial tasks of an architect are to study the demands of the building's users. With the knowledge, he or she first sketches the programme that indicates the functions and their interrelationships as well as the hierarchy or order of spaces. Traffic is decided in this step. Second, after considering the surrounding conditions, the architect locates the functions at the fixed positions in response to the site. Third, in respecting the dimension of the space, a grid is planned. Last, the specific structure and void-solid walls are decided. This general process is so called 'transformation from program to schematic design' (Laseau 2001).

In this research, the process is implemented inversely. From reality, the functions and the relationship between them are deduced, based on the knowledge of the surrounding conditions and the users' needs.

3.1.2. Principles of ecological design

Ecological studies are seeking explanations for life processes, distributions of organisms, natural resources and energy movement in living communities, and also successful developments of ecosystems. Therefore, ecology is an interdisciplinary science (Spellerberg 2005). Architecture, which is one of the disciplines responsible for the production of the human built environment, plays an essential role in the face of the current environmental crisis. The age of ecology followed the industrial and technological eras due to a new paradigm shift in architecture at the turn of the 21st century. An environmental awareness focusing on the relationship between humankind and its environments, both natural and man-made, appeared in the face of ecological destruction resulting from this environmental crisis. In *Ecological Design* by Sim Van der Ryn and Stuart Cowan (1997), design is defined as: '…the intentional shaping of matter, energy, and process to meet a perceived need or desire. Design is thus a hinge that inevitably connects culture and nature through exchanges of materials, flows of energy, and choices of land use'.

These authors believe that the environmental crisis and design are equal, and that manner of designing and constructing buildings, as well as landscaping, is also responsible for the environmental crisis (Da Cunha 1997; Van der Ryn and Cowan 2013). A clear and obvious response to the environmental crisis finds its expression in the introduction of ecological concerns into design concepts instead of what is called 'dump design', which is insufficient in considering not only the health of human communities but also ecosystems. Ecological design, or Eco-design, has been one of the approaches developed in response to these wants.

Ecological design is defined by Van der Ryn and Cowan (1997) as *'any form of design that minimizes environmentally destructive impacts by integrating itself with living processes.'* It is also defined as *'way of integrating human purpose with nature's own flows, cycles, and patterns.'* (Shu-Yang *et al.* 2004)

There are five principles for ecological design extracted from a detailed critical analysis of several examples specified in Van der Ryn's and Cowan's book *Ecological*

Design. The physical and cultural characteristics of a place which is not considered in most design processes form the first principle as *'Solutions Grow from Place'*. Most of the time, human, material, and ecological characteristics of a place are the context of design and its process.

'Ecological Accounting Informs Design' is the second principle, which plays an essential role in construction and architecture, as well as in LEED, the rating system of USGBC, which is based on financial metrics having equal roles as site, energy, water, material, and indoor air quality (social and environmental factors).

'Design with Nature' is the third principle. The measurements and models for the human built environment, technologies applied, and also social institutions are systems integrated with nature.

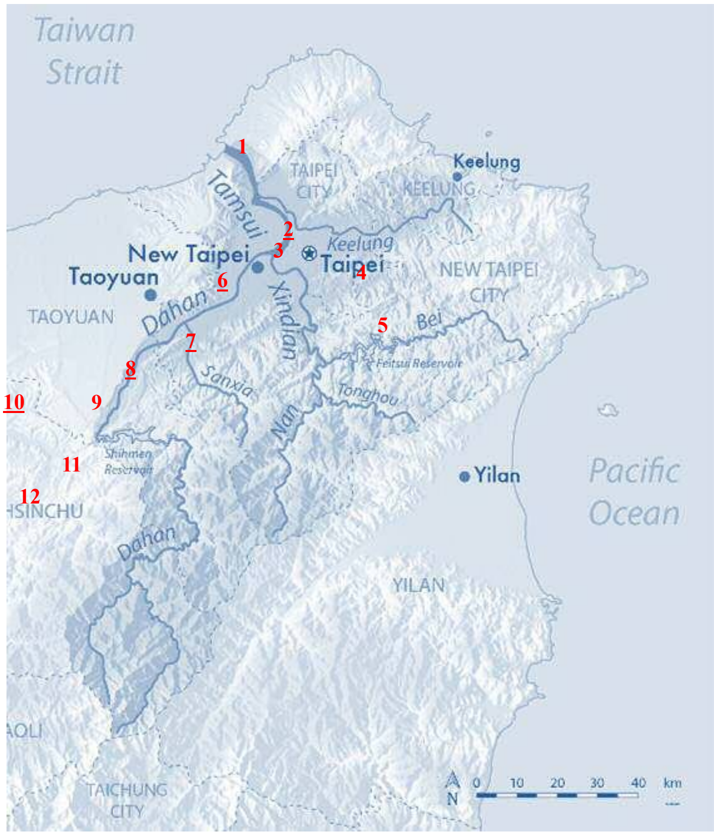
The fourth principal is *'Everyone Is a Designer'*, which states that cooperation is newly considered by a group of designers in the designers in the process of design, and as a result, makes an entire community involved in design.

The fifth and final principle specified for the ecological design is *'Making Nature Visible'*, which has been recently more seriously observed by designers and operators, whereby making the natural and living systems as well as processes more visible and accessible in the present urbanized world is critical. These principles help to think about the integration between the living and natural world, and the humanly designed and built environment within a continuum of spatial scales from small houses to great buildings, and also city textures.

'The search for a unified approach to the design of sustainable systems that integrates scales ranging from the molecular to global', is the expression representing 'Ecological Design' by Van der Ryn and Cowan (2013). Also, in *'Principles and Practice of Ecological Design'*, it is mentioned that 'Eco-design seeks to provide a framework for an environmentally appropriate system of design and management by incorporating both anthropogenic and ecological values, at relevant spatial and temporal scales (Shu-Yang *et al.* 2004).'

3.1.3. Overview of Northern Taiwan old town historic districts

During the past forty years of rapid development in Taiwan, much of its historical architecture has been torn down or glazed over with tiles that don't match the surrounding styles. Fortunately, some communities have recognized the significance of their old thoroughfares and taken steps to revitalize them. Similar to the surrounding towns in the region, the north part of Taiwan has an equable climate with typical weather phenomena of a sub-tropical warm humid region which greatly impacts both the on spatial planning and architecture of the towns. The following is a list of the most notable and accessible old towns or historic streets in the Northern Taiwan area, and the map (Figure 3.1) shows all of these old streets are near and/or along the Tamsui River outlet.



Old towns or historic streets:

1. Tamsui Old Street
2. Dihua Street
3. Bopiliao Old Street
4. Shenkeng Old Street
5. Pinglin Old Street
6. Xinzhang Road
7. Sanxia Old Street
8. Daxi Old Street
9. Sankeng Old Street
10. Hukou Old Street
11. Neiwan Old Street
12. Beipu Old Street

Figure 3.1: Map of the Tamsui River watershed and locations of historic streets. Those underlined streets are including in this research. (Source: GNU Free Documentation License, 2008)

Since most historic fabrics are located within these districts, their spatial compositions are in a sense fuzzy and fine-grained; moreover, the urban contexts themselves also reveal the metamorphosis of a city. For instance, it is common to find an overlap in historical contexts at different times or new developments of historic fabrics. These superimpositions are critical factors in the townscape.

As stated above, most of the street patterns are fuzzy due to the overlapping of town planning during different periods. In their evolutionary process, the impact of urbanization in the Japanese period (1895-1945) is significant. The introduction of a sewer system with thoroughfares designed by Japanese drainage engineers represented a radical change which completely transformed the conventional Chinese old town plot. This early 20th century street pattern, which imitated European land use planning in colonial cities, combined grid and radial systems for transportation convenience. Most lanes and alleys built during the period of Qing Dynasty (1644-1912) have been divided by newly built thoroughfares and become concealed inside the blocks. Due to this urbanization process, the organic street system was turned into geometrical shapes, and the land use pattern was transformed into zoning.

Morphologically, a typical block in the old town district has two layers: an exterior layer and an interior layer (Lin and Cheng 2008). The exterior layer is normally composed of row houses, which include retail stores on the ground floor and living spaces on the upper floors. Facing the through traffic, the continuous façade of row houses and their advertisements become the streetscape of the old town district. The interior layer, on the other hand, demonstrates a different spatial composition. It resembles a quieter residential community even if the density is at almost the same level as the exterior layer. Most housing units are reinforced concrete buildings, and some units enclose a temple plaza. A typical old town block with two distinguished layers actually functions as a mixed-use community. Yet, the morphological weakness is obvious. In between the two layers, there is not adequate concern for public health issues (Lin 2010). For instance, the connection between the two layers is ambiguous; the residual room between the exterior and interior layers is normally too tight for lighting and ventilation.

3.2. Impacts on development of shophouses in Taiwanses old towns

Since this research aims to develop the current situation of shophouses in Taiwanese old towns, the impact on the development process of the neighbourhood should be taken into account. Every building in the city would be affected by the surrounding environment it is located in and the Shophouse is no exception. Not only decided by the homeowners and the shop runners, the development of shophouses is also greatly affected by urban contexts and the natural conditions of the surrounding areas. By taking an overview on the city and the neighbourhoods as well as providing a critical description of the cultural significance and environmental performance review, this part of the study should be referred to suggest possible proposals for developing the shophouses towards continual Ecological Design.

3.2.1. Cultural significance of shophouses

The origin of vernacular shophouses can be traced back to the influx of Chinese immigrants from densely populated southern coastal provinces of China from the 19th century until World War II (Chen and Kanna 2012). By the early 20th century, this urban design spread to every major city in Southeast Asia. One of the most important features of traditional shophouses is the courtyard. Originally, interior courtyard houses were typically found in residences throughout China, but their composition and scale were different across the country (Knapp 1999). In general, the proportion of courtyards to structural spaces diminishes significantly from Northeast to Southeast China to restrict the infiltration of direct solar energy and to facilitate ventilation (Knapp 2000). Therefore, Knapp used the term ‘skywell’ to describe a relatively small courtyard, which is typical of those found in Southeast China, as opposed to a relatively large northern courtyard. Nowadays, most of the existing shophouses consist essentially of an elongated brick row house located in relatively dense urban areas.

A few years ago, the historic city centre of Malacca and George Town of Penang (Figure 3.2), with their mostly Chinese shophouses, colonial buildings, and colourful shophouses, were added into the list of UNESCO World Heritage Sites. The distinct structures are a dominant feature of its capital, George Town, and they are part of the reason why a part of the city was listed. A description quote from the International Council on Monuments and Sites (UNESCO 2008): *‘... The two towns constitute a unique architectural and cultural townscape without parallel anywhere in East and Southeast Asia’*. Indeed, they were most often built in contiguous blocks bound by a grid pattern network of roads and back lanes, many of which can be seen in the collection of seven thousand shophouses of different periods that remain in George Town to this day.

(a) *(b)* *(c)*

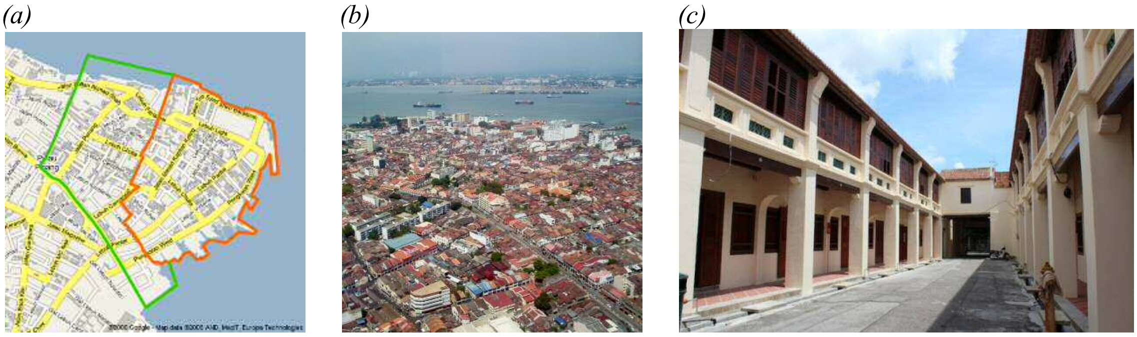


Figure 3.2: (a) Map showing the boundaries of George Town of Penang, Malaysia; (b) Aerial view of the historic city, George Town; (c) Shophouses in Khoo Kongsi compound of. (Source: ICOMOS, 2008)

By comparison, practically all of Taiwan's old streets can be labelled as 'historic districts', in that they all have a rich and varied past, an interesting stock of historic buildings and a rich history. Some of these streets or towns have become very popular with tourists due to their location, the attractions and historic buildings they contain, or the fact that the stories they tell can be particularly compelling. The aim is constructing a strong sense of place identity for public enjoyment on the streetscape. However, simply walking into the buildings, the traditional inner courtyards are frequently no longer open and are thus found to be unnecessary with large amounts of modern mechanical facilities such as air conditioning and electrical lighting installed. As a result, in the context of historical districts in Taiwan, this building, beyond the currently valued façade and walkways will have 'heritage value' only if owners and tenants retain the distinct historical features of their shophouses or restore those, such as the inner courtyards, that have been lost.

For the purpose of this review, the term 'historic districts' is taken to include the traditional town centre and shophouses that possess a local distinctiveness. The layout or morphology of these towns today is influenced by the landscape within which they are located as well as by the history and the manner in which they were developed. The main aesthetic components of historic centres are firstly their general form and character, which are influenced by their topographical context. A hilly site will, by its nature, influences the layout of a town or village. There will be views and vistas over the surrounding landscape and narrow winding streets which are full of surprises and intimacy. Conversely, settlements developed in the context of flat landscapes, generally have a more spacious and formal layout. The view from a single main street town located in the countryside has fewer surprises and its essential character is immediately recognizable. Many large cities or towns may combine elements of both.

Both George Town of Penang (Figure 3.4) and the three famous historic districts in Northern Taiwan (Figure 3.3) have a unique past which led them to develop into towns whose street pattern today reflects the layout of early settlements from the 17th century, and others that are framed around long established, if often now lost, industries. These settlements were also important markets and social centres for the surrounding urban catchment areas. Of course in some cases, these forms of settlement will overlap in particular towns. In the 1960s and 1970s, most Southeast Asian shophouses again became the common building idiom, especially in the central areas of new towns and in housing estates (Tazilan *et al.* 2012).

In Figure 3.3, it can be seen that the existing shophouses with clay roof tiles formed a linear street pattern, and they are now found to be surrounded by modern concrete building blocks. Almost all the shophouses are in such an environment. In Daxi Township, there are many shophouses that have been converted into a simple reinforced concrete building: modern shophouses (Figure 3.3b).

However, the other three cases here are able to be distinguished and still maintain their traditional characteristics, especially for the case of Sanxia Township (Figure 3.3a), although such examples are already very rare in today's Taiwan.

Figure 3.3: Satellite images showing examples of the form of historic old streets in Taiwan. (Source: Google Maps, 2017)

In contrast to the current situation in Southeast Asia, the distribution of traditional shophouses was still based on the urban blocks for arrangement, showing the type of development in block plan. These can be seen from the following satellite images of George Town of Penang (Figure 3.4), Ipoh Old Town (Figure 3.5), and Malacca Town (Figure 3.6) that show the high density of traditional shophouses in these locations. The most obvious example is in George Town, where a large number of organic street forms appear on the modern urban street blocks. In comparison, the urban texture of both Daxi (Figure 3.3b) and Malacca can be found to very similar as they have very long-deep building plan at about 60m and 100m respectively.

Figure 3.4: Satellite images showing examples of the form of historic urban settlement in George Town of Penang, Malaysia. (Source: Google Maps, 2017)

Figure 3.5: Satellite image of the city of Ipoh in Western Malaysia. (Source: Google Maps, 2017)

Figure 3.6: Satellite images of the historic urban settlement of typical/traditional long-deep plan shophouses in Malacca, Malaysia. (Source: Google Maps, 2017)

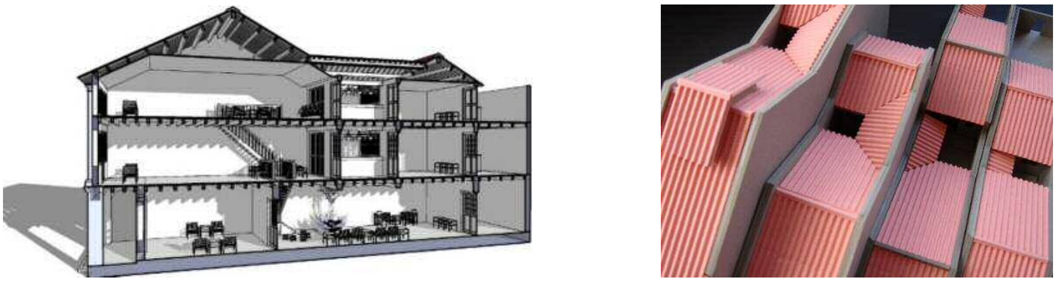


Figure 3.7: Typical and most basic layout of traditional shophouses with at least one skywell, a small courtyard space. (Source: Illustration and study models by author, 2008-09)

The shophouse is a kind of courtyard house (Figure 3.7). From its Southern Chinese typically square courtyard house origins, it is possible to imagine squeezing both sides until it becomes deep and narrow, rooms on the sides disappear into the party walls with the neighbouring units, and the lost enclosed space is redistributed to the front. Indeed, the squeezing is also applied by a row of neighbouring units, originally detached, until they are joined by party walls. The courtyard itself remains, with the intention of providing natural ventilation and lighting.

Spatial organization of traditional shophouses is based on the use of several bays (Figures 3.8). The first bay, or the front part of the shophouse (Figure 3.9a), contains space devoted to commerce as well as to the hall of worship to the God of Commerce. Sometimes, the first bay may also have a lounge or business offices. It is quite common that this front bay is longer than the other bays of the house, and sometimes may have a double pitched roof due to its great depth. Moreover, attic space may be used for storage of commercial goods. Finally, skylight openings are used in this section to provide light to the interior. The main entrance of the shophouse is also located in this first bay and it usually has the typical form of a central door with two side lights. Each window has a foldable shutter which is lowered during daytime to display goods, and hoisted up at night.

The second bay of the traditional shophouse is located beyond the first (Figure 3.9b), with a courtyard separating it from the first. This second bay includes the hall for ancestral worship as well as bedrooms. The third bay of the house, which includes the Buddhist hall and the residential spaces for the elderly, again is separated from the second bay by an intermediate courtyard (Figures 3.9c and 3.9d). Usually, a corridor on one side or in the middle of the courtyard links the three bays of the shophouse together. This corridor also serves as a kitchen. When the family size increases, or there is the need for additional commercial space, units are usually added as a rear extension, on additional story, or laterally.

In the Southeast Asian context, and with a focus in this study on Malaysia, Singapore, and Taiwan, the shophouse typology isn't always easily referred to as urban architectural heritage for several reasons (Chulasai 1985). Most shophouses are still functioning as purely utilitarian structures; as dwelling combined with stores or storages, free from any decoration and ornamentation. Only those that belong to prominent families have distinguishing characteristics. Shophouses in small hinterland towns appear much simpler and utilitarian than the ones in big coastal cities. Some in colonial administrative towns have distinguished 'European' characters which may be due to the Chinese social status in the colonial's bureaucratic structure or simply a lifestyle choice. However, most shophouses appear as common urban structures without any distinctive features and therefore they were given no special historic values. As common and utilitarian structures, they were also constantly changing due to additions, alterations, demolitions, and reconstructions.

Similarly in Taiwan, by the time shophouses were introduced into urban society, there was not any local type of architecture that could serve the new functions of commerce. A century later, shophouses are now an important type of commercial facility. For example, in suburban housing villages, a group of shophouses is always considered a community commercial centre. Shophouses were originally constructed with neither high technology nor complicated machinery, but only with locally available materials and craftsmanship. From the economic point of view, shophouses are evaluated in terms of construction costs. Due to their popularity, the large quantities, and the basically unchanged designs, shophouses have developed unofficial standards and practices by builders and manufacturers.

a: living room | **b**: shrine | **c**: master bedroom | **d**: bedroom | **e**: shopfront | **f**: courtyard
g: office | **h**: storage area | **j**: study room | **k**: restaurant | **m**: workshop | **n**: rear shop

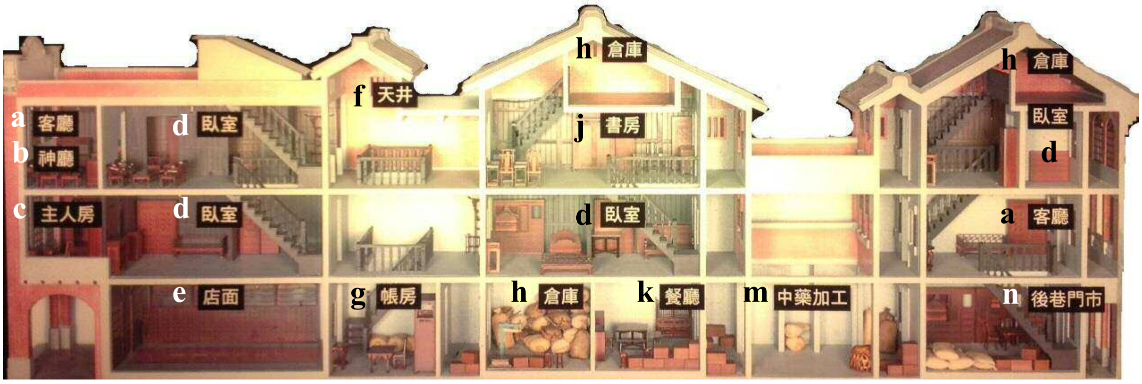


Figure 3.8: Long section of typical early shophouse building in Taipei City. (Source: Taipei Story House, photographs taken by author, 2012)

Figure 3.9: Model of typical shophouse: (a) shopfront layout, (b) residence layout, (c) courtyard and (d) warehouse layout. (Source: Taipei Story House, photographs taken by author, 2012)

3.2.2. Environmental performance review

Environmental control inside courtyards in this study refers to the required control of basic factors for the immediate needs of convenience and physiological comfort of the occupant of a shophouse building generated by or related to micro-climatic conditions. Courtyards have been an integral component of dwelling typology from the first human civilizations, whether it be the Indus Valley, Egyptian, Mesopotamian, or Chinese regions. Houses in those eras were characterized by deep long houses, and compact with three edges shared with adjoining homes (Brian *et al.* 2006; Brown and DeKay 2001; Rapoport 2007). While this arrangement allowed optimal use of land and higher densities, it deprived the inner spaces, thus allowing light and ventilation. As a result, internal courtyards came to be adopted as an inherent dimension of traditional shophouse typology.

We limit our discussion in this study to only the aspects of ecological design that are related to environmental control for comfort and convenience of the occupant of courtyard shophouses. It is argued that 'climatic responsive design' solutions with appropriate building orientation, configuration, and fabric design that take into consideration various climatic concerns, will reduce the dependency on mechanical means of environmental control for comfort and use less energy resources, and is therefore considered part of sustainable architecture (Hyde 2013). In this study we can see that environmental control is an essential part of traditional shophouses as defined above, and that a desirable ecological design is one that provides comfort and convenience for occupants of shophouse buildings.

The physical factors in relation to the tropical climate that need to be considered in environmental control in traditional shophouses (identifed by e.g. Georg 1980; Fry and Drew 1956; Koenigsberger al 1975; Olgyay *et al.* 1976), include:

1) solar radiation and sun path,
2) daylight and glare,
3) temperature and temperature change,
4) humidity and rain,
5) ventilation, and
6) noise and air pollution.

In the urban context of fast developing cities, these also include noise pollution in congested areas, where a design with many openings to encourage cross-ventilation will also invite noise and air pollution. In the control of rain, this may be in the form of a roof or a covered walkway of a certain proportion to provide protection for individuals to move with comfort and convenience from one part of the room to another in the tropical rain. For the control of heat for comfort, it can vary from providing a simple large roof over people's head, which can allow cross-ventilation from the sides to keep occupants cool, or to the use of an air-conditioning system in an enclosed space.

It is noted here that the use of air-conditioners and mechanical fans or ventilators to control various environmental factors for living comfort, as mentioned above, will be considered active approaches requiring the direct consumption of energy to operate. Passive approaches will be those that do not require electro-mechanical energy to control the climatic factors for comfort. Passive systems include orientating windows away from direct sunlight where possible, providing building elements such as louvres to shade direct and diffused solar radiation, openings to encourage ventilation, and suitable planting of vegetation to keep the inner spaces from overheating.

However, the overall thermal discomfort owing to the humidity problem cannot be effectively eradicated by cross-ventilation all year round. Coupled with this is the noise and air pollution in the congested city. Considering the economic, social, and cultural needs, as well as the climatic and urban conditions of Southeast Asia, air-conditioning has proven to be a widely adopted approach for providing the necessary comfort and convenience in a tropical environment.

3.2.3. A loss and gain problem

On the city and regional scale levels, the changes of urban and social spaces of post-war shopping areas between towns belonging to very similar cultures help understand the issue of different treatments of shophouses. The different heritage buildings and streetscapes in the historical districts all have a distinctive character, although they are also all recognizably part of their early old streets, linked by their particular histories, economies and cultures (Owen 1995; Clifford and King 1993). Small-scale changes to local landscape take place almost constantly in response to shifting values, fashions, availability of products and the spread of new technology.

Although change is inevitable it can be at the expense of those features that give historic districts their particular character. Over time these can have a real impact on the way these areas look and feel, often reducing the recognizable differences between different parts of the street or district and gradually diminishing the cultural character of these areas as a whole.

The key value, it is expected, will be in explaining the above theoretical concepts used in developing a particular kind of place-identity, which as a method or process of design intervention can help to construct their own place identity (Gustavsson 1999). For example, a street at the Traditional Handcraft Artists' Studios (Figures 3.10 and 3.11) was tailor-designed to represent their strong sense of identity. The buildings are imitations of early 19th century Taiwanese shophouses. There is also a replica of a Western style house from the Japanese occupation era in Taiwan (1895-1945).

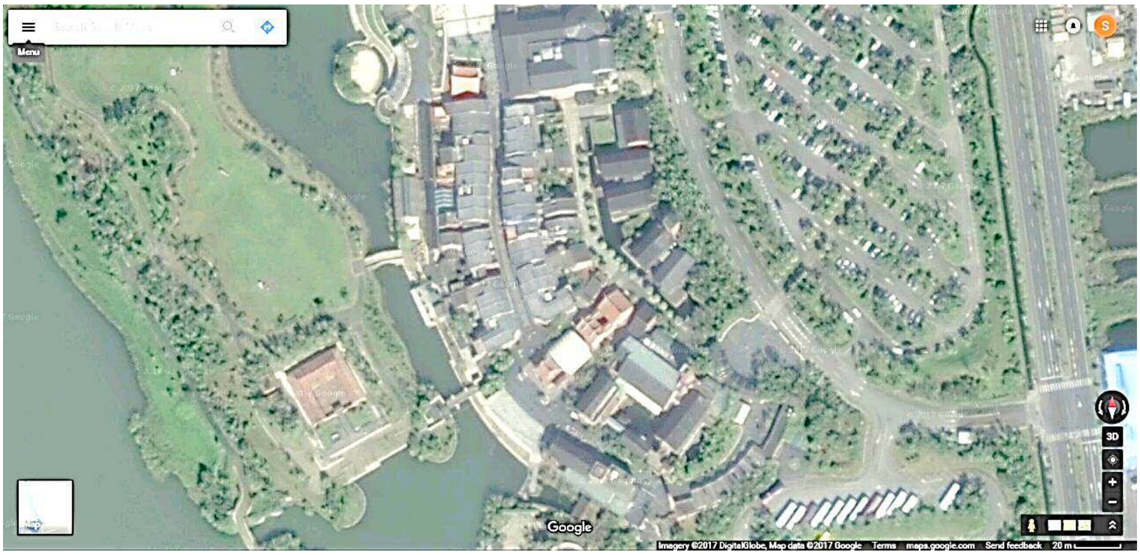


Figure 3.10: Satellite image of the Traditional Handcraft Artists' Studios, Center for Traditional Arts, Yi-Lan County, Taiwan. (Source: Google Maps, 2017)


Figure 3.11: Streetscape views of the Traditional Handcraft Artists' Studios, Center for Traditional Arts, Yi-Lan County, Taiwan. (Source: Official website of the Traditional Handcraft Artists' Studio, 2010)

In the 1980s, however, the new-found affluence of urban Asians sparked a booming car population and a consequent demand for car parks. Shophouses were replaced by high-rise buildings, complete with parking bays and surrounded by roads, which often became ‘islands’, isolated from adjacent buildings. The 1980s also marked the appearance of powerful corporations seeking expression through their buildings, and these were provided by the construction of high-rise buildings. In the late 1980s and during the 1990s, the merits of these isolated buildings as urban forms, unsupported by a structured urban framework, began to be questioned (Chulasai 1985; Fels 1994; Hermawan *et al.* 2013).

In Taiwan, most of the central blocks had developed from old urban districts; there were also some quite cultural streets and historical dwellings. These have clear characteristics patterns of old urban cities; folk customs; living lifestyles; wooden handicrafts, and some cultural content of certain eras. These were hidden chances for urban redevelopment. However, these old blocks were the focus of past urban development and had been designated as high volume commercial areas, but also those aged dwellings were private property. Thus, when the old blocks needed to be renovated for improving the quality of living environments, the cultural preservation and the high volume development of buildings turned into the architectural double-sided issue, which formed a conflict dilemma (Chen and Song 2011). In general, the economic incentives of high volume redevelopment and the cultural preservation had not been established with the residents yet, ‘the rebuild or demolish’ as a simple and a widely adopted method to renew, but it caused cultural assets to disappear. Then, we lost not only some evidence of a city’s history, but also the charm of the city characteristics for self-development.

Singapore is famous for its careful preservation of shophouses as part of its heritage, especially compared with the preservation in other countries in Southeast Asia (Yuen and Hock 2001). They believe the original use is always the best use for a conservation building. However, old buildings may often have to be restored and upgraded to meet modern living needs or to accommodate new uses. In restoring and adapting a conservation building to new uses, it is important to adhere to appropriate conservation principles in order to retain the intrinsic character and historical value of the building. Alteration or strengthening of the building structure is to be done in the most sympathetic and unobtrusive way, using the original methods and materials wherever possible.

Therefore, the Urban Redevelopment Authority (URA) has developed specific conservation guidelines for shophouses and terraced houses related to the Key Elements of the typology of the building as follows (Authority 1995; Yuen and Hock 2001):

(a) Roofs; (b) Party Walls; (c) Timber Structural Members;
(d) Airwells; (e) Rear Courts; (f) Timber Windows;
(g) Timber Staircases; (h) Front Façade.

Returning to Southeast Asia, and Taiwan, traditional shophouses preservation is not an isolated case, but is also meant to develop some similar conceptual treatments for urban renovation projects. They have to take two conditions into account: one is owners having the right for their building volume because of the historical buildings being largely privately-owned, and the other is owners also needing a fast preservation method for renewing their old house because of the Cultural Heritage Preservation Law being a lengthy process. Nowadays, they face two issues:

- To think about the two-sided problem of 'preservation' and 'renewal' from the discussion of historical dwellings. How can we balance these challenges?
- To think about the 'strategies' and 'tools' related to historical building preservation. How can we benefit settlement preservation efforts?

In light of the above theoretical concepts, these countries and/or cities have explored and developed some essential processes or guidelines (Ellisa 1999; Fels 2002). The first step is an investigation of the preserved district, to explore the characteristics of the living environment, establish the value of buildings in the historic district, and define 'Volume Control' (Figure 3.12A) levels for architectural preservation, and explore the basics of 'Minimal Preservation Space' (Figure 3.12B). Then, the next step is the renewed simulation studies for volume control, to seek the possibility of the preservation and rebirth. At the end is the post-operation evaluation of the research and discussion.

(A) volume control *(B) minimal range of preservation*

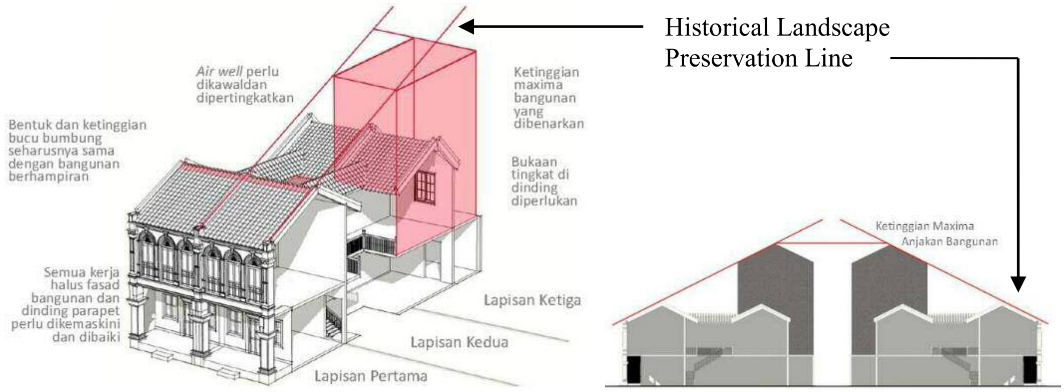


Figure 3.12: (A) 'Volume control' for renewal; (B) Minimal range of preservation for substances spaces. (Source: Malaysia Urban Conservation Initiatives, 2011)

The control of 'minimal preservation space' means 'limited preservation'; it is partly preservation and partly reconstruction. The reconstruction of historical buildings is part of 'reuse' preservation, so in order to control the efficiency of reconstruction from destroying the historical authenticity, it needs to preserve part of the building and prevent the reconstruction work from destroying the historical environment. On the other hand, consideration to satisfy the residents by the usage of the rate of capacity, therefore, 'minimal preservation space' serves as the bottom line for reconstruction work as well as balancing tools for both preservation and development in order to add support to a reconstruction proposal. The tools of the preservation are 'volume control' and 'historical landscape preservation line'. A building restriction is the area that defines zoning under the permitted building capacity to the operation of quantitative renewal. This is used to distinguish the parts which need to be preserved and that need additional build-up.

The Historical Landscape Preservation Line (refer to Figure 3.12) is intended to grasp the human view on both sides of the historical street to specify the height of the view and set up the control line. The method is to let a person stand at the opposite side of the street, at the eye level of 150cm, looking opposite the street to the highest point of the façade of the building. Using this extension line as a reference, buildings exceeding the restriction line had to move back in order to ensure the viewing quality of the historic cultural attractions.

The above methods are a top-down mechanism, but still retain the flexibility for the preserved range. In Taiwan, a better preservation effort will be expected in strengthening the preservation consciousness of its residents (Chen and Song 2011). For this reason, it is a dynamic preservation (Figure 3.13); to define hierarchy of the building preservation restriction. There are about five to six levels of building preservation from the street space to the end of house:

1) Building façade and streetscape,

2) First extension until the space of the first hall,

3) Second extension until the first courtyard,

4) Third extension until the second hall,

5) Extension continuation until the second courtyard, and

6) Final extension until the third hall.

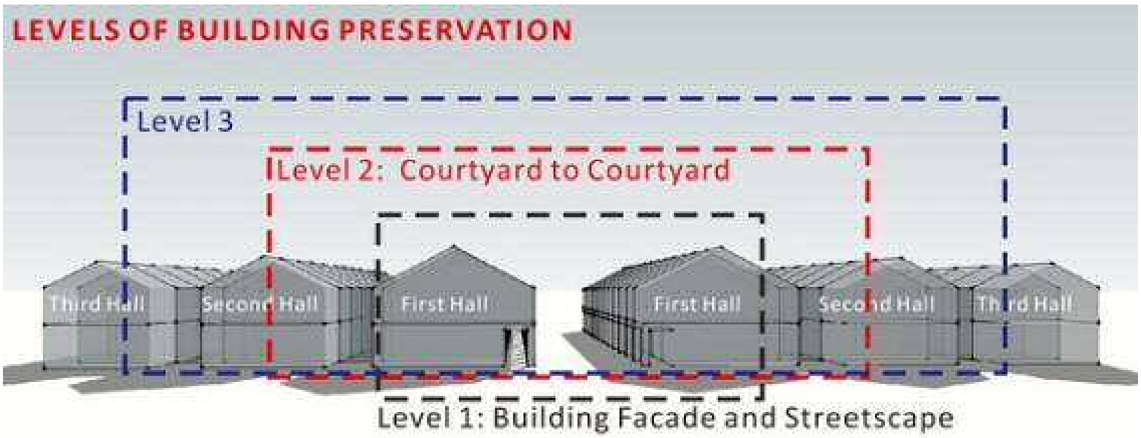


Figure 3.13: Levels of building preservation. (Source: Illustration by author, 2010)

Another current condition in Taiwan's historic towns, or old blocks, is where the focus of the past urban development has been placed in areas designated as high volume commercial areas (see Figure 3.14), but also on old privately owned shophouses. When these old blocks need to be renovated to improve the quality of living environments, the cultural preservation and the development of high volume lead to an architectural double-sided issue, which will form a dilemma.

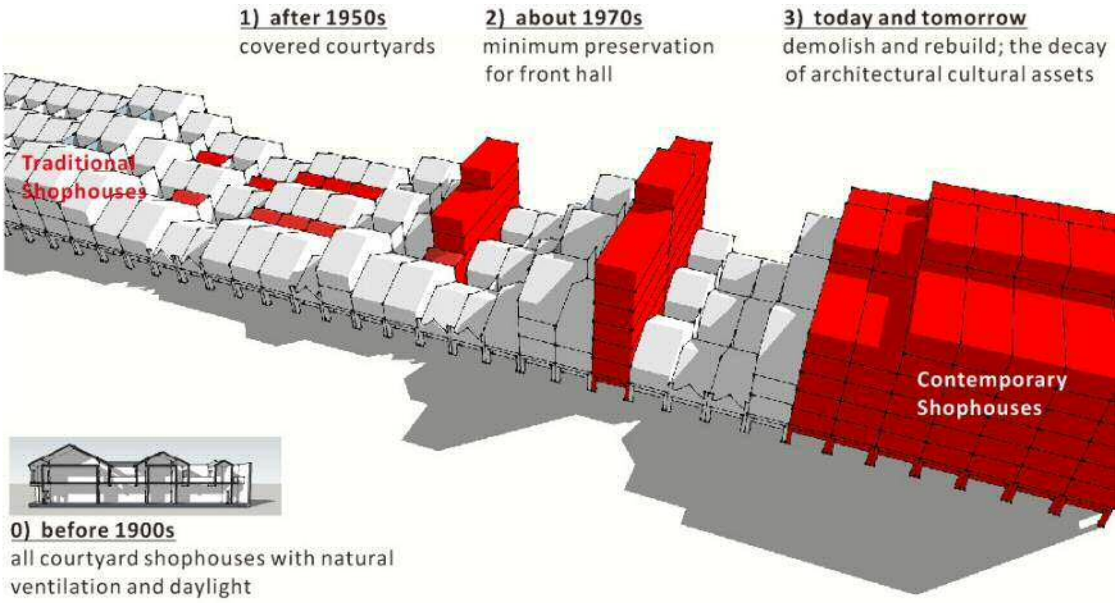


Figure 3.14: Visual model and levels of building (shophouse) reconstruction within the historic urban settlements. (Source: Illustration by author, 2009)

3.3. Summary

Among different types of building remaining, shophouses are one of the most-seen in Northern Taiwanese old streets. Besides the high historical value greatly recognized by considerate preservation, the long life span of the house originated from their own liveability. By the linear organization, the shophouses play their residential and commercial functions well. Moreover, their operation also has a low impact on the environment. Specifically, design elements (Davison and Invernizzi 2010; Guan 2011; Sujana 2002; Tan and Fujita 2014) related to spatial organization (Figure 3.15) are described in Table 3.1:

DESIGN ELEMENTS	PHYSICAL FEATURES	ADVANTAGES
Urban spatial organization	The neighbourhood is located nearby Tamsui River	To support the goods transportation to and from the shophouses
Building orientation	Houses were mainly built along the streets going the same direction as the river	To create a tight network for goods transportation
Primary spatial organization	Shophouse is divided into 3 distinct spaces with different functions	To ensure different demands of a multi-functioned building
	Those spaces are built continuously	To ensure the operation of the houses in spite of changes in weather conditions
	Those spaces are connected via a hallway going throughout the house	To create a wind path throughout the length of the whole house
Hierarchy order of spaces	Spaces are designed following orders of accessibility: first dynamic space, then still space; first public space, then private space, first served and then servant space	To ensure the typical spatial order of a living space
Courtyards	The small patio in the middle of the long narrow plot; often has plants and water basin	To distance the spaces used for shop and house; to ensure the privacy of both users To create a space for greenery; to enhance using of natural lighting and ventilation To create another green belt for a wind path over the neighbourhood
Backyard	The small patio in the end of the narrow plot; often has plants	To support demands of subordinate rooms such as kitchen, toilet and shower room To create a space for greenery; to enhance using of natural lighting and ventilation To create another green belt for a wind path over the neighbourhood
Deep overhang	At the front building of the house; like another span added to the main building	To create a setback and to play as a transitional space for the shophouses To avoid direct solar radiation as well as rainy crosswind
Balconies	For the first floor, looking down to the courtyard and the street in front of the house	To open the view to the courtyard or the street for watching and breathing fresh air To create another overhang for the space below
Storage room	In the bridging building and/or on the mezzanine upstairs the shop	To connect the shop with its own store well and make its operation not affect other spaces of the homeowners
Staircase	Often in the middle of the house although the location depends on the house's structure	To support goods storage or activities of the households in different situations

Table 3.1: Design elements related to spatial organization of a typical traditional shophouses.

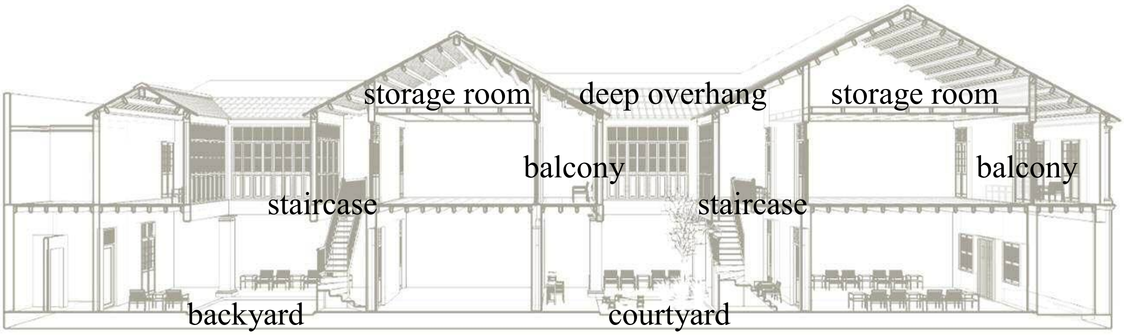


Figure 3.15: Design elements related to longitudinal section. (Source: Illustration by author, 2009)

In terms of urban planning, the greenbelt is one of the most significant characteristics of Taiwan's old towns. It has been created by a row of courtyards of the adjacent shophouses. In the perspective of Ecological Design, the void space helps create a wind path, and hence, improve the microclimate conditions of the neighbourhood.

From neo-classical buildings to shophouses, shopping centres, and finally to townhouses, all have developed at the same pace as urbanization in Taiwan. Shophouses influence, and are influenced, by urban culture and have become an important part of the history of the development of urban shopping facilities. However, there is a surplus of shophouses all over the city. A new form of urban housing for city living is high rise apartments, and modern commercial facilities are department stores and shopping complexes. On the other hand, shophouses have become old-fashioned as physical facilities and with no intervention are destined to be abandoned.

The question then is: are traditional shophouses a social heritage which we need to conserve for later generations, or are they a social detriment which we intend to eliminate from our urban areas? Whatsoever we do, it is the truth that difficulties surround the future of traditional shophouses today.

4. Methodology – Surveys: Establishing Change Requirements

The previous chapters addressed the many challenges faced by traditional shophouse buildings in the urbanization process, which largely have not appeared to address the consideration of environmental performance or sustainability within building maintenance and/or renovation works to date. This chapter outlines the research methodology for this phase of the research, and the methods used for the collection of data to understand the question posed; to establish the extent to which the use and presence of courtyards has begun to change and or diminish.

4.1. Introduction

Change in lifestyle, working conditions and business operating has resulted in further changes in the scope of the use of the shophouse courtyard. Howard Davis (2012) pointed out that the shophouse as an archetype has not received much attention from scholars, and less so by practitioners of urban development. He noted that since the beginning of the twentieth century urban designers and city zoning agencies have favoured buildings with single functions and have prevented the integrated way of life afforded by working and living in the same building. However, the following qualitative research is focused on describing and understanding this phenomenon or process.

4.1.1. Phase 2: The questionnaires' design and implementation

In this phase of the study, the research was performed by using field surveys of the shophouse physical environments and questionnaires for gathering information on public attitudes toward community planning and vernacular shophouse architecture. The studies for continuity and development of each community's environment were performed as follows:

a. Collecting primary data
b. Field-survey of the physical environment
c. Community opinion survey
d. Integrative analysis of both field-survey of physical environment and opinion survey
e. Ecological design concepts for continuity of traditional shophouse related to sustainable tourism

Collecting primary data: Primary data of the study areas were collected and analyzed so as to assess the cultural significance of historic towns and to prioritize community problems. The studied subjects were concepts and theories of urban planning, sustainable development, sustainable tourism development, origins of local district, histories of the old streets, socioeconomic factors, and community environment impacts on tourism growth, the last of which covered both levels of community planning and vernacular architecture.

Field survey of the physical environment: In this study, the community environment was studied in relation to tourism; from community planning to vernacular architecture. On the vernacular architecture survey, the study investigated significant criteria including levels of shophouse building preservation and community image.

Community opinion survey: Self-administered questionnaires and interviews were used for collecting opinions from shophouse owners and occupants in all districts and towns. A convenience sampling technique and statistical assessment on SPSS were applied to analyze the data obtained. The same scope of works; planning and design, user experiences, and vernacular architecture issues, was asked about in these questionnaires to understand occupants' attitudes towards the above issues and current problems related to tourism growth.

Integrative analysis of both field surveys of physical environment and opinion survey: Data derived from steps (i) to (iii) were analyzed in order to determine the solution plan for architectural problems. The results of the main surveys framed the selection of the ecological design proposed for shophouses' continuity and development in two levels; planning and architecture.

Ecological design concepts for continuity of traditional shophouses related to sustainable tourism: The ecological design concepts or guidelines for continuity and development of old streets and/or historic towns was proposed in terms of conceptual diagrams, drawings, as well as perspective views.

4.1.2. Survey questionnaires

The study employed two separate questionnaire surveys:

1. for shophouse owners or occupants,
2. for on-street visitors

in collecting data on the barriers and success factors that affect the retention of shophouse courtyards (see objectives and hypothesis, Section 2.2).

These two questionnaires were similar in asking about the internal courtyards of shophouses, but each was designed to elicit relevant perspectives and experiences from each target population.

4.2. Case study neighbourhoods

In Taiwan, the above surveys were conducted in three historic districts and three tourism streets (Figure 4.1). These six major districts from south to north are:

1. Beimen Street, Hsinchu City
2. Hukou Township, Hsinchu County (tourism)
3. Daxi Township, Taoyuan County (tourism)
4. Sanxia Township, New Taipei City (tourism)
5. Xinzhuang Road, New Taipei City
6. Dihua Street, Taipei City

Both Beimen Street (Figure 4.3) and Hukou Township (Figure 4.4) are located within the Hsinchu City region and are just under 30 minutes by car from Chung Hua University, the place of work of the researcher. Another four districts are located along the same river system; both Daxi Township (Figure 4.5) and Sanxia Township (Figure 4.6) are upon the Dahan River, and both Xinzhuang Road (Figure 4.7) and Dihua Street (Figure 4.8) are upon the Tamshui River. The Dahan River originates in Hsinchu County and then flows through Taoyuan City and New Taipei City for 135 kilometres before joining Xindian River in Taipei to form the Tamshui River.

Figure 4.1: Map showing the locations of the selected historic streets (old towns) in Northern Taiwan and its surroundings. (Source: Google Map, 2013; Fieldwork, 2011)

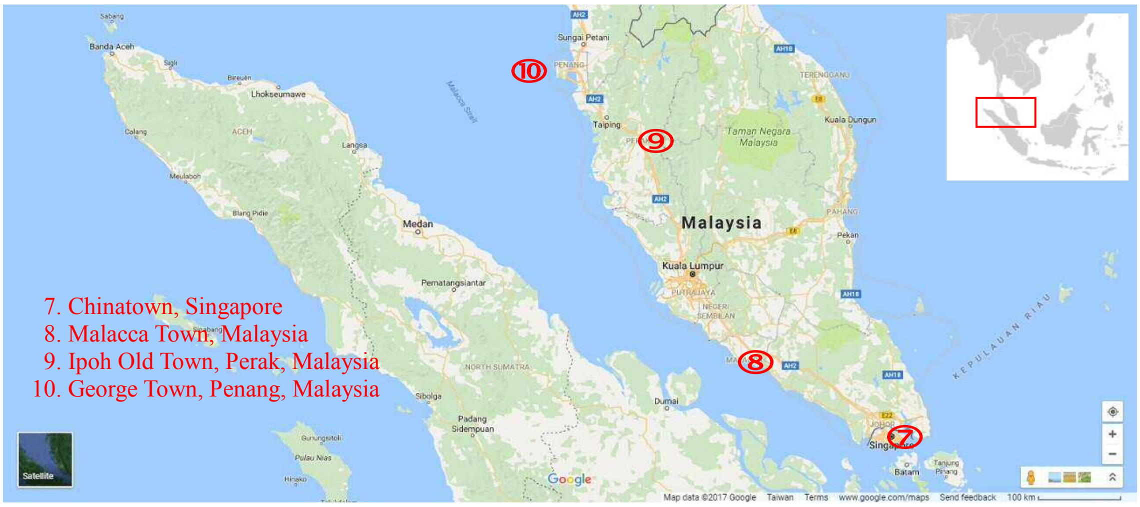


Figure 4.2: Map showing the locations of the selected historic towns in the Malay Peninsula and its surroundings. (Source: Google Map, 2017; Fieldwork, 2009-2012)

In the Malay Peninsula, located in Southeast Asia, the above surveys were conducted in four historic towns (Figure 4.2). These four major towns from south to north are:

7. Chinatown, Singapore (Figure 4.9)
8. Malacca Town, Malaysia (Figure 4.10)
9. Ipoh Old Town, Perak, Malaysia (Figure 4.11)
10. George Town, Penang, Malaysia (Figure 4.12)

Due to the limited time available for the data collection, however, the Occupant Survey and the Visitor Survey were mainly based in Taiwan and the Malay Peninsula respectively. Table 4.1 shows the actual number of survey respondents from the different historic towns, and also the following A3-format pages show their urban context in maps and streetscape images for the reader's reference.

	Locations of Case Study	Physical Survey	Occupant Survey	Visitor Survey
Taiwan	1. Beimen Street, Hsinchu	--	21	--
	2. Hukou Township, Hsinchu	--	33	17
	3. Daxi Township, Taoyuan	1	30	26
	4. Sanxia Township, New Taipei	--	36	31
	5. Xinzhuang Road, New Taipei	--	26	--
	6. Dihua Street, Taipei	--	25	9
Malay Peninsula	7. Chinatown, Singapore	--	--	12
	8. Malacca Town, Malaysia	--	--	13
	9. Ipoh Old Town, Malaysia	--	--	6
	10. George Town, Penang, Malaysia	--	11	37

Table 4.1: Number of survey respondents in each location of case study.

Figure 4.3

Beimen Street 1

Hsinchu City, Taiwan

Number of occupant surveys = 21

(Source: Hsinchu City, 2017; Google Maps, 2017; Photographs taken by author, 2010-2011)

Beimen Street was the earliest developed commercial area in Hsinchu City. It experienced two fires that almost destroyed the traditional Qing Dynasty (1644-1912) architectural appearance on the street. Nowadays, it has stores that have survived since the Qing Dynasty and the Japan-ruled period (1895-1945) as well as modern commercial buildings. This market has more than two hundred years of history and is inhabited by over 250 shophouses.

(a) Satellite image of Southern Beimen Street

(b) No. 9 to No. 15

(c) No. 82

(d) No. 144 and 146, were partly destroyed

(e) No. 57 to No. 61

Figure 4.4

Hukou Township 2

Hsinchu County, Taiwan

Number of occupant surveys = 33
Number of visitor surveys = 17

(Source: Hsinchu County, 2017; Google Maps, 2017; Photographs taken by author, 2010-2011)

Hukou Township is a 300-metre long street occupied by over 200 shophouses that were built around 1920. This old street is lined by two-storey, redbrick buildings that are probably the most complete Japanese-era urban thoroughfare remaining in Taiwan. It is also preserved well with a number of government-funded restorations going on. Hukou Old Street has been repaved with granite slabs, with the façade repaired and cleaned up, as well as sculptures of dragons, deer, cranes and other symbols that are important features of Chinese-style architecture.

(a) Satellite image of Hukou Township

(b) Southern back-view of shophouses

(c) Street view at east end

(d) View of covered walkways

(e) Briefing from a tourist guide

Daxi Township 3

Taoyuan County, Taiwan

Number of occupant surveys = 30
Number of visitor surveys = 26
Physical survey = 1

(Source: Taoyuan County, 2017; Google Maps, 2017; Photographs taken by author, 2010-2011)

Daxi Township is one of the famous Taiwan old streets that used to be a bustling hub for camphor and tea trade, and the passage of Daxi Old Street was built as a shortcut for workers to pass through so that they could transport goods without walking a long way. This old street is occupied by over 200 shophouses and is filled with diverse stores with the façade designed in a Baroque style that is a blend of Eastern and Western styles.

(a) Satellite image of Daxi Township

(b) Example of a typical façade

(c) New rise behind the old buildings

(d) Space for future new building

(e) Walkways

(f) Street view in the evening

Figure 4.6

Sanxia Township 4

New Taipei City, Taiwan

Number of occupant surveys = 36
Number of visitor surveys = 31

(Source: New Taipei City, 2017; Google Maps, 2017; Photographs taken by author, 2010-2011)

Sanxia Township is a traditional, suburban district in New Taipei City. Historically, Sanxia (meaning three gorges) was an important goods distribution centre in Northern Taiwan due to its location. It quickly became a base for production and the streets of the town were lined with shops that sold dyes, manufacturing materials, and tea. However, after the modernization of this industries, the town lost its economic advantages over other locations, and the riverfront area around there now serves to educate visitors about the past. Nowadays, this 300-metre long street is occupied by approximately 160 traditional shophouses.

(a) Satellite image of Sanxia Township

(b) A case of combined property on the street

(c) Walkways

(d) View from the roof floor of the police station

(e) Street view at noon

Xinzhuang Road 5

New Taipei City, Taiwan

Number of occupant surveys = 26

(Source: New Taipei City, 2017; Google Maps, 2017; Photographs taken by author, 2010-2011)

Xinzhuang Road has a long and coloured history. It began its rise during the last few years of the Qing dynasty, more than three centuries ago, and at one point it was the commercial centre of Northern Taiwan and the island's third most bustling city. Also nicknamed Temple Street, the 300-metre long street is lined with various temples. It is a street with the highest density of temples in Taiwan.

(a) Satellite image of Xinzhuang Road

(b) (c) & (d) Remarkable shophouse façades on Xinzhuang Road

(e) Today's streetscape

(f) View of Japanese colonial period

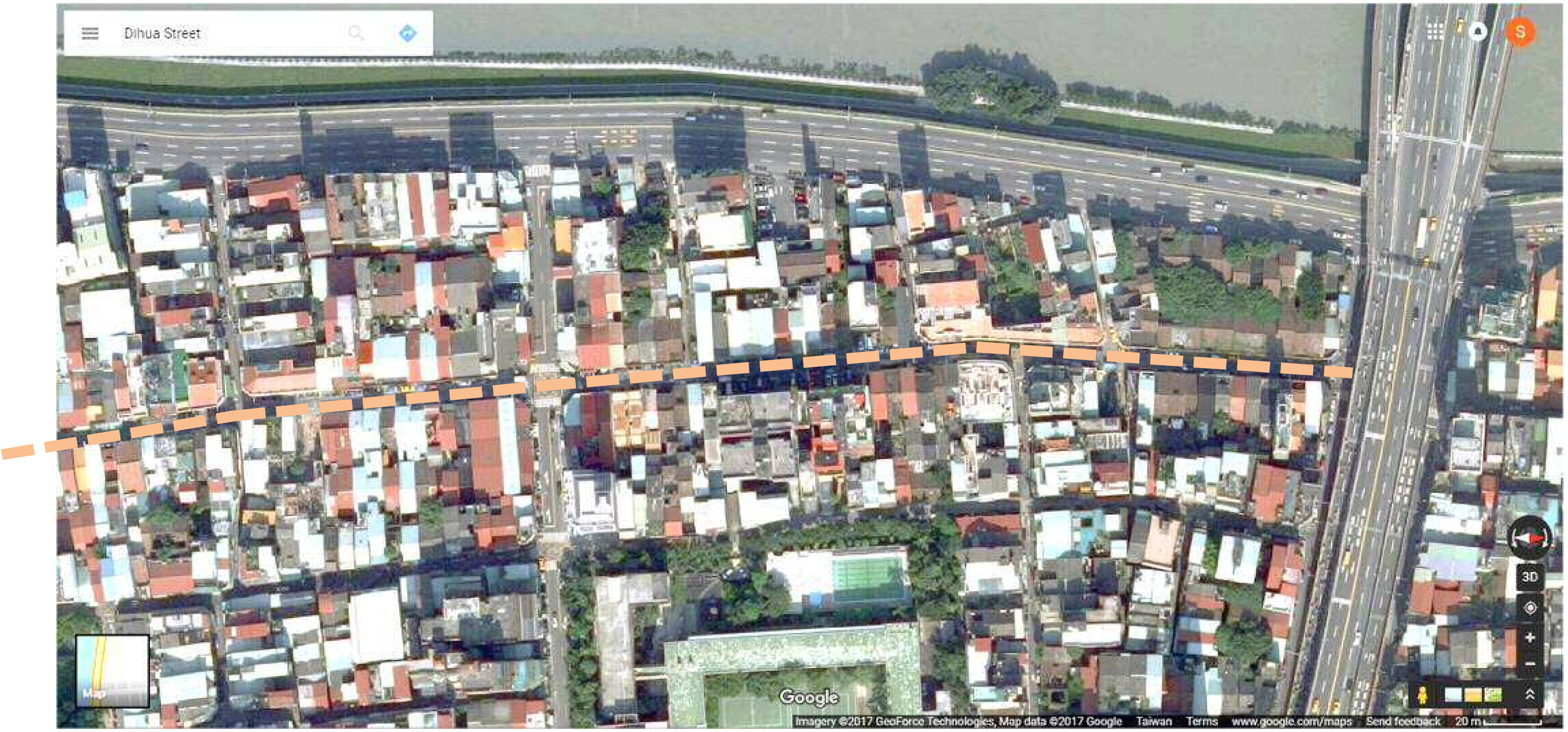
Dihua Street 6

Taipei City, Taiwan

Number of occupant surveys = 25
Number of visitor surveys = 9

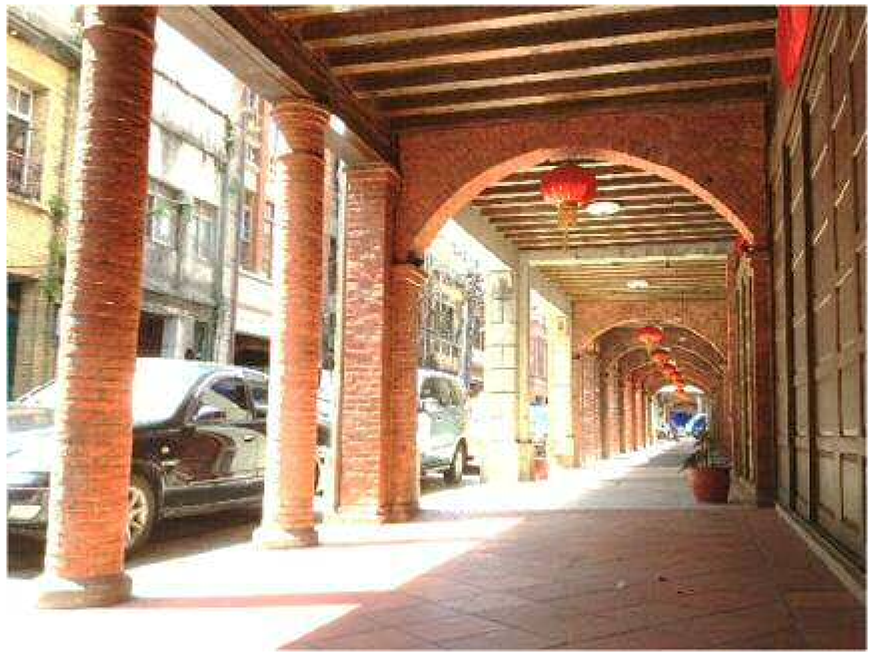
(Source: Taipei City, 2013; Google Maps, 2017; Photographs taken by author, 2010-2011)

Dihua Street was built in the 1850s and is the most popular grocery market for shopping for Chinese New Year goods. It is located in Datong District of Taipei City, with a total length of 800 metres. On ordinary days, Dihua is a relatively quiet street. However, the street will become lively and crowded a few weeks before Chinese New Year.



(a) Satellite image of northern part of (the most elite and oldest) Dihua Street

(b) Typical façade of shophouses



(c) Renovated walkways at northern end of the street

(d) Restoration projects

(e) Original and typical block of shophouse

(f) Satellite image of Dihua Street

Figure 4.9

Chinatown 7

Singapore

Number of visitor surveys = 12

(Source: Google Maps, 2017; Singapore City Gallery, 2010; Photographs taken by author, 2010)

(a) Satellite image of Chinatown

While exteriors differ, most share common characteristics like tile pitched roofs, party walls, and internal courtyards – a prototype prescribed by Singapore Governor Sir Stamford Raffles in 1822 which required that "all houses constructed of brick or tile should have a uniform type front, each having a verandah of a certain depth, open to all sides as a continous and open passage on each side of the street." In the 1980s, the City's Urban Redevelopment Authority began conservation work on more than 5,000 shophouses, which were converted into offices, hotels, restaurants, spas and residences. Today, there are about 94 conservation areas in Singapore, and restored shophouse homes are some of the most sought after real estate on the island.

(b) & (c) Cramped five-foot-ways along Amoy Street

(d) Streetscape of Amoy Street, Outram District, Chinatown

(e) Model of Chinatown in City Gallery

Figure 4.10

Malacca Town 8

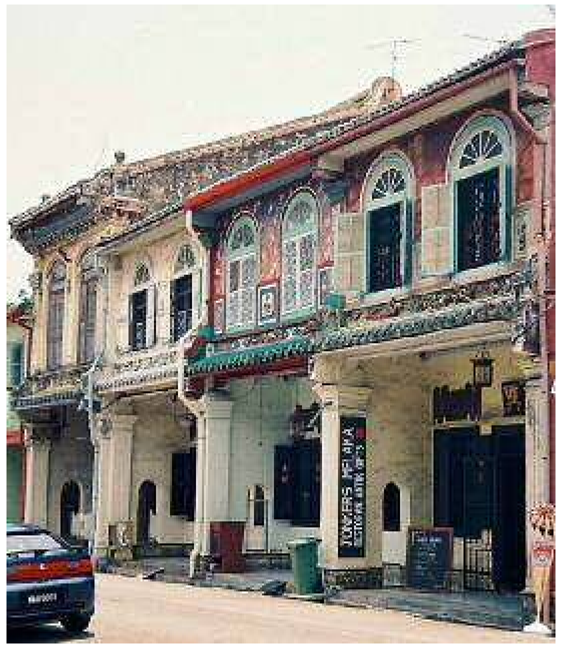
Malacca, Malaysia

Number of visitor surveys = 13

(Source: Tan Yeow Wooi Culture & Heritage Research Studio, 2011; Google Maps, 2017; Photographs taken by author, 2004-2009)

In 2008, the historic town of Malacca with its Chinese shophouses and colonial buildings was added into the list of UNESCO World Heritage Sites. On the west side of the river is the Historic Residential and Commercial Zone. There are over 600 properties in this zone, including many shophouses that date back to the early part of the 20th century, and a few to the 19th century.

(a) Satellite image of the historic Malacca Town



(b) Chinese shophouses

(c) Baba Nyonya Heritage Museum

(d) & (e) Inner courtyard of a shophouse hotel

(f) View from entrance to inner courtyard

Figure 4.11

Ipoh Old Town 9

Perak, Malaysia

Number of visitor surveys = 6

(Source: Tan Yeow Wooi Culture & Heritage Research Studio, 2011; Google Maps, 2017; Photographs taken by author, 2010)

(a) Satellite image showing both old (western bank) and new (eastern bank) town of Ipoh

Ipoh City initially grew on the west bank of the river. It was well-known for being the largest tin producing region in the world during the early 1900s. When the other side of the river (eastern bank) was developed from the 1900s to the 1930s, this area became the ‘Old Town’ as it is known today. Compared with the old town, the lengths of the shophouse buildings in the new town are relatively short. The heritage area of Ipoh City consists of a core zone and a buffer zone, and has been gazetted on the 18th of December 2014 due to provision of Town and Country Planning Act (Act 172).

(b) 3D satellite image of the old town

(c) 3D satellite image of the new town

(d) Streetscape of Concubine Lane

Figure 4.12

George Town 10

Penang Island, Malaysia

Number of occupant surveys = 11
Number of visitor surveys = 37

(Source: Tan Yeow Wooi Culture & Heritage Research Studio, 2011; Google Maps, 2017; Photographs taken by author, 2010)

George Town and Malacca were also registered as a UNESCO World Heritage Site on the same date, and together, they are recognized as the Historic Cities of the Straits of Malacca. Featuring residential and commercial buildings, George Town represents the British era from the end of the 18th century. Its buildings were most often built in contiguous blocks bound by a grid pattern network of roads and back lanes, many of which can be seen in the collection of 7,000 shophouses of different periods that remain in town to this day.

(a) Satellite image of the George Town of Penang

(b) Streetscape of residential buildings

(c) & (d) Poor buildings waiting for renovation

(e) View from Komtar Tower

(f) Internal courtyard at the PHT

4.3. Shophouse Occupant Survey

The Urban Shophouses Spatial Use Survey Form (Appendix B) was prepared for each shophouse that was over 60 years old within the old town centres in Taiwan. This questionnaire survey was divided into three sections:

1. shophouse environment profile data,
2. spatial use behaviour and perception data, and
3. environmental attitudes.

The objective of this survey was to record user requirements through observing and questioning the dwellers regarding proposed renovation work. It focused on the visualization of spatial ideas through physical means. In order to clarify the specific requirements, selected occupants were asked to fill out the questionnaire.

In addition, the aim of this interview approach was to study the indirect factors of participants' habits, as well as the overall experience and expectations towards the use of older buildings, which may not be directly apparent in public interactions. The previous section discussed that an interview guided approach was employed as an interview strategy. In order to reach this research goal, based on the literature review and the influences of participant observation, this study constituted of three major frameworks. Each of these includes more specific questions to elicit the ongoing answers.

In addition to the interview, the process also included a framework to collect a basic visual record, supplemented by the minimum of information needed to identify the building's location, age and type. This is the simplest record to identify the overall profile, such as storeys of building, numbers of courtyard, whether the courtyards are open or covered, the business categories, and any obviously additional works that have been undertaken on such traditional shophouse buildings. Those are likely to take the form of sketches (Figures 4.13) before or after the implementation of the questionnaire.

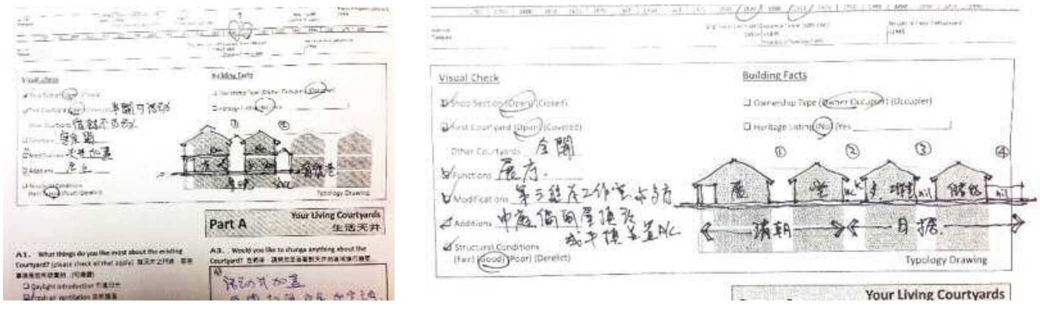


Figure 4.13: Examples of visual record. (Source: Field works, 2010-2011)

Part A – Investigating occupants' habits: The first part of a questionnaire development is related directly to the respondents' views on their existing courtyards. Questions A1 and A2 are focused on answering 'how they used to live and/or manage the courtyards?' A3 is an open-ended question to predict any actions on courtyard in the future (refer Appendix B). Rating scale questions are used in the fourth (A4) to measure their satisfaction with different aspects regarding the local cultures. The questions are as follows:

A1. What things do you like most about the existing courtyard?

- Daylight introduction
- Fresh air ventilation
- Gardening for good atmosphere
- Storage space

A2. If the courtyard is covered, what were your main reasons for covering the existing courtyard?

- Get strong sunlight on wall
- Get strong wind on windows and doors
- Increase space for multiple
- Water leakage at the connection
- Floors and stairs slippery when raining

A3. Would you like to change anything about the courtyard?

A4. Would you tell us how satisfied you are with the following aspects of your shophouse?

- Personal preference towards old shophouses
- Expression of Chinese art and culture
- Location of shophouse in district area
- Working atmosphere in shop section
- Living conditions in main courtyard
- Functional efficiency of space in main courtyard

Part B – Investigating occupants' overall experiences and/or satisfaction: The second part of a questionnaire development is related personally to human physical senses in the aspects of visual and thermal comforts. The objective of this partial survey was to clarify what lighting and temperature levels people in these regions prefer in order to feel comfortable, with special focus on their courtyard environment. The questions are as follows:

B1. Is there an overall lighting mood or feeling you want to set within the courtyard? … Describe?
B2. Are there particular spaces that should have a specific lighting mood? … Where?
B3. Do you prefer a particular style of lighting? (e.g. direct or indirect, wall-lights or table-lights, etc.)
B4. For air circulation in summer time, do you prefer windows, a fan or air conditioning?
B5. How about the indoor climate of the shophouse? What is it like in summer and winter?

Lighting plays a very important role in showcasing shophouse owners' store merchandise as well as providing a great part of the design in their store. Where they use lighting and why they use lighting will make the difference of a successful store layout versus an unfinished store layout. A few points to consider when asking the respondents about how their lighting done and/or can help their store includes: hard, soft or combined lighting (B1); mood lighting or conventional lighting (B2); and a particular style of lighting (B3). However, there is no single store lighting formula that one can follow as a retailer to ensure one is using one's lighting correctly, but the points above allow respondents to think again the lighting decisions they have made or need to make.

Part C – Investigating occupants' expectations and attitudes toward heritage preservation: The last part of a questionnaire development is related to their daily experiences and opinions on preservation of cultural assets, the traditional shophouses, under the rising pressure of the district housing markets. The first four questions (C1 to C4) are just focused on answering 'how they think of their current traditional shophouses?' Open-ended questions are used in the last three to find out more about a person, their wants, needs, problems, and so on. The questions are as follows:

C1. Has the quality of life in the shophouse changed over the past year? Yes (If it has changed, has it become…?)

- Better
- Stayed the same
- Become worse

C2. How would you rate your shophouse as a place to live, compared to other types of homes in the nation?

- Much better
- Fair
- Much worse

C3. What would you consider the overall structural condition of your shophouse to be?

- Good
- Fair
- Poor

C4. Does your current shophouse meet your particular living needs?

- Mostly meets needs
- Somewhat
- No longer meets needs

C5. What do you think is the single most important problem shophouses face today?

C6. In your opinion, what is the best solution to this problem?

C7. What is the thing you like least in living in a shophouse?

4.3.1. Pilot phase

It is noted here that Piloting is a 'vitally important' part of the research design process (Chisnall 1972) and one of the ways in which reliability can be improved (Newman and Smith 2000). As many aspects of a design as possible should be tested in this way before it is finalized (Oppenheim 2000). Ideally, the number of people used in the pilot will be equal to approximately 10% of the planned sample, but this has to be weighed against the constraints of time, cost, practicability and resources (Chisnall 1972; van Teijlingen and Hundley 2001; Gilbert and Troitzsch 2005). In this case, such a large pilot project (i.e. 10%) was not feasible. The more important issue, however, was that the pilot group provided as much coverage as possible of the key characteristics of the 'real' respondent group (van Teijlingen and Hundley 2001). To ensure the validity of responses, it is often necessary to ensure that the sample for the pilot survey is selected from, or approximates, the actual sample of the main survey (Pole and Lampard 2002).

4.3.2. Responses from the pilot survey

As a result of the distance from the case study area; and the time constraints, about half of the sample for the pilot survey in this study was drawn from graduate students at Chung Hua University, Taiwan, who had a contextual knowledge of the case study area. In addition, eighty-three shophouse occupants completed and returned the questionnaires and twenty-six owners refused to take part, representing a response rate of 76%. The analysis of the pilot survey results provided useful insights into parts of the questionnaire that needed to be revised prior to the main survey. From the feedback provided by respondents, some questions were reframed and the average time to complete one questionnaire was about 25 minutes. Where appropriate, the details of such changes for each questionnaire are discussed below.

This study used a self-rated questionnaire that asked about the living experiences of shophouse occupants, the conditions they faced, and the solutions they adopted. This consisted of 19 questions with lists of possible responses and tick boxes, including several questions where more than one response could be given (see Appendix A). The questionnaire also asked about the age group and gender of each respondent. Most of the respondents for the pilot questionnaire were based on face-to-face interviews of graduate students at the Chung Hua University's Department of Architecture and Urban Planning, Taiwan. In order to survey a population broadly representative of the general population, questionnaires were presented in person to shophouse occupants in four historic districts: Dasi, Hukou, Sanxia, and Beimei of Hsinchu City, during both day and evening working hours beyond weekend, beginning in late July, 2008. The questionnaires were offered to all shophouse occupants who were willing to participate.

The sample chosen to survey was not a truly random sample of the general population, as sites and times of surveying were selected in the northwestern part of Taiwan to represent a range of socio-economic groups. A significant limitation to this survey was its relatively low response rate, which wasn't surprising since it is often difficult to obtain a high response rate in surveys of this kind. The respondents may only represent a sub-group that is more confident, knowledgeable, and aware of the relevant content. Half of the respondents were 60 years old or older, and it is suggested by the findings of the pilot that this age group are very concerned about the development of the old streets. Due to the possible selection bias and the relatively small sample size, this report focused on the respondents' overall information and general trends between their perceptional profile and the stated knowledge.

This pilot study highlighted a clear lack of attention regarding the living courtyard in several areas. The current situation requires only some developments to address how buildings are related to streets. The changes adopted in these locations, if applied more widely, would mean that all aged shophouses in old streets or historic town centres, mixed use and commercial areas, including residential street types, will have to consider how their design contributes to the quality and amenity of pedestrian activities along the street frontage. This is to encourage a variety of retail, commercial, and amenity activities that provide a vibrant street life and viable employment opportunities. To support the above development of quality urban environments in existing historic town centres, a traditional street typology consisting of old-day looks, but with new materials will have been identified. These have been learned from most of existing old streets through Taiwan over the past years. The fact that occupants and shophouse users did not consistently agree on some of the spatial preserves treated, the methods used, and the adoption of public communication channels was perhaps not surprising given the range of different styles and forms of their dwelling redesigns. Another important observation of this pilot study related to the users' views concerning the official guidelines of building renovation. The users who were still maintaining their courtyards open would to do so. In contrast, the occupants who had enclosed their courtyard space wanted to leave it alone behind the shop frontage.

The occupants who responded to this pilot survey were aware of the principles of the overall changes of spatial use when performing building renovation for any purpose. However, due to various obstacles and difficulties, there appeares to be a lack of information on their actual renovation works. Most occupants or owners welcomed the development of such a guideline but many indicated they had a need by official informed in the options of design work.

4.4. Courtyard Physical Survey

The goal of this study was to understand the microclimatic conditions of a traditional shophouse courtyard in warm and humid climates. The method of analysis was field measurement, including daylight illuminance, wind speed, outdoor air temperature, and humidity. The study of air flow, thermal and visual environmental shortcomings of the field investigation, and the analysis of existing outdoor space not only helped to further explore the thermal comfort conditions of courtyard areas, but was also intended to learn about and rethink our conceptions about the lifestyles of shophouses in the past, present, and future.

The selected building was a single storey, elongated traditional shophouse building with brick outer walls, located in Daxi Township, Taoyuan County, Taiwan, at No.88 He-Ping Road (Figure 4.14), which was previously measured the author. As an owner and carpenter, Mr. Q. K. Liu, fully supported this survey in many ways, including his response to the user and visitor questionnaires, measurement of the existing building, field tests, and also the storytelling regarding the shophouse itself.

Looking into the 2011 climate data from Taiwan’s Central Weather Bureau (CWB 2011), the highest monthly global radiation in Taoyuan County could be found between June and September. The months of July and August had the highest records of dry-bulb temperature. Accordingly, the field measurements were obtained from 8th-9th and 13th-15th August 2012.

Figure 4.14: Shop front (left) and drawing of elevation (middle) of selected shophouse building in Daxi; the owner, Mr. Liu, assisted for building measurement (right). (Source: Photographs taken and illustration by author, 2008)

Figure 4.15: The three hand held digital meters for field tests: Datalogging Light Meter by TES-1336A (left); Humidity Temperature Meter by Center-314 (middle); and Hot Wire Anemometer by AM-4204 (right). (Source: Supported and provided by the D.A.U.P., Chung Hua University)

.Variable	Instrument Model	Range and Accuracy
Illuminance	Clover TES-1336A	CIE photopic curve V(1); $f'_1 \leqq 6\%$; $f'_2 \leqq 2\%$; 20/200/2000/20000 Lux; ±(3%rdg+5dgts) (calibrated to standard in candescent lamp 2856K)
Temperature & Relative Humidity	Center Tech Center-314	-20 ^{O}C~60^{O}C; ±(0.3%+1d) 0~100%RH; ±2.5%RH at 25 ^{O}C
Air Velocity & Temperature	Lutron AM-4204	0.2~20.0m/s; 0.1m/s; ±(5%+1d) reading or ±(1%+1d) full scale; 0.1 ^{O}C/0.1^{O}F; 0.8^{O}C/1.5^{O}F

Table 4.2: Description of measurement instruments.
(Source: Industrial machinery manuals, 2007)

For the in-situ data collection, a set of digital metres were used, as shown in Table 4.2. These are small, hand held devices (Figure 4.15) that are easily operable and that take measurements of lux, temperature, humidity, and airflow rates. At the time of this research, Shophouse No.88 was open and operated as a wood craft gallery, and during the measurement period, was occupied only on weekdays from 9:30-19:30. Although the design of traditional shophouses varies over different construction years, this shophouse was considered to be representative of typical shophouses from the late Chinese Qing Empire (1644-1911) and early Japanese colonial era (1895-1945) in Taiwan.

Shophouse No.88 had four courtyards, whose sizes and functions varied (Figure 4.16). The first three courtyards were tiny courtyards surrounded by pitched roof structures and party walls, and the rear large courtyard was enclosed by a single-storey building, party walls, and a fence wall. The front courtyard measured 4.6m by 5.4m and was in good condition. The second courtyard was the same size, and operated as an open kitchen. The third courtyard had smaller dimensions, which were 4.6m by 3.4m, and was in use as an open air storage area. Against the sizes of the courtyards on the ground floor level, the corresponding roof openings were smaller as the roof overhangs provide protection it against rain and solar radiation. The size of the roof opening in the front courtyard was 3.3m by 3.5m, which was approximately 74% of the area of the courtyard below.

The windows in the shophouse were composed of half-height timber frame windows with upper ventilation openings that were permanently open. These ventilation openings were also found on almost all of the interior partitions. The exterior doors and windows were opened when the building was occupied (from about 9:00-19:30 on weekdays). Air conditioning units and ceiling fans were installed in the first building. However, both modern facilities were not used during the measurement period, except for the fan located near the kitchen area. The building structures consisted of a timber frame and brick with lime plaster masonry walls. As shown in Figure 4.18, the front courtyard had different kinds of trees and plants, as well as a moss stone floor surface.

The microclimatic conditions were measured at a height of 0.7m above the stone floor in the centre of the front courtyard (test point C5, Figure 4.17), and 0.3m above the ridge height of the first building (test point T1). As shown in Figure 4.17, there was one piece of partition with a large opening which was separated as an open pantry, and there were no partitions between the front courtyard and the first two buildings;

therefore, these living rooms were considered to be semi-closed spaces to the outdoor. The floor-to-roof heights were approximately 3.2m to 5.5m in the first building, and approximately 4m to 6m in the second building. As shown in Figure 4.17, horizontal illuminance profiles were measured in grid format in the first courtyard, which were set for nine test points. The air temperature and relative humidity were measured at fixed test points T1 and C5. The corresponding outdoor measurements were recorded every 10 minutes.

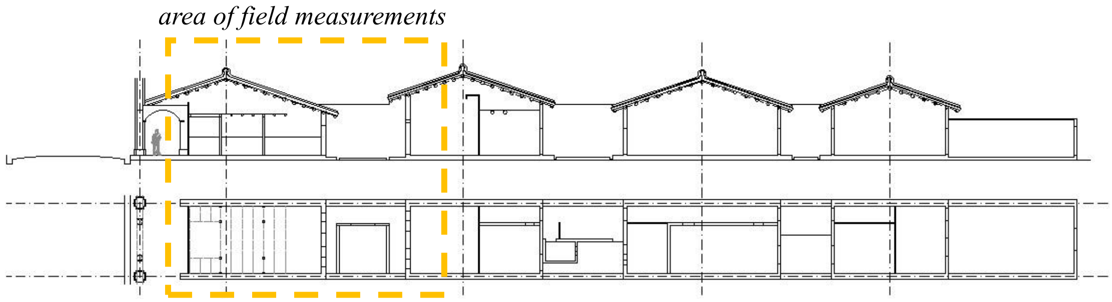


Figure 4.16: Floor plan and longitudinal section of case study shophouse no.88. (Source: Measured and illustration by author, 2007-08)

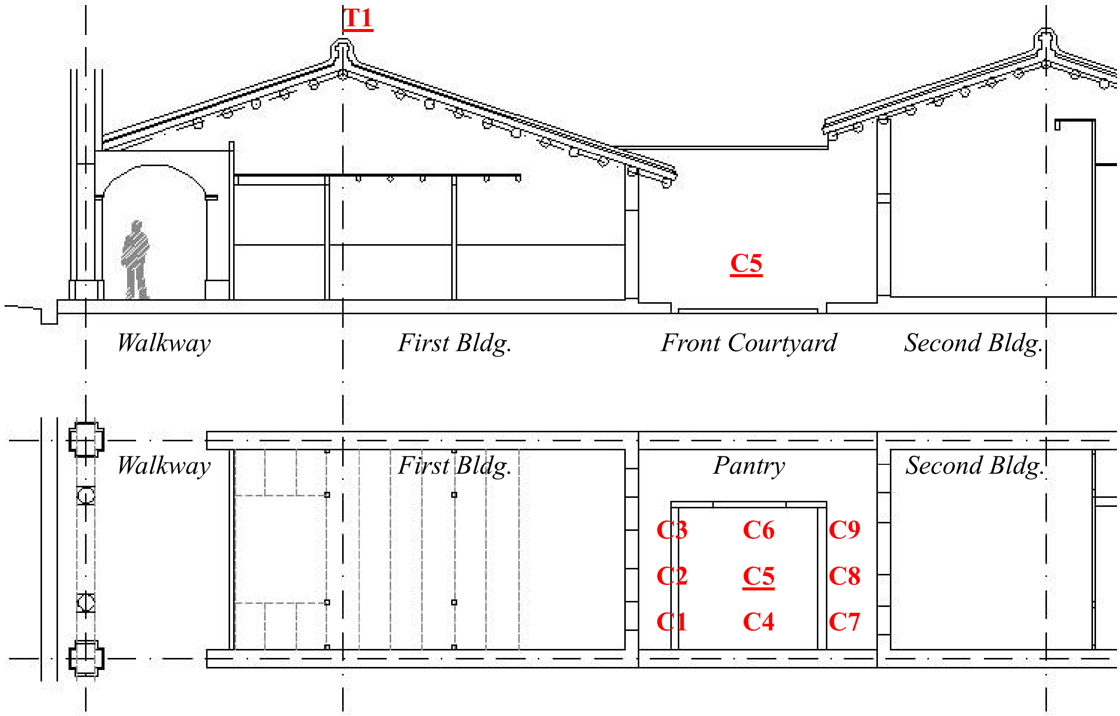


Figure 4.17: Area of field measurements and the location of test points. (Source: Illustration by author, 2007-08)

Figure 4.18: View of the Case Study Shophouses No.88 at front courtyard (left) and the ridge height (right). (Source: Photographs taken author, 2007-08)

4.5. On-Street Visitor Survey

The On-Street Visitor Survey Form (Appendix C) was prepared for a sample of visitors present at historic shophouse streetscapes in Taiwan, Penang, Malacca and Singapore. This questionnaire was also divided into three sections:

A) perception data,
B) environmental attitudes, and
C) personal data.

The purposes of this survey were to collect opinions from the public about the existing conditions of the shophouses and streetscapes, and to identify areas for the improvement of the shophouses.

The above user and public opinion surveys were conducted at four districts. These four major districts are, namely:

1. Georgetown of Penang,
2. Town centre in Malacca,
3. Chinatown of Singapore,
4. Old town centres in Northern Taiwan.

All the above types of surveys were conducted to understand what historic resources are provided by Vernacular Shophouses. The information collected in the surveys was more broadly intended to enable an assessment of the potential for listing resources as a historic district in Taiwan. However, this purpose was outside the scope of the current research. The aim of this method for this research was to study the population of interest and develop an understanding of the public opinion with regards courtyards retention.

Exploring local cultures is one of the main reasons people enjoy holidaying in historic districts, where sightseeing on foot within urban area is the most popular activity. Who are these visitors? What are their motives for visiting the shophouses or the special events? How much time do they spend in historic districts? Are they satisfied with the local cultures and urban facilities? What is the opinion of different kinds of visitors about the activities on the old streets? Do they know or become aware that there are some inner courtyards inside the traditional shophouses?

In order to reach this research aim, this study consisted of three major interview parts.

Part 1: Investigating on-street visitors' perception data.

Q1. Based on your experience as a "visitor" at this historic street and traditional shophouses, how would you rate each of the following?

- Expression of local art and culture
- Local foods and special goods
- Integration of walkway into the surroundings
- Quality of open courtyards
- Quality of building façade and decorations
- Personal appreciation of historical streetscape

Q2. In your opinion what are the three most favourable elements of this historical street? (please tick 3 only)

- Building façade and decoration
- Covered walkway
- Inner courtyards
- Overall streetscape and skyline
- Shopping selection
- Art and culture
- History

Q4. Do you like these historic buildings? If yes, because of (please check all that apply)

(1) Historical characteristics

(2) Combine several functions

(3) Atmosphere in courtyards

(4) Environment in courtyards

Q6. How many times have you been here?

(1) First time

(2) Rarely come here

(3) Come here regularly

(4) Come here daily

Part 2: Investigating on-street visitors' environmental attitudes.

Q5. Do you think that visitors should have access to inner courtyards?

Happy to see, or Unnecessary?

Q11. What activities and services would you like to see changed, added or improved?

Part 3: Investigating on-street visitors' personal data.

Q3. Why did you come to this historic street? (please check all that apply)

(1) Business

(2) Visiting family or friends

(3) Pleasure

(4) Atmosphere

(5) Shopping

(6) Culture

(7) Eating and drinking

Q7. What is your gender?

Male or Female?

Q8. What is your age group?

(1) under 18

(2) 18 to 39

(3) 40 to 64

(4) 65 and over

Q9. What is your educational level?

(1) High school

(2) University

(3) Postgraduate

Q10. Where do you come from?

City or Country?

4.6. Approaches to data analysis

Once the questionnaires were returned the author took a number of steps to process the data. The first step was to input the data into the SPSS analytical tool. Then the author coded the data appropriately and then designed approaches to analyse the data. At this stage, descriptive and inferential statistical techniques were identified as the most relevant to enable the analysis of the data and interpretation of the findings.

A cross tabulation is a simple technique where results are displayed as a contingency table with each cell of the table displaying a single cross tabulation value. It is a common method for displaying data when investigating associations between two categorical variables (De Vaus 2013). The cross tabulation is easily interpreted by looking at the individual values in each cell and determining if it is different from the expected value. Chi-square is the statistical test used to test for the strength of association in a cross tabulation. This test indicates whether the relationship is strong enough that an inference can be made from the sample to the population.

The chi-square test does have a requirement that no more than 20% of cells have expected cell counts of less than five (Miller and Acton 2009) for it to be usable. To avoid the problem of violating the minimum recommended cell size when using relatively small sample sizes, it is possible to recode the data so that categories collapse into each other, resulting in smaller numbers of cells for each table, but with the loss of some granularity of data. Various tests can be used to test for the statistical significance of the difference between the observed and the expected values in the cross tabulation contingency tables. The most appropriate test for nominal values in a table greater than 2x2 is the Cramer's V. For this test a value of 0 indicates the absence of any association and 1 indicates a perfect association, (-1 indicates a perfect inversion) (De Vaus 2013).

4.7. Summary

This chapter has outlined the methodology used within this second phase of the thesis as well as the areas of data collected and the manner in which they were analyzed. In summary, the purpose of this phase of the research was to obtain relevant data and be able to realize this proposal because of the state of three trends:

- the loss of vernacular shophouses;
- the loss of inner courtyard, the rise in their value; and
- discontent with present renovation forms and tools.

The application of this data to a Case Study in Phase 3 of this research established whether the form of courtyard is likely to have a significant impact on the light received and air flow movement by the building occupant, resulting in a proposal for ecological development of shophouses in Taiwan.

5. Results of Survey of Current Shophouses

The previous chapter described the research methods that have been used in this phase of the research process of data selection, collection and analysis. This chapter provides description and interpretations of the resulting data, addressing the research questions – to determine what kind of factors influence the application, outcomes, and changes over time of early shophouse dwellers. The results of the 2 surveys are presented in turn:

1. Occupant Survey,
2. Visitor Survey.

Firstly, the characteristics of traditional shophouses are investigated from occupant survey data collected in six old districts or towns in Northern Taiwan and as well as George Town in Penang, Malaysia.

Secondly, the results of the occupant surveys are analysed concerning how living spaces of current traditional shophouses are organized to suit occupants' social activities and living styles and reflect vernacular cultural values in families while achieving environmental and climate adaptation. Further, the daylighting and also the thermal performance are examined to provide an understanding of how traditional ventilation mechanisms are used in shophouses. This includes, an investigation of the spatial organization in both courtyard and adjacent spaces, in order to interpret the relationship of spaces in a continued process of natural lighting and ventilation. To address the problem of the use and organization of spaces in vernacular shophouses, this chapter contains findings on:

- the main issues of the community planning and vernacular architecture;
- occupants' use of living spaces in shophouse buildings, especially around the courtyard area; and
- characteristics of inner courtyard in traditional shophouses.

5.1. Introduction

The expansions of urbanization and economic growth over the island of Taiwan has generated rapid changes on several small communities surrounding northern areas, especially in the historic and tourist districts such as Hukou, Daxi, and Sanxia (Figures 5.1 to 5.3). Due to their unique physical, social and cultural virtues, most of them have been promoted as eco-cultural tourist attraction. This, to some extent, has impacted on their physical transformation concerned with their original way of life and cultures, causing the difficulties between retaining the cultural heritage and modernizing the community area.

Figure 5.1: Existing layout plan and visual record of Hukou Old Street, Hsinchu County.
(Source: National Land Surveying and Mapping Center, Taiwan, 2015; Fieldwork, 2011)

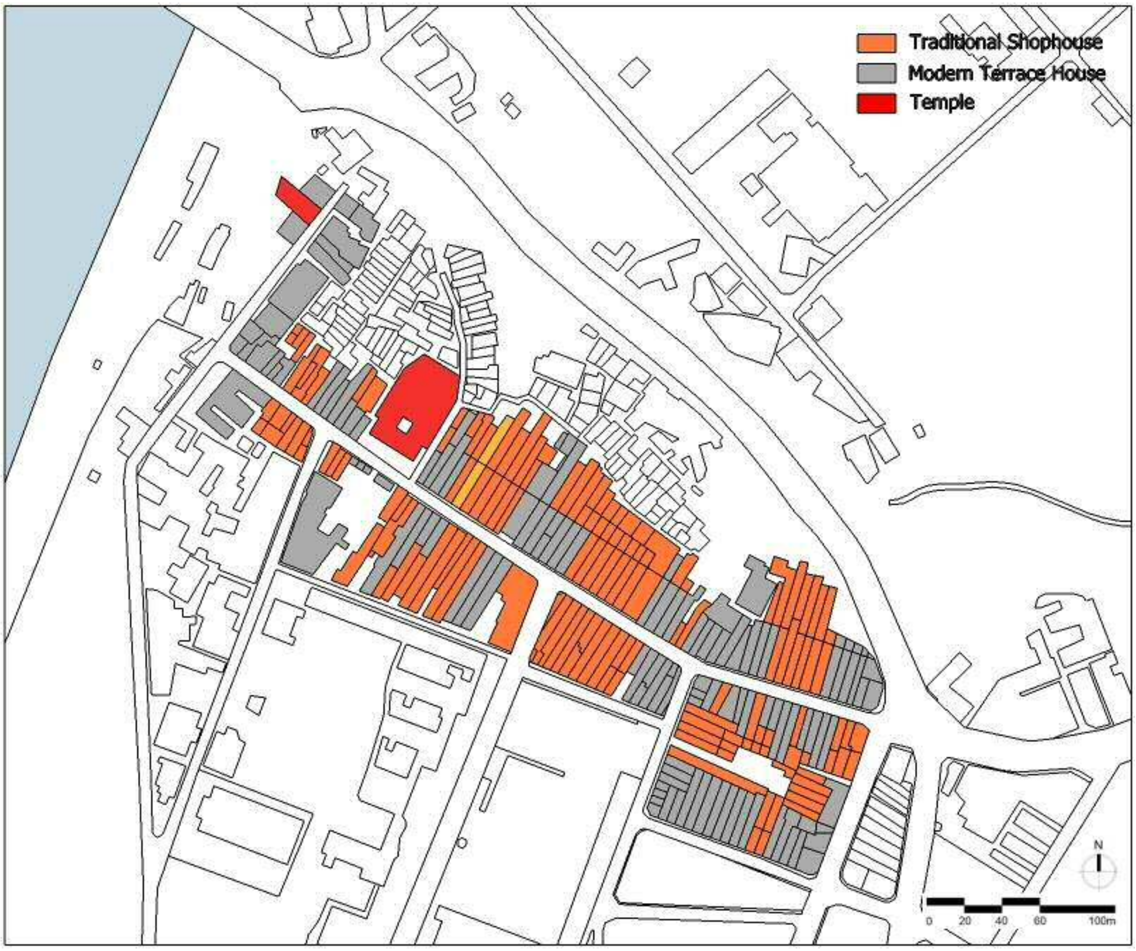


Figure 5.2: Existing layout plan and visual record of Daxi Old Street, Taoyuan City.
(Source: National Land Surveying and Mapping Center, Taiwan, 2015; Fieldwork, 2011)

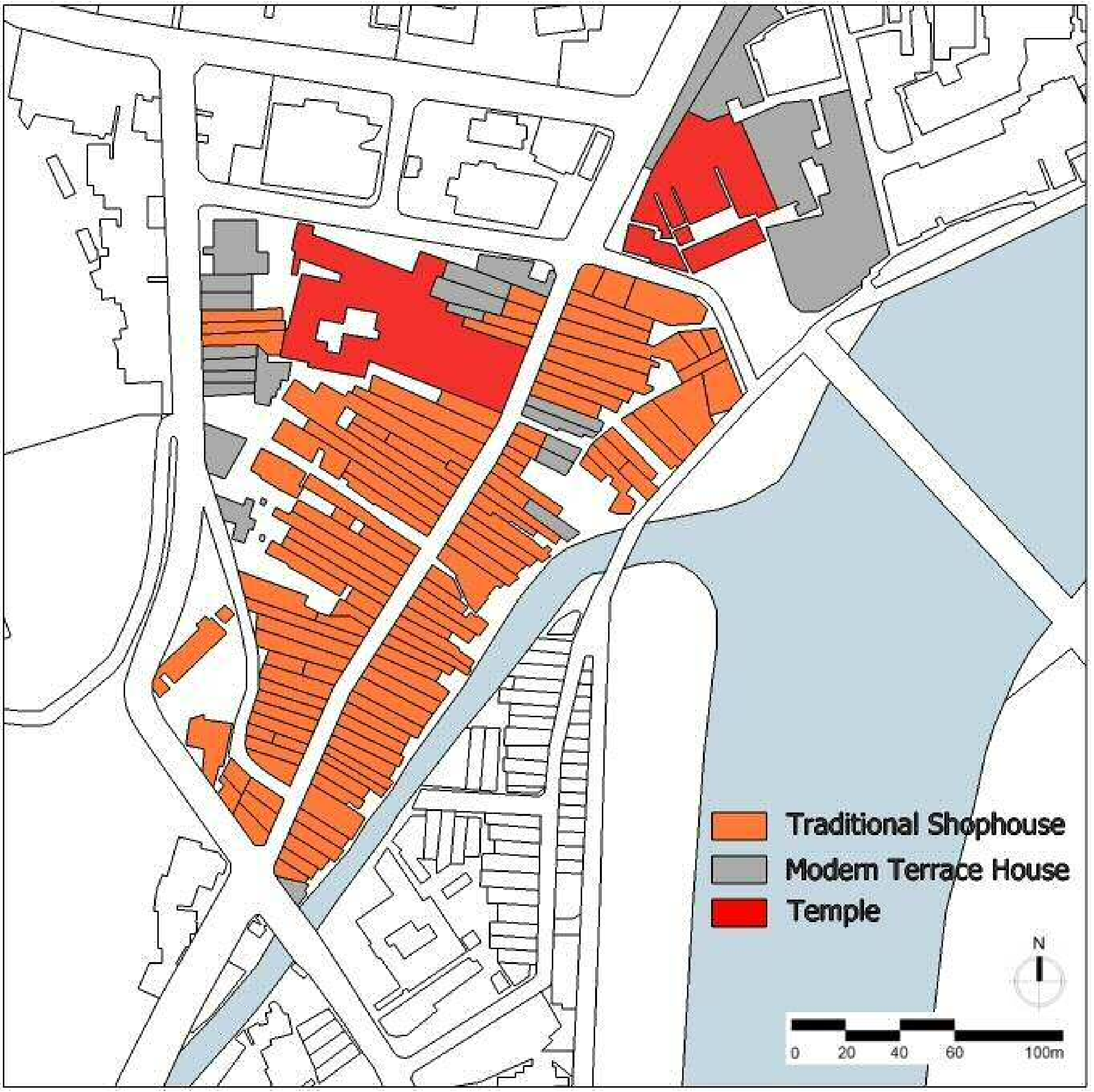


Figure 5.3: Existing layout plan and visual record of Sanxia Old Street, New Taipei City.
(Source: National Land Surveying and Mapping Center, Taiwan, 2015; Fieldwork, 2011)

This chapter studies both theoretical and related topics along with field research, to focus on the study of conservation and sustainable development of historic community environment related to tourism. The contributing research was performed using field surveys and questionnaires for gathering information on community attitudes towards the above issues. This is intended to help to identify the approaches or solutions that are responsive to the issues of local community. The approaches for continuity and development of historic environment as shown in this research could be applied to underpin the selection of ecological design that can be implemented practically in the traditional shophouse.

5.2. Occupant survey

This section presents the results of the questionnaire survey that was carried out between May 2010 and July 2011, to gather information on aspects of urban shophouses and spatial use issues in their working and also living dwelling. The general profile data regarding the buildings were also recorded. The main survey consisted of 16 groups of questions (Appendix B) with lists of possible responses and tick boxes, including several questions where more than one response could be given. This was organized in different parts covering:

Part A: Living Courtyards

Part B: How Do You Feel?

Part C: How Do You Think?

A total of 182 respondents were collected mainly from northern Taiwan and George Town of Penang in Malaysia. Figure 5.4 represents the distribution of total respondents to the main questionnaire survey according to location of traditional shophouses. From Table 5.1, only the George Town of Penang had the least number of respondents at 6.0% of total respondents due to the times of travelling. Back to Taiwan Island, Beimen Street, Dihua Street and Xinzhang Road had 11.5%, 13.7% and 14.3% respectively. The location with the highest number of respondents in the survey was the most-visited tourist district, Sanxia Township, at 19.8%.

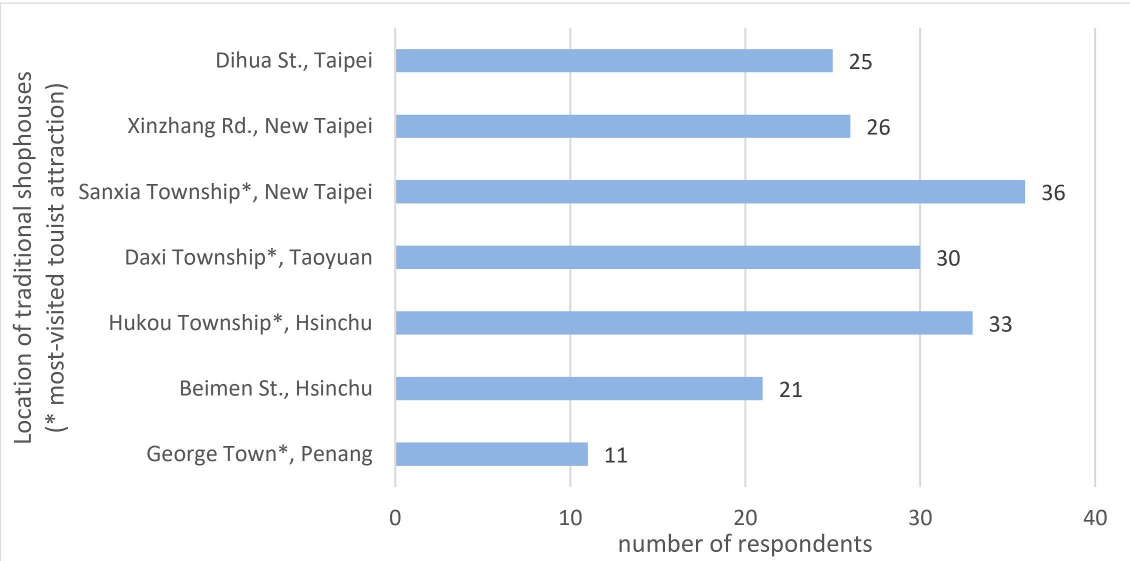


Figure 5.4: Respondents by location of traditional shophouses.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TW-Beimen	21	11.5	11.5	11.5
	TW-Hukou	33	18.1	18.1	29.7
	TW-Daxi	30	16.5	16.5	46.2
	TW-Sanxia	36	19.8	19.8	65.9
	TW-Xinzhang	26	14.3	14.3	80.2
	TW-Dihua	25	13.7	13.7	94.0
	MY-Georgetown	11	6.0	6.0	100.0
	Total	182	100.0	100.0	

Table 5.1: Respondents by location of traditional shophouses.

Figure 5.5 presents the types of building (number of traditional shophouse occupants interviewed) distribution by all seven historic districts. From the table 5.2, *double-storey building* has the highest proportion of the shophouse types (55.5%).

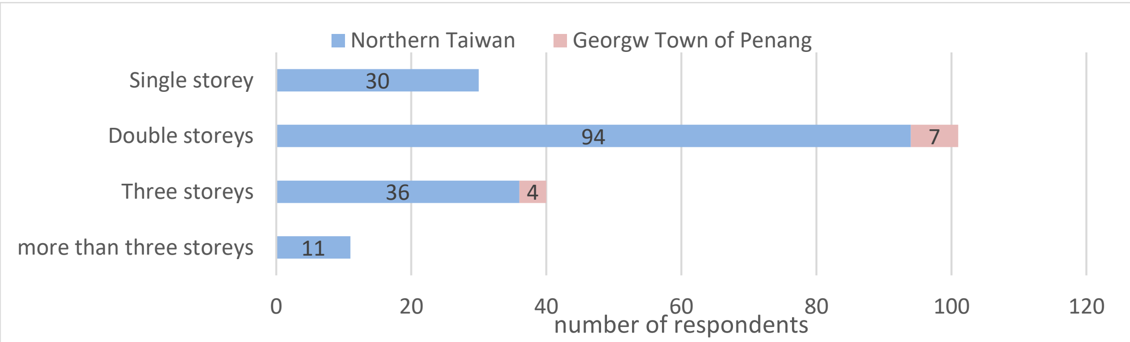


Figure 5.5: Respondents by types of traditional shophouses.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single storey	30	16.5	16.5	16.5
	Double storeys	101	55.5	55.5	72.0
	Three storeys	40	22.0	22.0	94.0
	more than three storeys	11	6.0	6.0	100.0
	Total	182	100.0	100.0	

Table 5.2: Respondents by types of traditional shophouses.

Table 5.3 and Figure 5.6 focus on the relationship between the geographic locations and types of traditional shophouses. It is apparent that the *double-storey* and *three-storey* are major types. And it can be seen from the cross tabulation of location against number of storeys, that those with a single-storey 16.5% are all located in Daxi Township only.

			Building Facts (C) Typology				
			Single storey	Double storeys	Three storeys	more than three storeys	Total
Location of Shophouse	TW-Beimen	Count	0	8	12	1	21
		% within Location of Shophouse	0.0%	38.1%	57.1%	4.8%	100.0%
		% within Building Facts (C) Typology	0.0%	7.9%	30.0%	9.1%	11.5%
	TW-Hukou	Count	0	32	1	0	33
		% within Location of Shophouse	0.0%	97.0%	3.0%	0.0%	100.0%
		% within Building Facts (C) Typology	0.0%	31.7%	2.5%	0.0%	18.1%
	TW-Daxi	Count	30	0	0	0	30
		% within Location of Shophouse	100.0%	0.0%	0.0%	0.0%	100.0%
		% within Building Facts (C) Typology	100.0%	0.0%	0.0%	0.0%	16.5%
	TW-Sanxia	Count	0	32	4	0	36
		% within Location of Shophouse	0.0%	88.9%	11.1%	0.0%	100.0%
		% within Building Facts (C) Typology	0.0%	31.7%	10.0%	0.0%	19.8%
	TW-Xinzhang	Count	0	19	4	3	26
		% within Location of Shophouse	0.0%	73.1%	15.4%	11.5%	100.0%
		% within Building Facts (C) Typology	0.0%	18.8%	10.0%	27.3%	14.3%
	TW-Dihua	Count	0	3	15	7	25
		% within Location of Shophouse	0.0%	12.0%	60.0%	28.0%	100.0%
		% within Building Facts (C) Typology	0.0%	3.0%	37.5%	63.6%	13.7%
	MY-Georgetown	Count	0	7	4	0	11
		% within Location of Shophouse	0.0%	63.6%	36.4%	0.0%	100.0%
		% within Building Facts (C) Typology	0.0%	6.9%	10.0%	0.0%	6.0%
Total		Count	30	101	40	11	182
		% within Location of Shophouse	16.5%	55.5%	22.0%	6.0%	100.0%
		% within Building Facts (C) Typology	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.3: Cross-tabulation of shophouse types on different locations.

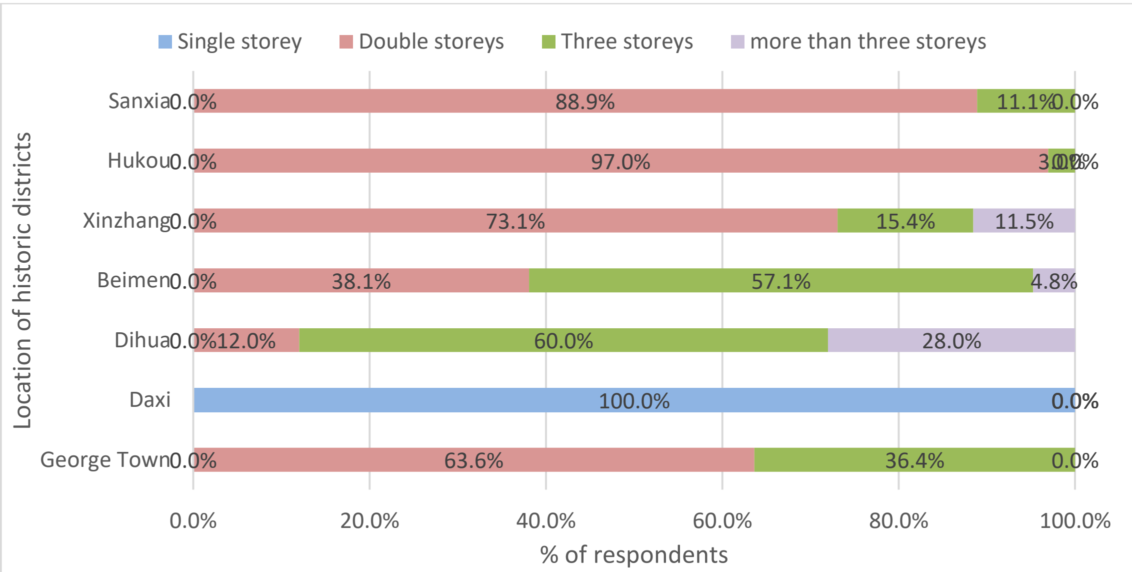


Figure 5.6: Cross-tabulation of shophouse types on different locations.

All existing traditional shophouse buildings (both northern Taiwan and George Town) within this sample are believed to have been constructed between 120 to 150 years ago around the 1840-60's (Table 5.4 and Figure 5.7).

			Building Facts (C) Typology				
			Single storey	Double storeys	Three storeys	more than three storeys	Total
Year Constructed	1800-1850	Count	30	47	20	1	98
		% within Year Constructed	30.6%	48.0%	20.4%	1.0%	100.0%
		% within Building Facts (C) Typology	100.0%	46.5%	50.0%	9.1%	53.8%
	1850-1900	Count	0	54	20	10	84
		% within Year Constructed	0.0%	64.3%	23.8%	11.9%	100.0%
		% within Building Facts (C) Typology	0.0%	53.5%	50.0%	90.9%	46.2%
Total		Count	30	101	40	11	182
		% within Year Constructed	16.5%	55.5%	22.0%	6.0%	100.0%
		% within Building Facts (C) Typology	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.4: Cross-tabulation of shophouse types in the year of construction.

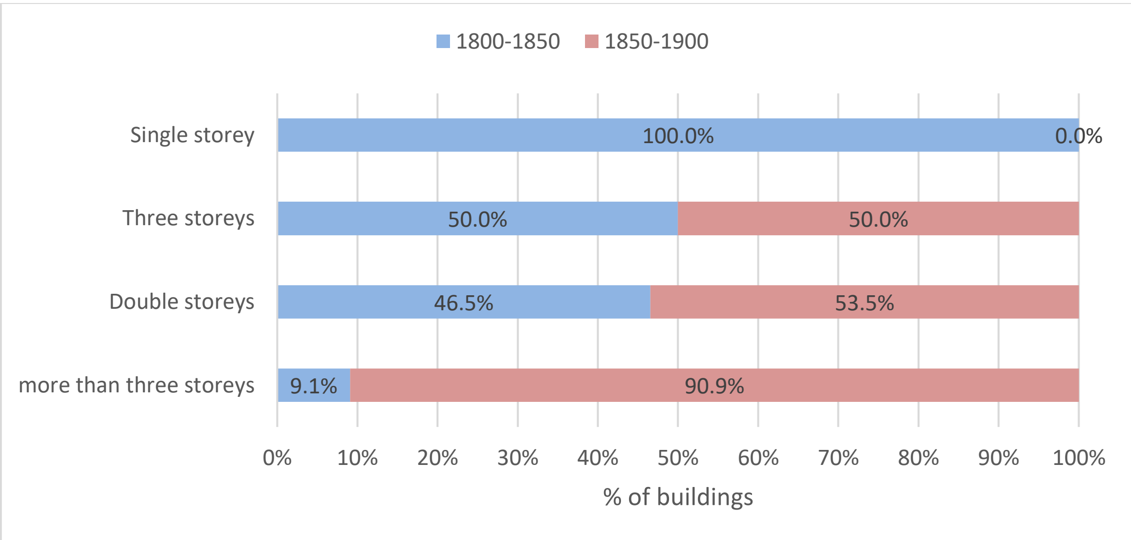


Figure 5.7: Cross-tabulation of shophouse types in the year of construction.

From now on, the following findings focus on the six historic districts in Taiwan for the research problems addressed. Table 5.5 and Figure 5.8 present the results of visual records on the status of the shop section, whether it is open or not by the types of building, where 'not open' represents these shophouse buildings no longer used for commercial purposes but for family homes.

			Building Facts (C) Typology				
			Single storey	Double storeys	Three storeys	more than three storeys	Total
Visual Check (A) Shop Section	Open	Count	21	71	34	9	135
		% within Visual Check (A) Shop Section	15.6%	52.6%	25.2%	6.7%	100.0%
		% within Building Facts (C) Typology	70.0%	75.5%	94.4%	81.8%	78.9%
	Closed	Count	9	20	2	2	33
		% within Visual Check (A) Shop Section	27.3%	60.6%	6.1%	6.1%	100.0%
		% within Building Facts (C) Typology	30.0%	21.3%	5.6%	18.2%	19.3%
	not ascertained	Count	0	3	0	0	3
		% within Visual Check (A) Shop Section	0.0%	100.0%	0.0%	0.0%	100.0%
		% within Building Facts (C) Typology	0.0%	3.2%	0.0%	0.0%	1.8%
Total		Count	30	94	36	11	171
		% within Visual Check (A) Shop Section	17.5%	55.0%	21.1%	6.4%	100.0%
		% within Building Facts (C) Typology	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.5: Cross-tabulation of status of shop section is open or not by building types in Taiwan.

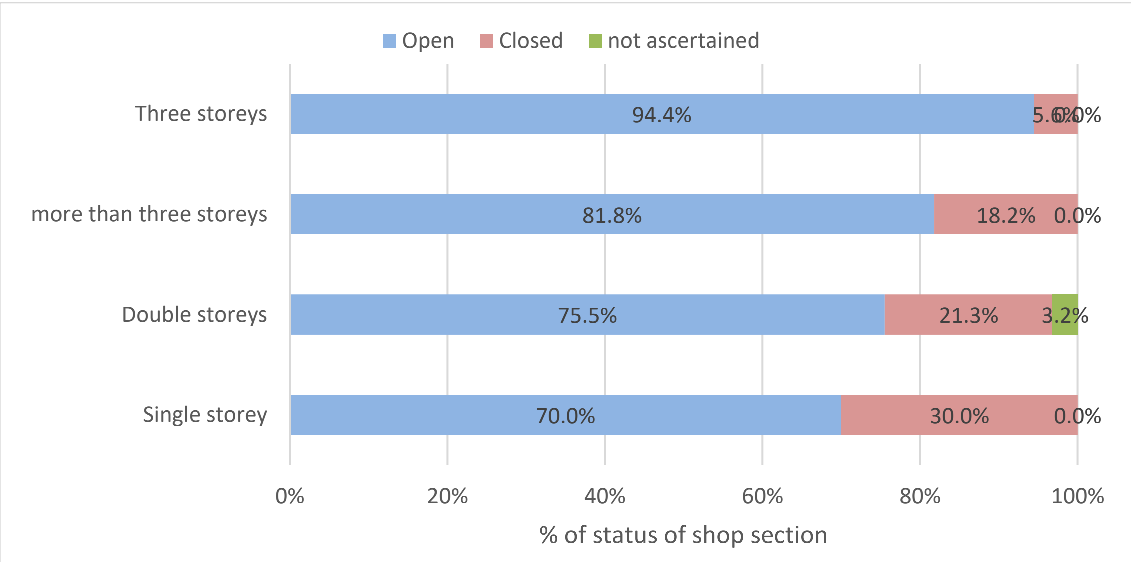


Figure 5.8: Cross-tabulation of status of shop section is open or not by building type in Taiwan.

Table 5.6 and Figure 5.9 present the results of visual checks on the status of the first (front) courtyard open by the types of building. From the figures, it is apparent that the majority typology is of *double-storey* buildings that are all open in their shop sections, but that there are also high numbers that have their courtyard *covered*.

			Building Facts (C) Typology				
			Single storey	Double storeys	Three storeys	more than three storeys	Total
Visual Check (B) First Courtyard	Open	Count	18	41	10	5	74
		% within Visual Check (B) First Courtyard	24.3%	55.4%	13.5%	6.8%	100.0%
		% within Building Facts (C) Typology	60.0%	43.6%	27.8%	45.5%	43.3%
	Covered	Count	10	51	26	5	92
		% within Visual Check (B) First Courtyard	10.9%	55.4%	28.3%	5.4%	100.0%
		% within Building Facts (C) Typology	33.3%	54.3%	72.2%	45.5%	53.8%
	not ascertained	Count	2	2	0	1	5
		% within Visual Check (B) First Courtyard	40.0%	40.0%	0.0%	20.0%	100.0%
		% within Building Facts (C) Typology	6.7%	2.1%	0.0%	9.1%	2.9%
Total		Count	30	94	36	11	171
		% within Visual Check (B) First Courtyard	17.5%	55.0%	21.1%	6.4%	100.0%
		% within Building Facts (C) Typology	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.6: Cross-tabulation of status of first courtyard (open or covered) by building types in Taiwan.

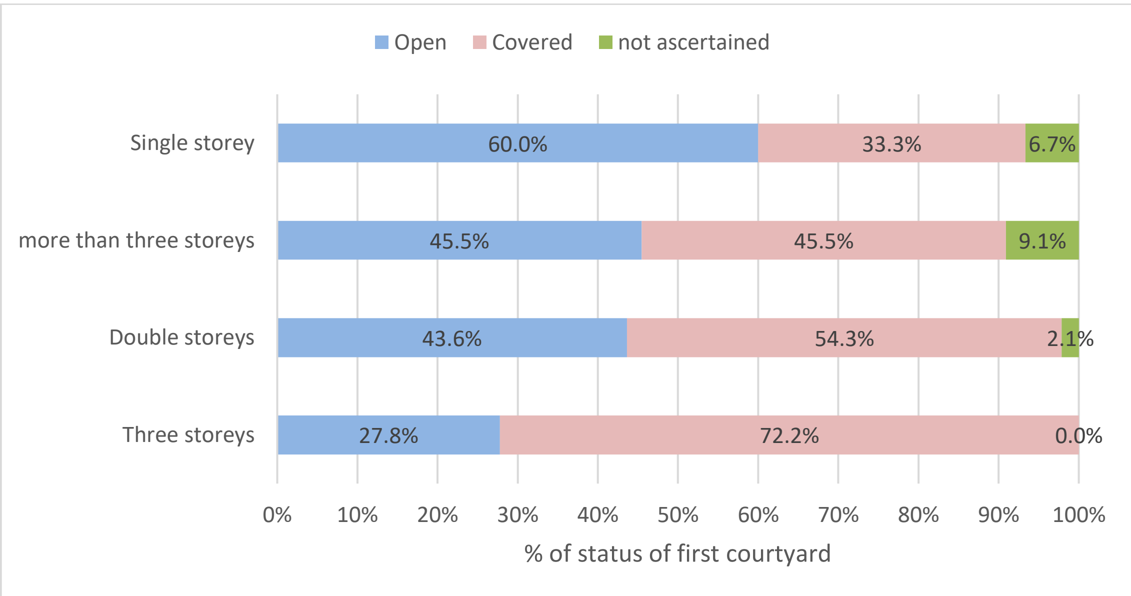


Figure 5.9: Cross-tabulation of status of first courtyard (open or covered) by building type in Taiwan.

Using Table 5.7, some associations can be seen. Of those who operate the business types of *food and drink*, 35.9% were covered and 40.0% were more likely to cover the front courtyard in different kinds of shading. However, the percentage of this business type and the other one, *art and craft*, also were 36.5% and 29.7% for remaining open courtyard respectively.

			Visual Check (B) First Courtyard			
			Open	Covered	not ascertained	Total
Visual Check (D) Functions	Art and Craft	Count	22	17	2	41
		% within Visual Check (D) Functions	53.7%	41.5%	4.9%	100.0%
		% within Visual Check (B) First Courtyard	29.7%	18.5%	40.0%	24.0%
	Creative Living	Count	8	14	0	22
		% within Visual Check (D) Functions	36.4%	63.6%	0.0%	100.0%
		% within Visual Check (B) First Courtyard	10.8%	15.2%	0.0%	12.9%
	Leisure Services	Count	4	8	0	12
		% within Visual Check (D) Functions	33.3%	66.7%	0.0%	100.0%
		% within Visual Check (B) First Courtyard	5.4%	8.7%	0.0%	7.0%
	Food and Drink	Count	27	33	2	62
		% within Visual Check (D) Functions	43.5%	53.2%	3.2%	100.0%
		% within Visual Check (B) First Courtyard	36.5%	35.9%	40.0%	36.3%
	not ascertained	Count	13	20	1	34
		% within Visual Check (D) Functions	38.2%	58.8%	2.9%	100.0%
		% within Visual Check (B) First Courtyard	17.6%	21.7%	20.0%	19.9%
Total		Count	74	92	5	171
		% within Visual Check (D) Functions	43.3%	53.8%	2.9%	100.0%
		% within Visual Check (B) First Courtyard	100.0%	100.0%	100.0%	100.0%

Table 5.7: Cross-tabulation of business categories in relation to first courtyard checks (Taiwan).

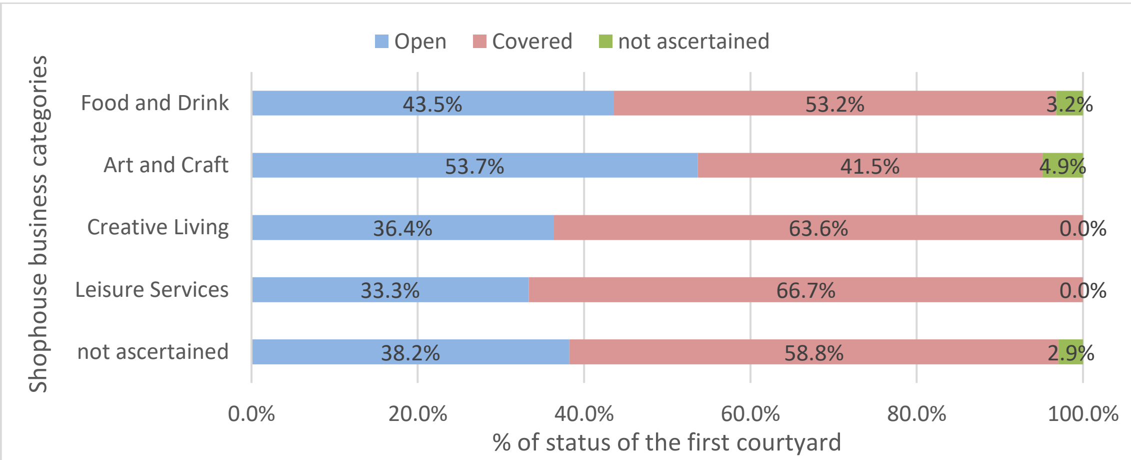


Figure 5.10: Cross-tabulation of business categories in relation to first courtyard checks (Taiwan).

5.2.1. Analysis of responses to Part A: Living courtyards

The results from question A1: What things do you like most about the existing Courtyard (please check all that apply)? The 5 possible responses:

1. Daylight introduction
2. Fresh air ventilation
3. Gardening for good atmosphere
4. Storage space
5. Others

In Figure 5.11, it can be seen that most respondents express their satisfaction with the *fresh air ventilation* both in northern Taiwan and George Town in Penang. Beyond the fresh air, the second majority of the respondents from all districts express their almost same satisfaction with the point of *gardening for good atmosphere* of a courtyard. These results also coincide with most researched topics: Courtyard is a Traditional Device used for Ventilation and Daylighting.

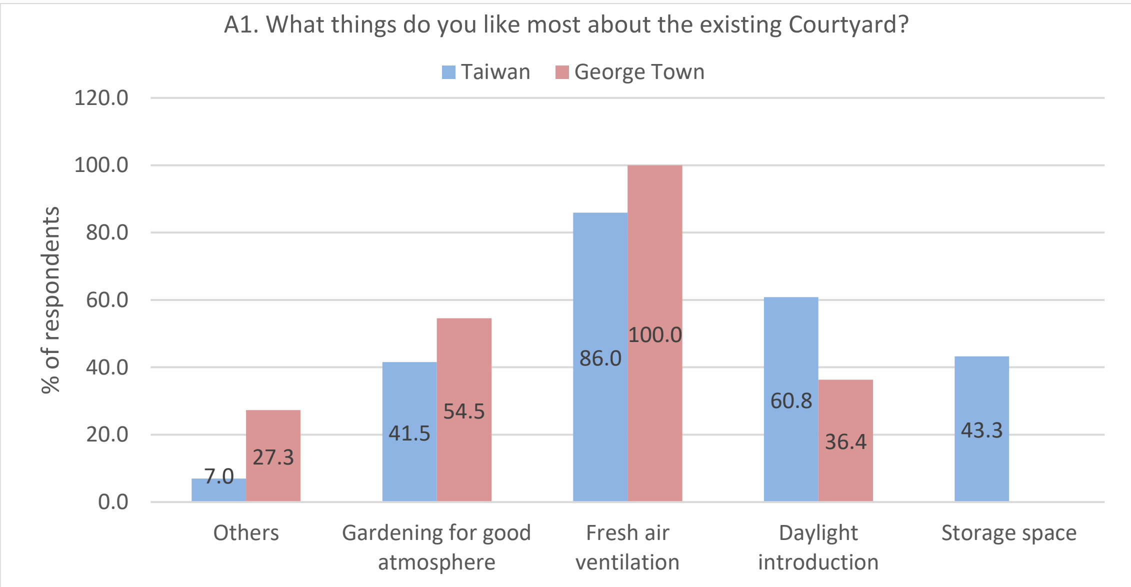


Figure 5.11: Respondents by the possible things to like the existing courtyards (question A1).

However, when respondents were asked their reasons to be thinking of covering their courtyards, it appears that its role in terms of ventilation and daylighting is no longer important. The results from question A2: What were your main reasons for covering the existing Courtyard (please check all that apply)? The 5 possible responses:

1. Get strong sunlight on wall
2. Get strong wind on windows and doors

3. Increase space for multiple uses
4. Water leakage at the connection
5. Floors and stairs slippery when raining

Figure 5.12 show the opinions of respondents with respect to the covering of the existing courtyards. In the rating 84.8% of *increase space for multiple use* refer to all possible responses. Beyond of this issue, in the rating over 54.4% of *get strong sunlight on wall* refer to Taiwan is slightly higher than other possible things. It appears that the traditional advantages of courtyard are changing and losing their place.

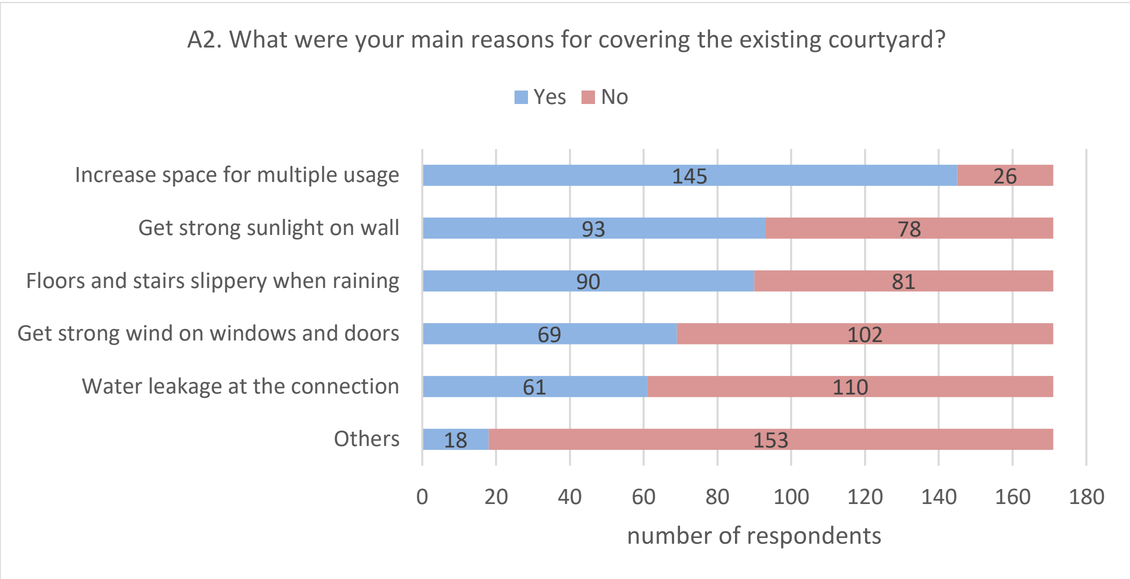


Figure 5.12: Respondents by the main reasons for covering the existing courtyards (question A2).

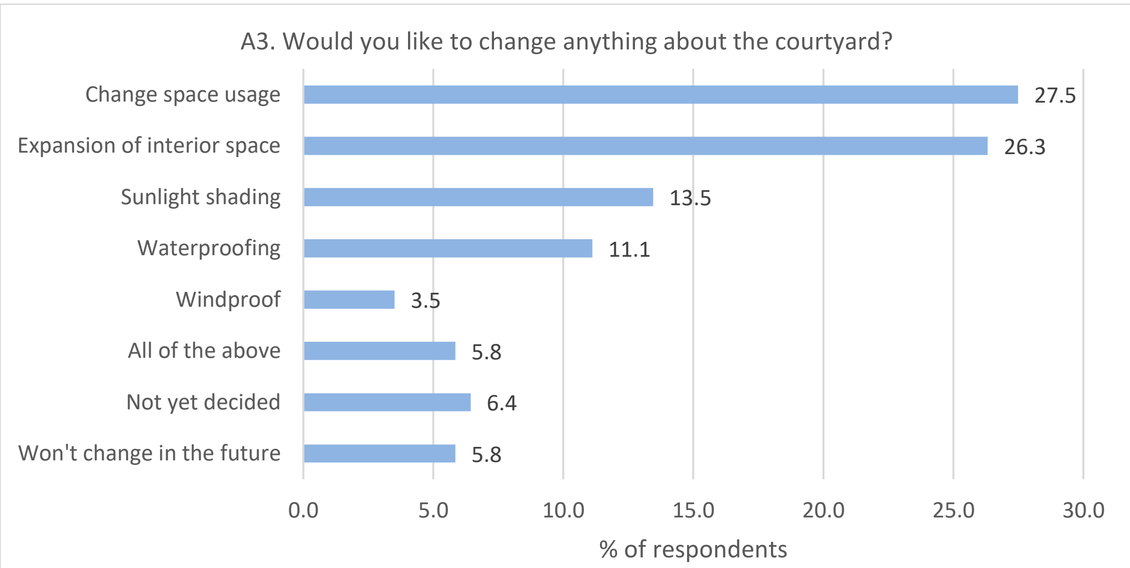


Figure 5.13: Respondents by the future changes about the courtyard (open-ended question A3).

Following their main reasons for liking the courtyard, and for covering the existing courtyard. The results from open-ended question A3: Would you like to change anything about the Courtyard? Figure 5.13 show the opinions of respondents with respect to the change of courtyards. It is apparent that these responses can all be categorized as being about the reuse of space. The majority of respondents say they are thinking about *change space usage* with 27.5% and *expansion of interior space* second at 26.3%. In contrast to the opinion in other reasons, almost 30% of respondents describe themselves as considering about changing in the future. Again, it appears that the courtyard are not only losing their place, but also must be changed.

For self-rating to the different aspects of their traditional shophouses, Figures 5.14 presents and illustrates that the overall response to six sub-questions from question A4: Would you tell us how satisfied you are with the following aspects of your shophouse?:

1. Personal preference towards old shophouses
2. Expression of Chinese art and culture
3. Location of shophouse in district area
4. Working atmosphere in shop section
5. Living conditions in main courtyard
6. Functional efficiency of space in main courtyard

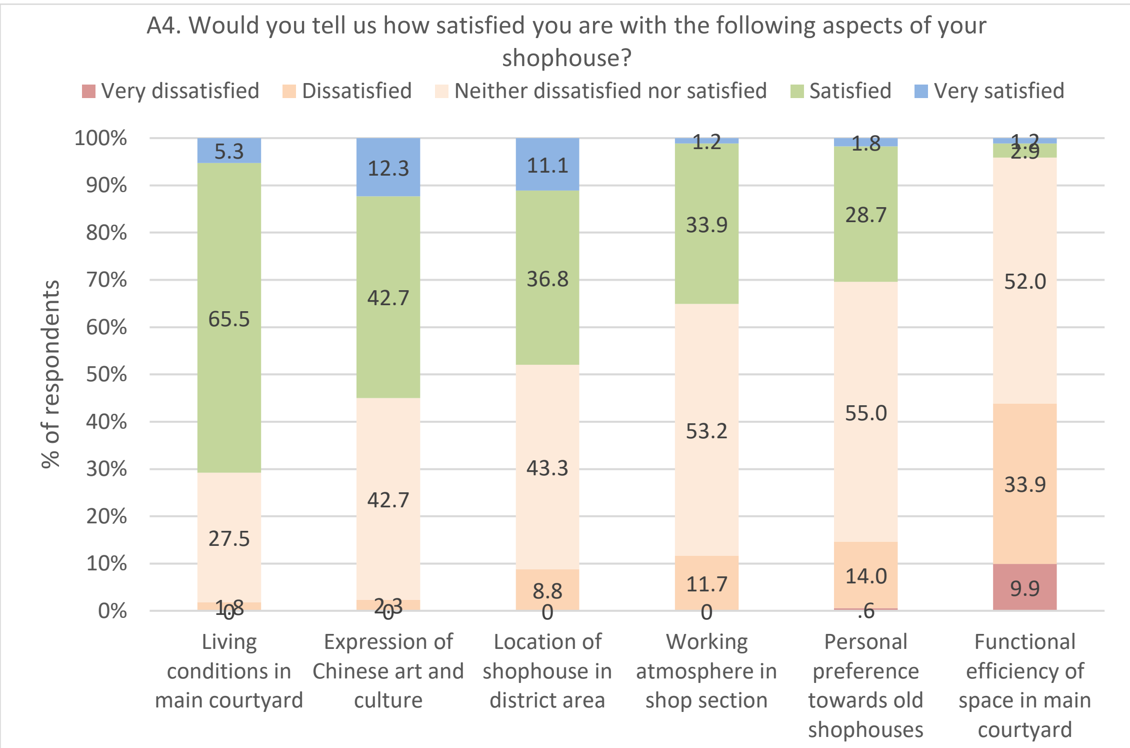


Figure 5.14: Assessment of respondents' rating with the 6 sub-questions (self-rating question A4).

However, in a scale that ranged from *very dissatisfied* to *very satisfied*, approximately 29.3% of respondents in the survey indexed the *living conditions in main courtyard* between *dissatisfied* and *neither dissatisfied nor satisfied*, while over 70% rated their courtyard between *satisfied* to *very satisfied*. Similarly approximately 95.8% of respondents indexed the *functional efficiency of space in main courtyard* between *dissatisfied* and *neither dissatisfied nor satisfied*, while just about 4.1% rated between *satisfied* to *very satisfied*.

Given these descriptive statistics, it is clear that many respondents appear to satisfy living in their shophouses but also wish having changes to the courtyards in the future.

5.2.2. Analysis of responses to Part B: How do you feel?

In Part B, the data from George Town were included for the purpose of providing comparisons across different countries but similar cultures. As described previously, the vast majority of shophouse occupants or owners are immigrants from China in the entire region of Southeast Asia, and through this comparison it will be interesting to learn how those in other locations deal with different environmental conditions.

The results from open-ended question B1: Is there an overall lighting mood or feeling you want to set within the courtyard? … Describe? The 3 possible responses provided by displayed cards (refer to Appendix B):

1. Hard lighting
2. Soft lighting
3. Combined lighting

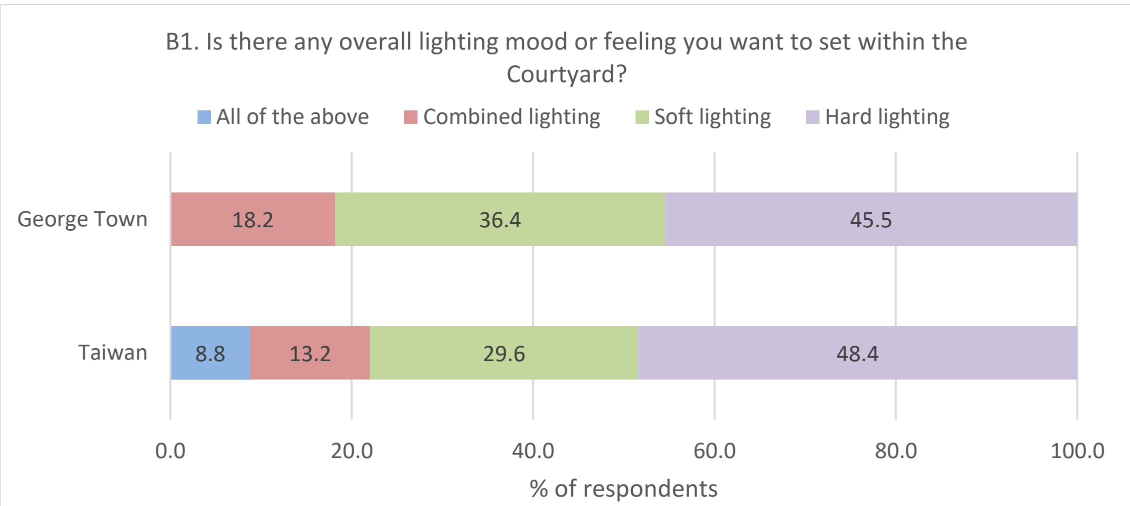


Figure 5.15: Respondents by the overall lighting mood within the courtyard (open-ended question B1).

Figure 5.15 displays results regarding the wishing choice of overall lighting design at courtyards. By contrast 48.5% in total of respondents from Taiwan expressed *hard lighting*, while 29.6% expressed their choice on *soft lighting*. This proportion is similar to George Town.

The results from open-ended question B2: Are there particular spaces that should have a specific lighting mood? … Where?

As for the location in a traditional shophouse, figure 5.16 shows that most of the respondents, through in varying degrees, show their choice with a specific *mood lighting at bedrooms, living room and dining room*. By contrast only 1.3% in total of respondents from Taiwan expressed *mood lighting at courtyards*, while no response on this item from George Town.

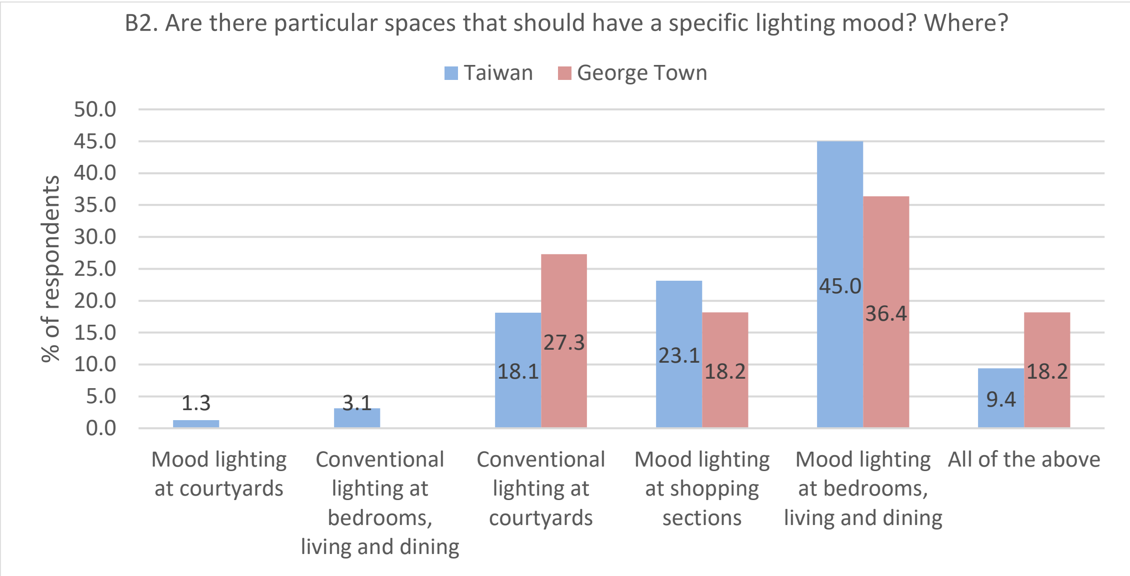


Figure 5.16: Respondents by the spaces that should have some lighting mood (open-ended question B2).

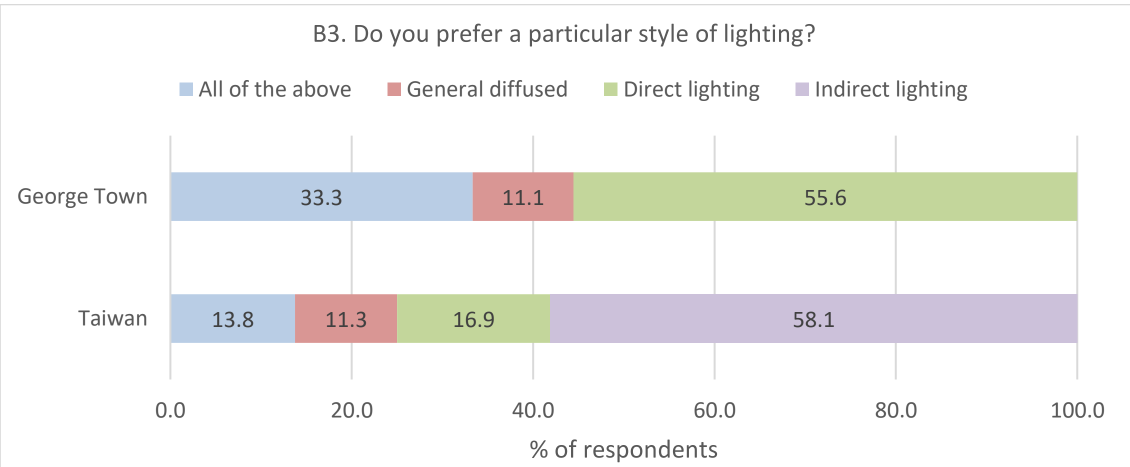


Figure 5.17: Respondents by the style of lighting (open-ended question B3).

The results from open-ended question B3: Do you prefer a particular style of lighting? The possible responses: 1) direct or indirect, 2) wall-lights or table lights, etc.

From the figure 5.17, the majority of the respondents from Taiwan are making choice with the style of *indirect lighting*. On the contrary, the *direct lighting* top the list with 55.6% chosen from George Town and without the choice of *indirect lighting*. This may be the number of questionnaires is not enough to reflect the real situation.

In forms of indoor air circulation, the results from open-ended question B4: For air circulation in summer time, do you prefer windows, a fan or air conditioning?

Figure 5.18 displays the choice from Taiwan for *fans and air conditioning* top the list with 57.2% chosen followed by the choice for *windows and fans* with 22.9% chosen. In comparison, the *windows and fans* and the *fans and air conditioning* with 60.0% and 40.0% of the respondents expressed the only two choices from George Town respectively.

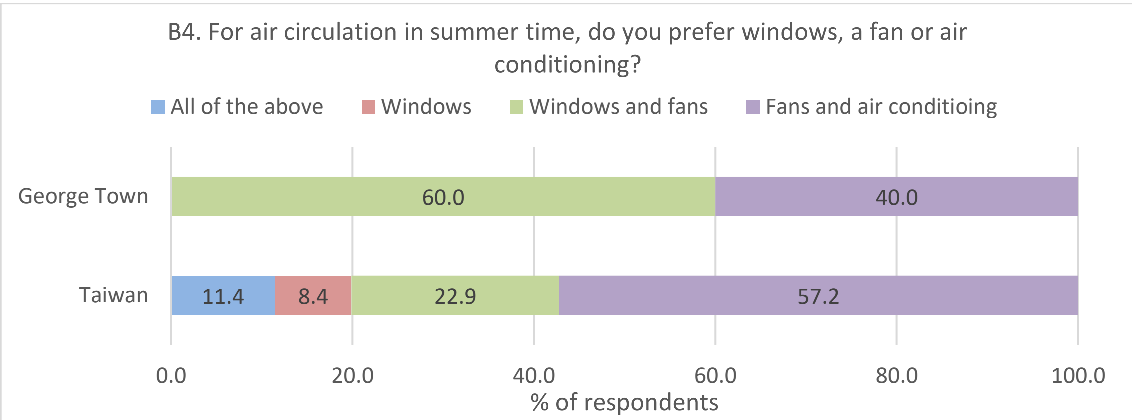


Figure 5.18: Respondents by the choice of devices for air circulation (open-ended question B4).

For self-rating to the aspects of the indoor climate of the shophouse, Figures 5.19a and 5.19b presents and illustrates the results from question B5 in Taiwan and George Town: How about the indoor climate of the shophouse? What is it like in summer and winter?

In a scale that ranged from too cold to too hot, 63.2% of respondents of Taiwan in the survey indexed the climate levels between *hot* and *too hot* in summer afternoon, while about 31.0% rated the levels at *neutral* (Figure 5.19a). Conversely 76.6% and 72.5% of respondents indexed the indoor climate levels at *neutral* in the evening and at nighttime for sleeping respectively.

During the winter months in Taiwan, approximately 41.0% of respondents in the survey indexed the indoor climate levels between *cold* and *too cold* in the morning, and then increased to 53.2% rated the same ranges as well in the afternoon; it is apparent that about 12.2% of respondents felt colder in winter afternoon (Figure 5.19a). Continuously about 90.1% of respondents indexed the climate levels in the evening between *cold* and *too cold*, and then increased again to 94.1% rated the same ranges as well at nighttime for sleeping. As a device for ventilation and daylighting, the form of courtyard, which in turn leads to internal coldness.

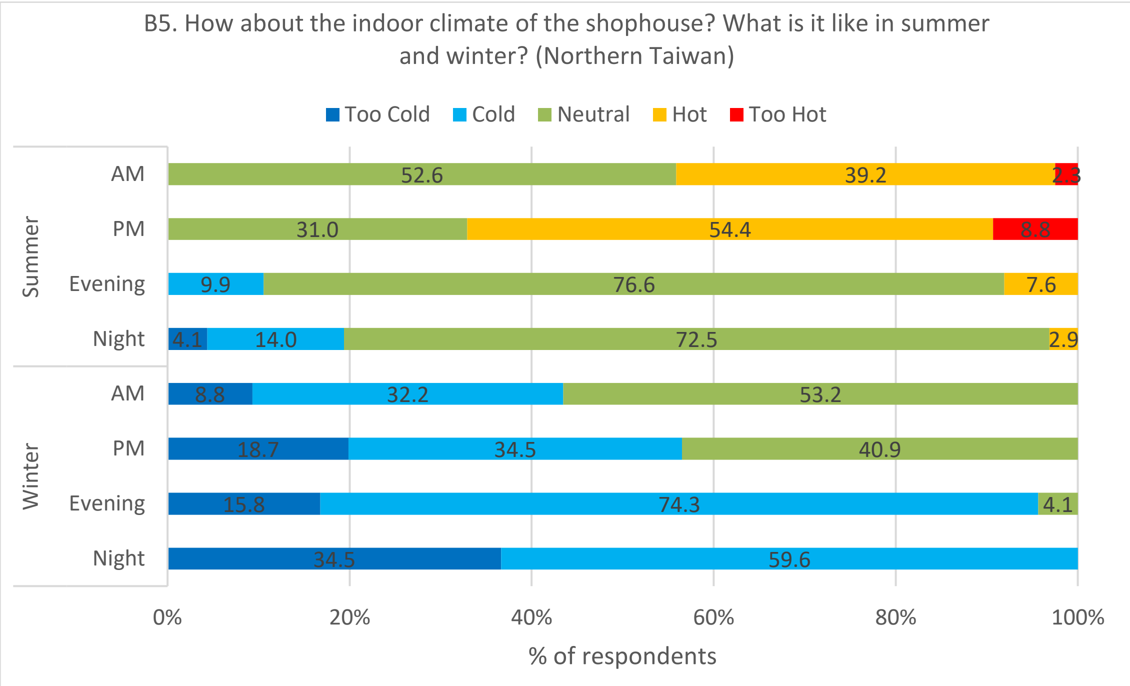


Figure 5.19a: Assessment of respondents' rating with the indoor climate, Taiwan (self-rating question B5).

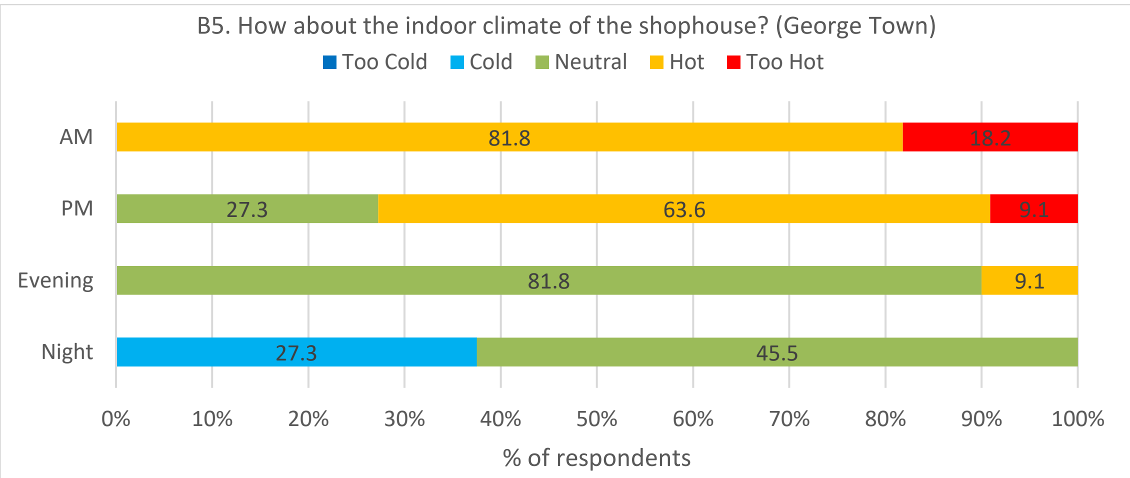


Figure 5.19b: Assessment of respondents' rating with the indoor climate, George Town (self-rating question B5).

In contrast to the Malay Peninsula in the tropics, the courtyard did the effect of internal cooling. Figure 5.19b presents and illustrates the results from the same question B5 in George Town. Although most of the respondents pointed out that during the daytime period was very hot, over 80% rated the climate levels at neutral from the evening to the nighttime. It appears that the form of traditional shophouse is quite suitable for tropical environments.

5.2.3. Analysis of responses to Part C: How do you think?

The first three questions (C1, C2, and C3) are focused on the personal feelings of the occupants on their current shophouses. Due to the relationship between the numbers of questionnaires, the observation of this part will be based in the region of Northern Taiwan. These three questions have 4 similar responses:

1. Better, much better, or good;
2. Stayed the same, or fair;
3. Become worse, much worse, or poor;
4. Not applicable.

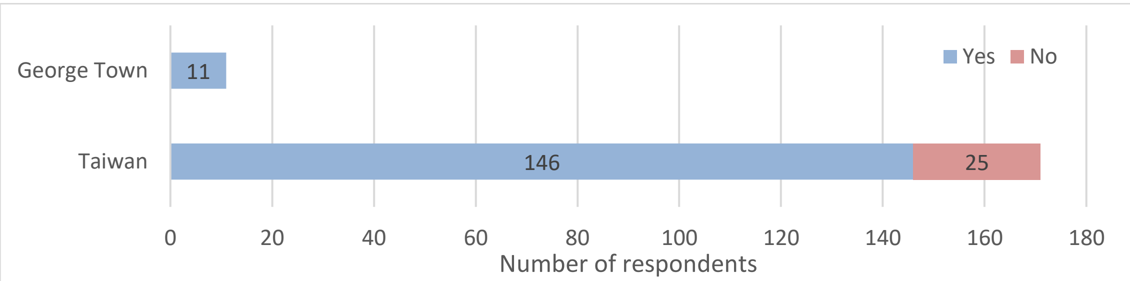


Figure 5.20a: Respondents by the quality of life changed or not (question C1).

The results from question C1: Has the quality of life in the shophouses changed over the past year? … Yes or No?

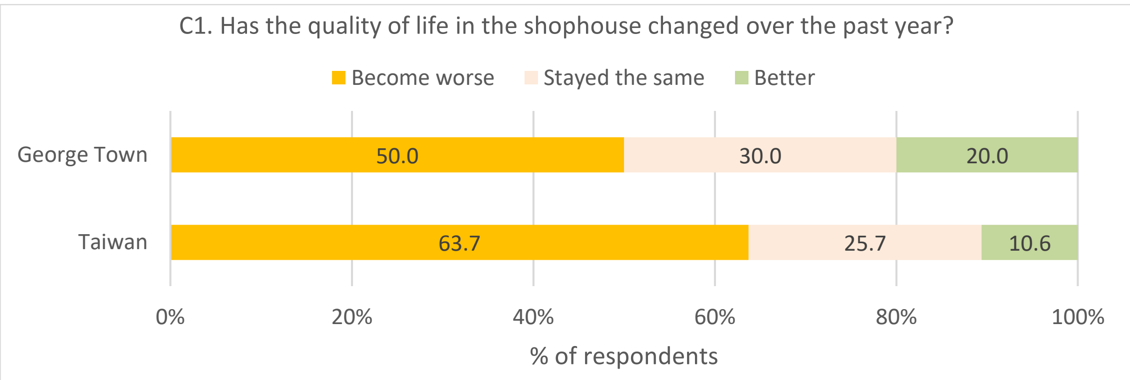


Figure 5.20b: Respondents by the quality of life changed (question C1).

Figure 5.20a shows that the majority of respondents agree that the quality of life in the shophouse had been changed over the past few years. It is easily noted that a total of 157 respondents chose *Yes* while only 25 respondents from Northern Taiwan chose *No*. Figure 5.20b delineates the response choices out of 182 total respondents. In Taiwan, there were 42.1% respondents who selected *become worse*, 17.0% selected *stayed the same*, 7.0% selected *better*, and 19.3% of respondents selected *not applicable*. Both respondents of Taiwan and George Town agree the overall quality of life in the current shophouses had become worse.

The results from question C2: How would you rate your shophouse as a place to live, compare to other types of homes in the nation?

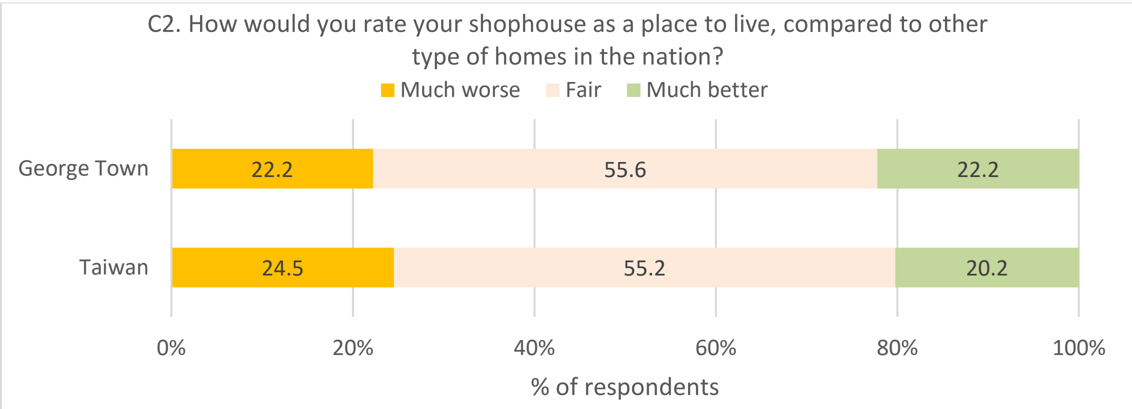


Figure 5.21: Respondents by rating as a place of home to live (question C2).

Figure 5.21 represents results outlining the comparison between shophouses and other types of homes in the nation. As a place to live in Northern Taiwan, there were 55.0% respondents who answered *fair*, and 19.3% answered *much better*. However, there were 25.7% and 4.7% of respondents selected much *worse* and *not applicable* respectively. Overall, more than 60% of the respondents in both regions agreed that the traditional shophouses continue to suitable for living.

The results from question C3: What would you consider the overall structural condition of your shophouse to be?

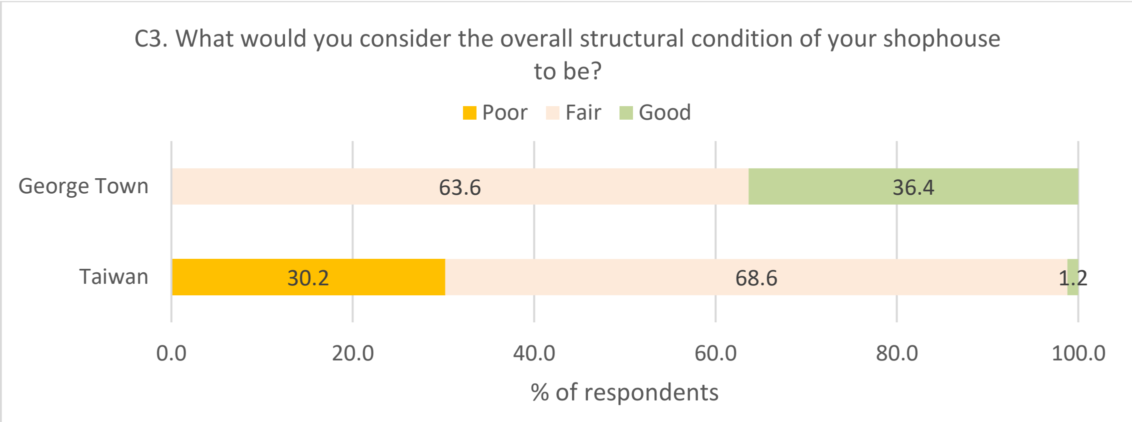


Figure 5.22: Respondents by rating the overall structural condition of shophouse (question C3).

Figure 5.22 shows that more respondents ensure their shophouse buildings were kept in good condition up to date. It is easily noted that up to 69.8% of respondents in Taiwan chose *good* and *fair* while 30.2% answered *poor*. However, by visual records during the interviews, the author agreed with respondents' view at about 20 percent off.

The results from question C4: Does your current shophouse meet your particular living needs? The 3 possible responses:

1. Mostly meets needs
2. Somewhat
3. No longer meets needs

Figure 5.23 represents daily lives divided into three periods (daytime, evening, and nighttime), for personal living needs in traditional shophouse today. In a scale that ranged from *mostly meet needs* to *no longer meet needs*, 55.0% of respondents of Taiwan in the survey responded *somewhat* during daytime, 65.5% of respondents responded *somewhat* again in the evening, while about 38.0% of respondents answered *no longer meet needs* during nighttime. However, there are more than 54% of respondents answered *somewhat* during whole day.

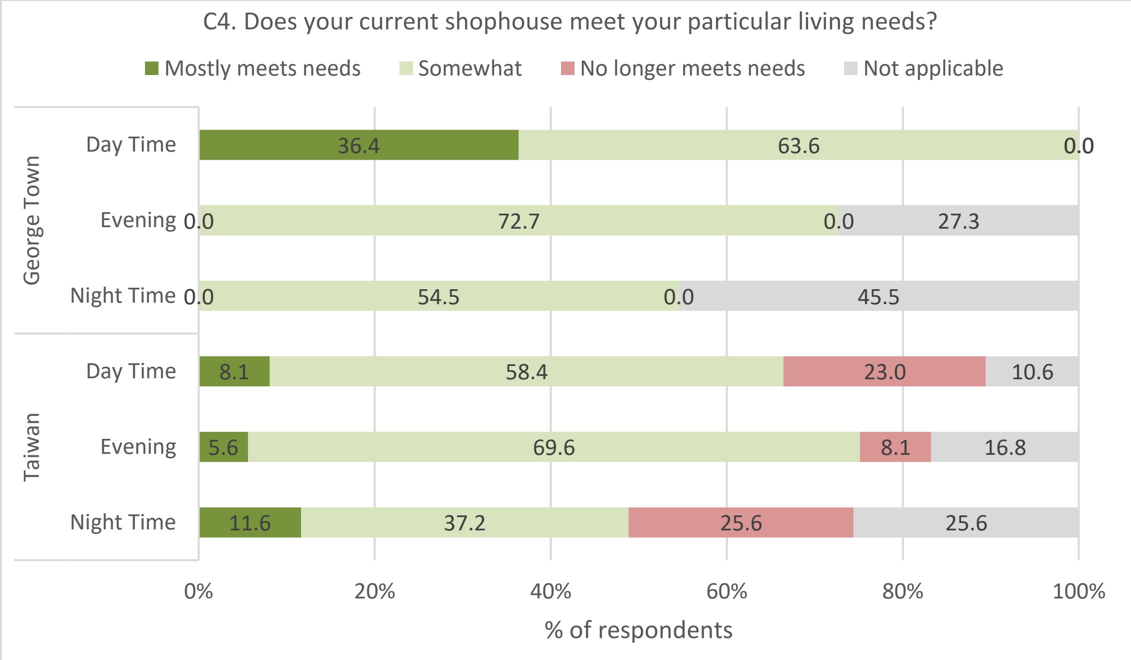


Figure 5.23: Respondents by rating any particular living needs (question C4).

The last 3 questions of Part C result in Figures 5.24, 5.25 and 5.26 provide open-ended data on the answering for facing problems regarding their traditional shophouses today. This is a complex issue that involves not only the shophouse owner occupants, but also the tourists, the local government and the land developers. In response to the two different regions, the results of questions C5 and C6 are similar.

The results from open-ended question C5: What do you think is the single most important problem shophouses face today?

Figure 5.24 illustrates that at 45.0%, the largest proportion of respondents say it is *too difficult to maintain* an old shophouse building, with a perception that shophouses are losing their *self-image* was the second largest response category at 14.6%, and it is *too old for modern use* third at 14.0%.

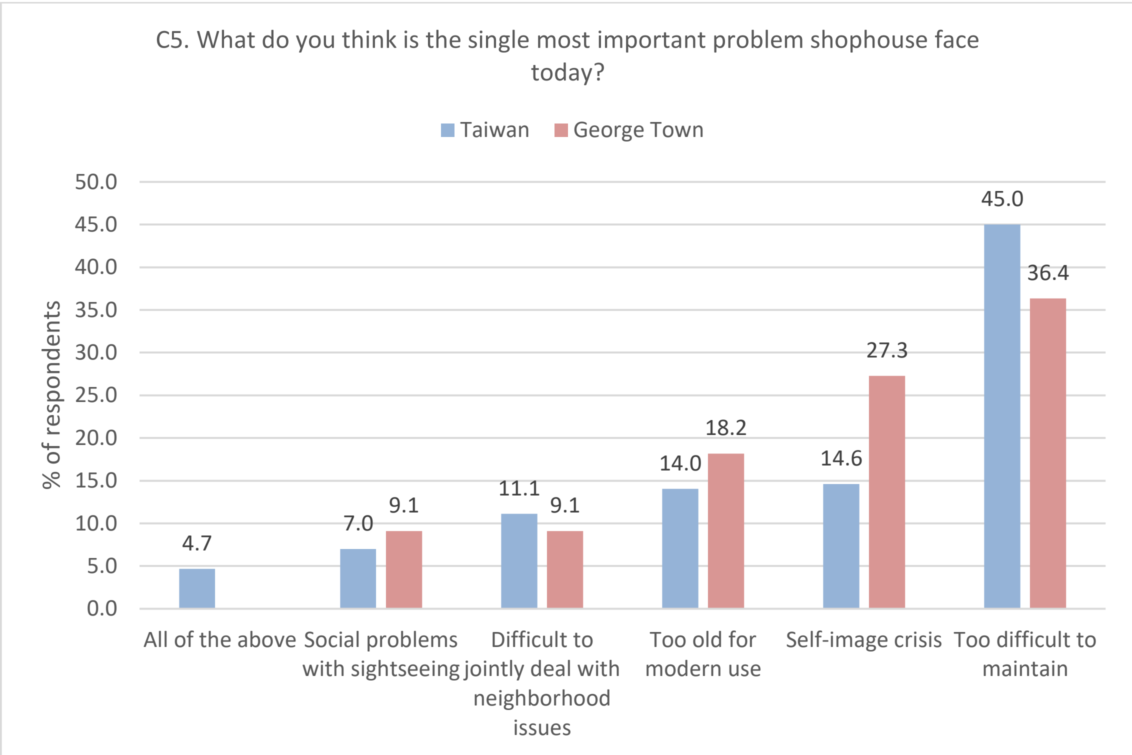


Figure 5.24: Respondents by most important problem shophouse face today (open-ended question C5).

The results of open-ended question C6: In your opinion, what is the best solution to this problem?

Figure 5.25 shows that 40.9% of respondents indexed the best solution to the above problems is to *bridge the gap for common sense* between owner occupants themselves, two groups of 18.1% of respondents think of *government assistance* and *hope to rebuild* their buildings.

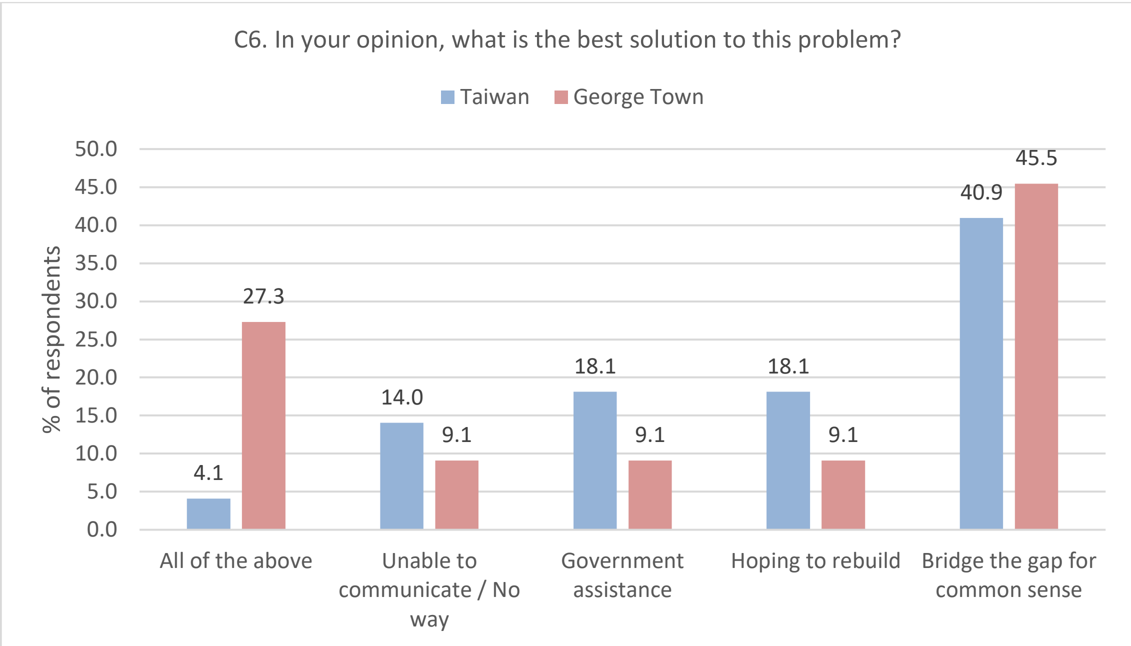


Figure 5.25: Respondents by best solution to this problem (open-ended question C6).

The results of open-ended question C7: What is the thing you like least in living in a shophouse?

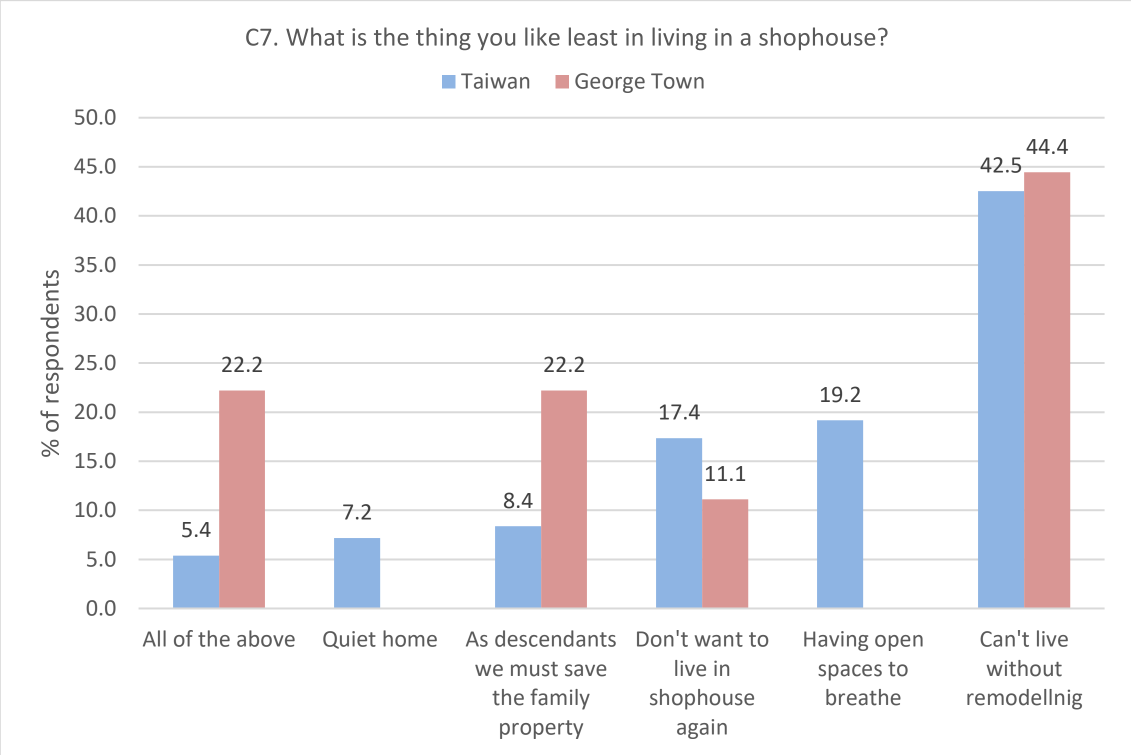


Figure 5.26: Respondents by the thing to least in living in a shophouse (open-ended question C7).

From a negative point of view, majorities of respondents say *it can't live without remodelling* with 42.5% and *don't want to live in shophouse again* second at 17.4% (Figure 5.26). However, approximately 25% of respondents from Taiwan in the survey mentioned that shophouse is having open spaces to breathe and a quite home.

Another interesting common response comes from both regions say *as descendants we must save the family property* at 22.2% and 8.45% in George Town and Taiwan respectively, where this response from George Town respondents was almost three times that of Taiwan. Presently, Malaysia is a multicultural society including Malays, Chinese, Indians, and others. It is worth noting here that these three ethnic groups have significantly distinct cultural and religious heritages. They continue to maintain their separate identities, preserving their separate cultures which manifest themselves in the languages they speak, dress codes, customs and behavior patterns (Lim 2001; Yeoh and Yeoh 2015). There is no similar cultural identity crisis in today's Taiwan, where this struggle is more apparent between the old and new.

5.2.4. Findings of the survey: Think of the future

The previous sections described a general analysis of respondents to all three parts of questionnaire. In summary, the majority of respondents appear to be satisfied with the living conditions in their traditional shophouses but also wish to have more changes to their courtyards in many ways in the near future, even though it incorporates traditional devices used for ventilation and daylighting (survey Part A). In terms of microclimatic conditions, the unique building form can be an advantage in providing additional ventilation and promote higher air velocity on the ground plane. The strategy of courtyards plays a significant role in the region of Southeast Asia. However, in the winter of Taiwan, this benefit will become a disadvantage (survey Part B).

For the future of traditional shophouses and/or the historic streets or districts, in this regard the majority of respondents expressed pessimism (survey Part C). The reason for this is quite broad and will be discussed in Chapter 9, which focuses on an analysis of home-based business (HBB) in urban context as well as public enjoyment.

Currently, most of the respondents are worried about the extent to which their quality of life had become worse over the past few years (question C1), because of the current conditions in the shophouse buildings. Although they are satisfied with the history, cultures, architecture, and overall environments (question A4) as well as, as a home to live in (question C2), it is still considered too difficult to maintain such old buildings (question C5).

From the results of visual records on the status of the first courtyard. The business types of *food and drink* within *double-storey* buildings were more likely to cover the front courtyard (refer to cross tabulations, Tables 5.6 and 5.7) for the expansion of interior space (questions A2 and A3).

Tables 5.8 and 5.9 present the cross tabulation between the status of first courtyard and microclimate conditions respect to the changes of courtyards. In relation to strong sunlight and wind are concerned, Figure 5.27 and 5.28 show that both *change space usage* and *expansion of interior space* come at the major reasons for covering.

			A3 Would you like to change anything about the Courtyard?								
			Expansion of interior space	Change space usage	Waterproofing	Sunlight shading	Windproof	All of the above	No response or not yet decided	Won't change in the future	Total
A2 To Cover (A) Get strong sunlight on wall	No	Count	24	19	7	15	4	4	2	3	78
		% within A2 To Cover (A) Get strong sunlight on wall	30.8%	24.4%	9.0%	19.2%	5.1%	5.1%	2.6%	3.8%	100.0%
		% within A3 Would you like to change anything about the Courtyard?	53.3%	40.4%	36.8%	65.2%	66.7%	40.0%	18.2%	30.0%	45.6%
	Yes	Count	21	28	12	8	2	6	9	7	93
		% within A2 To Cover (A) Get strong sunlight on wall	22.6%	30.1%	12.9%	8.6%	2.2%	6.5%	9.7%	7.5%	100.0%
		% within A3 Would you like to change anything about the Courtyard?	46.7%	59.6%	63.2%	34.8%	33.3%	60.0%	81.8%	70.0%	54.4%
Total		Count	45	47	19	23	6	10	11	10	171
		% within A2 To Cover (A) Get strong sunlight on wall	26.3%	27.5%	11.1%	13.5%	3.5%	5.8%	6.4%	5.8%	100.0%
		% within A3 Would you like to change anything about the Courtyard?	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.8: Cross-tabulation of changing courtyards due to strong sunlight.

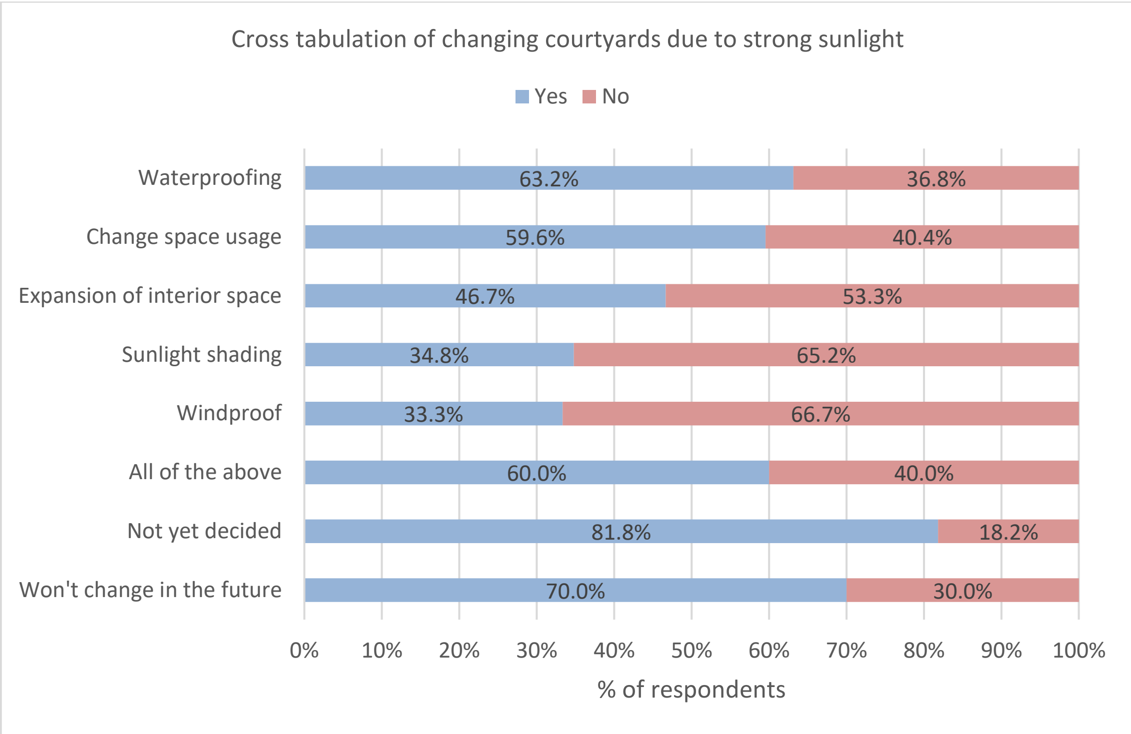


Figure 5.27: Cross-tabulation of reasons for changing courtyards plotted against waterproofing to strong sunlight.

Figure 5.27 shows that the *waterproofing* comes at the top list with 63.2% of the respondents followed by the response of *change space usage* and *expansion of interior space* with 59.6% and 46.7% respectively. It is expressing their onward actions to changing the open courtyard as an interior space. However, the percentage of the *won't change in the future* is 70% for remaining open courtyard.

			A3 Would you like to change anything about the Courtyard?								
			Expansion of interior space	Change space usage	Waterproofing	Sunlight shading	Windproof	All of the above	No response or not yet decided	Won't change in the future	Total
A2 To Cover (B) Get strong wind on windows and doors	No	Count	27	23	13	18	4	4	8	5	102
		% within A2 To Cover (B) Get strong wind on windows and doors	26.5%	22.5%	12.7%	17.6%	3.9%	3.9%	7.8%	4.9%	100.0%
		% within A3 Would you like to change anything about the Courtyard?	60.0%	48.9%	68.4%	78.3%	66.7%	40.0%	72.7%	50.0%	59.6%
	Yes	Count	18	24	6	5	2	6	3	5	69
		% within A2 To Cover (B) Get strong wind on windows and doors	26.1%	34.8%	8.7%	7.2%	2.9%	8.7%	4.3%	7.2%	100.0%
		% within A3 Would you like to change anything about the Courtyard?	40.0%	51.1%	31.6%	21.7%	33.3%	60.0%	27.3%	50.0%	40.4%
Total		Count	45	47	19	23	6	10	11	10	171
		% within A2 To Cover (B) Get strong wind on windows and doors	26.3%	27.5%	11.1%	13.5%	3.5%	5.8%	6.4%	5.8%	100.0%
		% within A3 Would you like to change anything about the Courtyard?	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5.9: Cross-tabulation of changing courtyards due to strong wind.

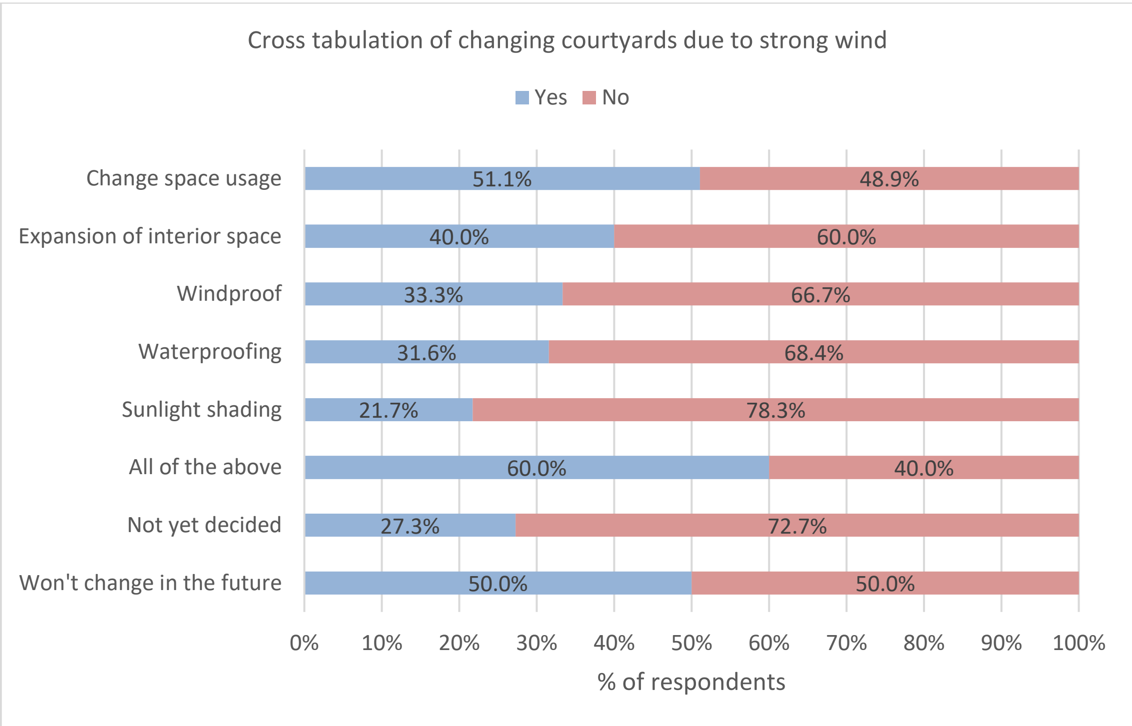


Figure 5.28: Cross-tabulation of changing courtyards plotted against change space usage to strong wind.

Figure 5.28 shows that the *change space usage* comes at the top list with 51.1% of the respondents followed by the response of *expansion of interior space* with 40.0%. In contrast to the opinion in terms of function in first courtyard, over 30% of respondents describe themselves as being considered about changing courtyards due to the problems of *windproof* and *waterproofing*.

	Peninsular Malaysia *George Town of Penang and Malacca*	Northern Taiwan *Beiman, Hukou, Daxi, Sanxia, Xinzhuang, and Dihua*
Art and Craft	art & painting, photo printing services, photographic studio, jewelry, wooden craft,	wooden furniture, wooden craft, framed and mounting, religious goods, glass products
Creative Living	souvenir, stationary, sports, clothing, private museum & gallery	souvenir, stationary, local specialty, showroom, old time toys store, drapery, handicraft, gardening & flower
Leisure Services	beauty salon, bar & pub, nightclub, karaoke lounge, tourist information office, hotel & youth hostel, backpack hotel, amusement centre, health centre, childcare centre	massage parlour, beauty salon, hotel, bar & pub, office, community centre, chess club, dance club, reading room
Food and Drink	bakery, coffee house, tea house, restaurant, fast food, takeaway food, snack bar, candy, supermarket	bakery, coffee & tea, restaurant, snack bar, breakfast, candy, takeaway food
not ascertained	medical clinic, office, grocery store, food catering & production, funeral parlour, coffin shop, commercial school, electrical products	medicine, medical clinic, real estate office, home office, grocery store, religious use, ironware, 24hrs store

Table 5.10: Visual records for up-to-date business uses at shop front units in the two research area sites. (Source: Fieldwork, 2007-12)

Table 5.10 presents on-street visual records regarding the business uses found at ground floor level in the shop front units, comparing the two research area sites: Peninsular Malaysia and Taiwan. From the general results it can be seen that the types of business uses are similar in each categories, however, there are more types of business uses in Peninsular Malaysia in comparison with Northern Taiwan. In terms of the forms of historic urban settlement, traditional shophouses have only existed on streets in Taiwan’s historic districts but they are throughout the cities of Peninsular Malaysia. It is the difference between linear space and plane grid. On the other hand, looking at the above table, it is apparent that one of the business types, *leisure services*, is quite concerned about the issue of traditional shophouses. This could indicate that it might be the best business type to survive in an old street or historic town centres.

5.3. On-street visitor survey

The visitor experience of historic districts is influenced by a number of factors, including ease of access and movement, visual impressions, the range and quality of things to do and see, and human interaction (Chang *et al.* 1996). In order to learn more about what visitors like and dislike about Taiwan's and Southeast Asia's historic streets and/or towns, especially in relation to shophouse courtyards, this study undertook a face-to-face survey of on-street visitors in Northern Taiwan as well as some major towns or cities in the Malay Peninsula. Approximately ten to twenty overseas or local visitors were interviewed in each of the districts and/or towns, giving a total sample size of 151. The aim of the survey was to assess their level of satisfaction on street fronts and internal courtyards with their visit to these streets or towns.

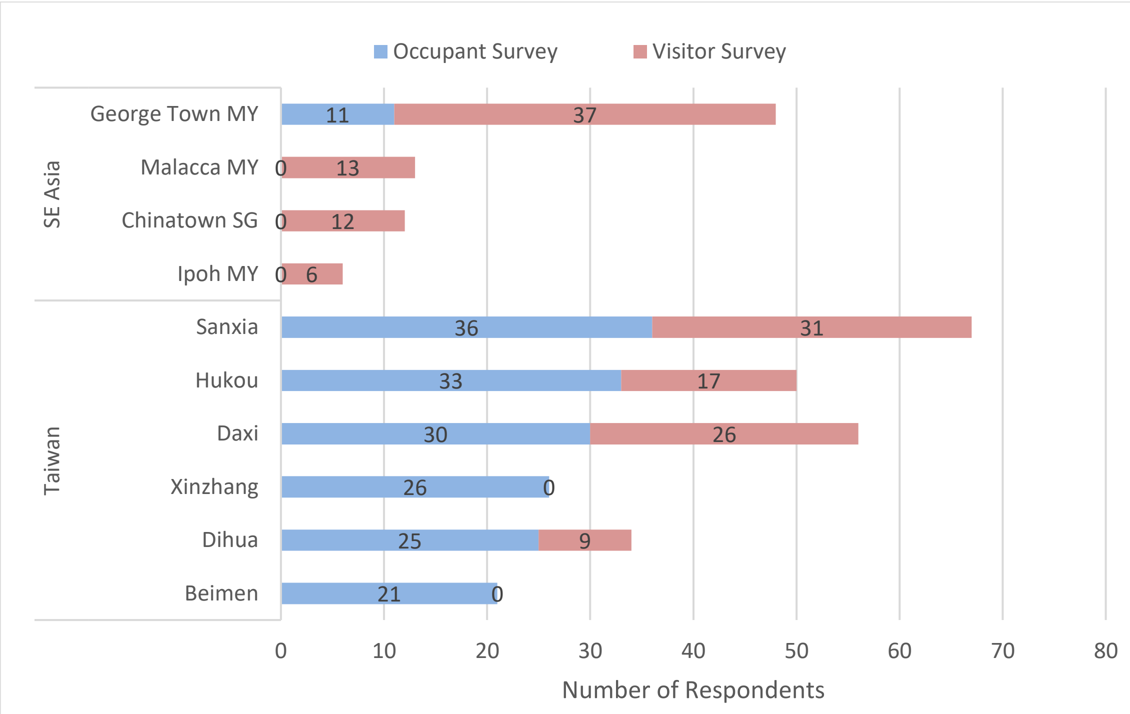


Figure 5.29: Distribution of survey respondents by locations.

5.3.1. Approach

The study was conducted during periods of summer holidays from 11th July to 22nd August 2010, and 29th July to 6th August 2011; and covered eight historic districts across three countries as detailed in Figure 5.29. Surveyors from the Department of Architecture and Urban Planning, Chung Hua University, were hired to carry out the majority of the visitor surveys in Taiwan, while the overseas surveys were carried out by the author. All respondents to this survey were anonymous and selected at random from those who were in the study area at the time of the survey and were willing to participate. The time allocated for each respondent to complete the survey was between 10 to 15 minutes. A blank copy of questionnaire used in On-Street Visitor Survey is included in Appendix C.

The study focus is on people who visit the target areas, and not those passing through, so the surveyors avoided the peak morning and afternoon commute hours in an attempt to exclude most of the pedestrians passing through the area to work or school. In this study, SPSS statistics software was used for data analysis. This section provides selected analysis of the data obtained from the On-Street Visitor Survey. The findings are presented relating to the general statements that were used for categorization, description and discussion purposes.

When exploring the on-street visitor surveys, one central idea focuses upon whether or not the public believed a small space, the courtyard of the shophouse, would help not only spur economic development, but also the rise of heritage preservation. Three groups of survey questions gathered the necessary data, so they were initially considered. The key question Q5 asked: *Do you think that visitors should have access to the inner courtyards?* While another question (Q11) nominally elicited a response to this statement: if there were more courtyards open to public, I would visit more often. As noted, some of these survey questions were initially considered to help determine a sound discovery process, but the first was chosen for the issues of inner courtyards. The research question, and our primary variable, is as follows: Do the occupants or users of traditional shophouses believe an existing and opened courtyard will encourage economic development?

5.3.2. Statistical analysis

As stated previously (refer to Section 4.5), this questionnaire was divided into 3 sections of total 11 questions:

A. Perception data by questions Q1, Q2, Q4, and Q6;
B. Environmental attitudes by questions Q5 and Q11;
C. Personal data by questions Q3, Q7, Q8, Q9, and Q10.

The results of question Q1: Based on your experience as a “Visitor” at this historic street and traditional shophouse, how would you rate each of the following? The 6 sub-questions:

1. Expression of local art and culture
2. Local foods and special goods
3. Integration of walkway into the surroundings
4. Quality of open courtyards
5. Quality of building façade and decorations
6. Personal appreciation of historical streetscape

In a scale that ranged from *very dissatisfied* to *very satisfied*, approximately 7.5% of respondents in the survey indexed the *integration of the walkway into the surroundings* between *very dissatisfied* and *neither satisfied nor dissatisfied*, while over 66.3% rated the covered walkways between *satisfied* to *very satisfied*. In addition there are more dissatisfied with the *local foods and special goods*, almost 20% of respondents in Taiwan, on the whole is very satisfactory (Figure 5.30).

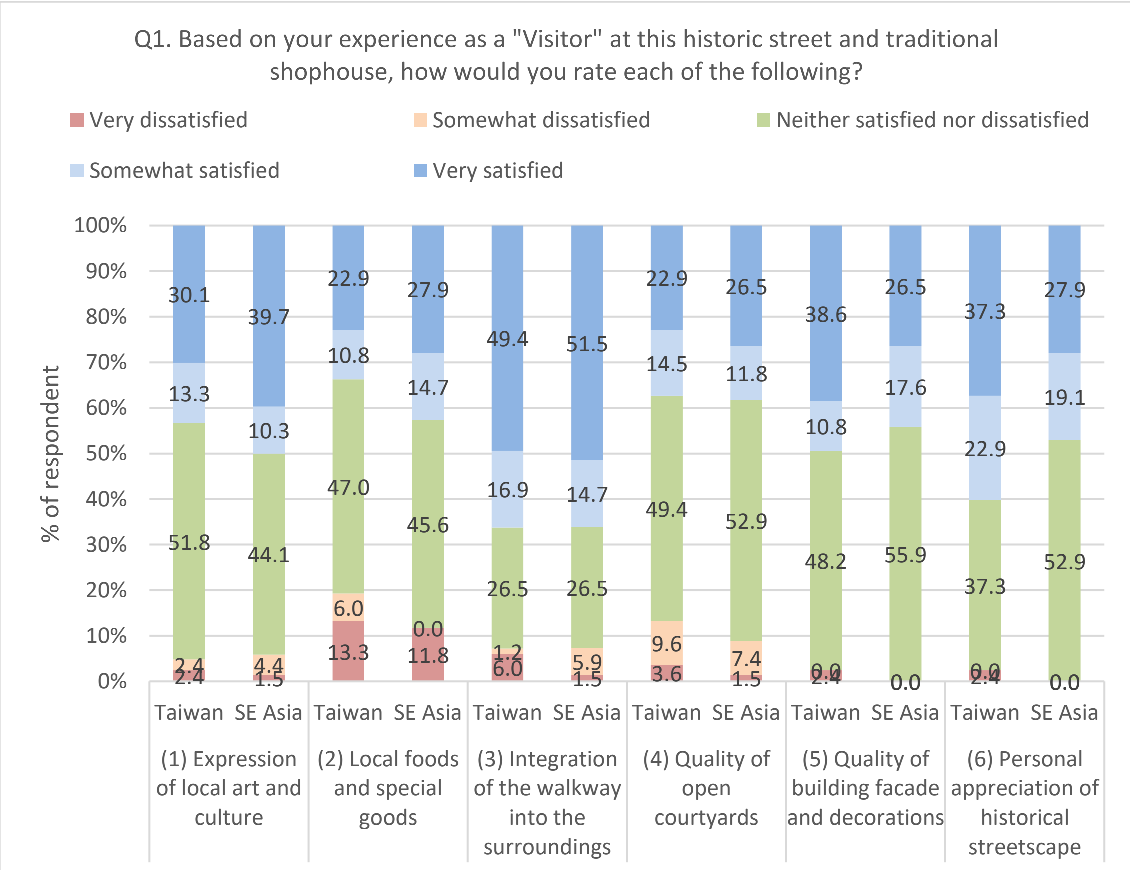


Figure 5.30: Assessment of respondents' rating with the 6 sub questions (question Q1).

The results of question Q2: In your opinion what are the three most favourable elements of this historical street (please tick 3 only)? The 8 possible responses:

1. Building façade and decoration
2. Covered walkway
3. Inner courtyards
4. Overall streetscape and skyline
5. Shopping selection
6. Art and culture
7. History
8. Other

In Figure 5.31, it can be seen that most respondents in Taiwan express their opinion with the *building façade and decoration*, *overall streetscape and skyline*, and *covered walkway* were the 3 most favourable elements of the historical street. In Southeast Asia, the *overall streetscape and skyline* was replaced by the *inner courtyards*. From the author's experience, most of the shophouses in Southeast Asia are open for visiting at ground floor area due to many types of business uses. In addition to the decorative façade, visitors have more opportunities to visit the whole building especially for the *inner courtyards* as well.

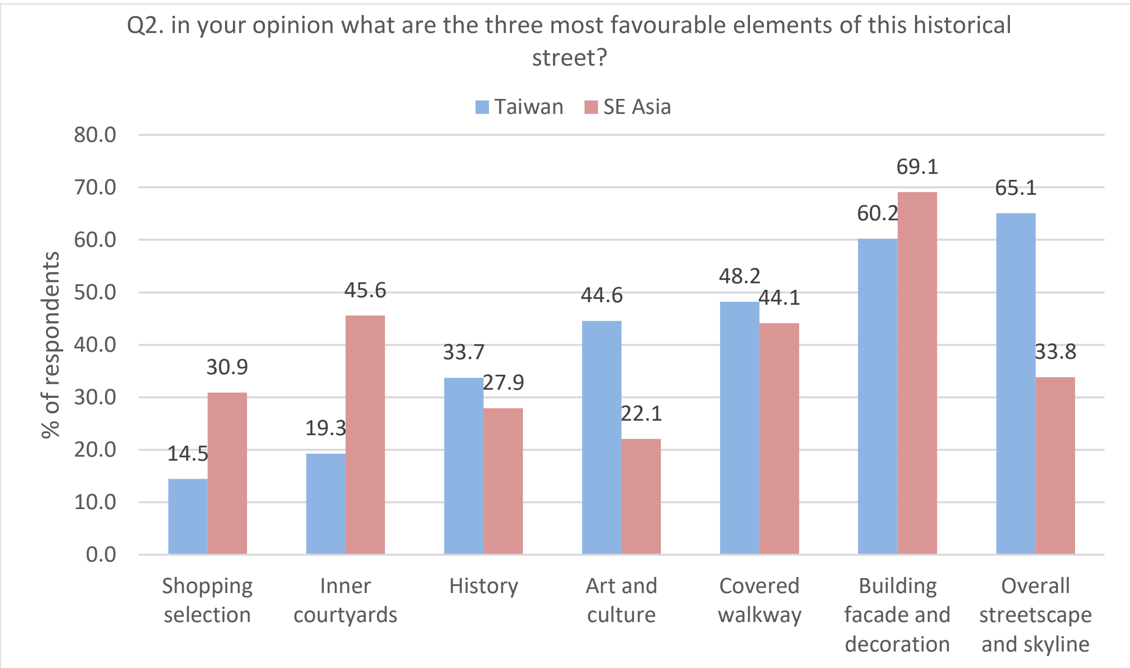


Figure 5.31: Respondents by most favourable elements on the historical streets (question Q2).

The results of question Q4: Do you like these historic buildings? If yes, the 5 possible responses:

1. Historical characteristics
2. Combine several functions
3. Atmosphere in courtyards
4. Environment in courtyards
5. Other

Figure 5.32 show the opinions of respondents with respect to liking these historic buildings. In the rating 77.1% of *historical characteristics* refer to all possible responses. In Southeast Asia, the rating is biased towards *combine several functions* at 76.5%. Looking at the whole chart, these two are the main factors relative to the courtyards.

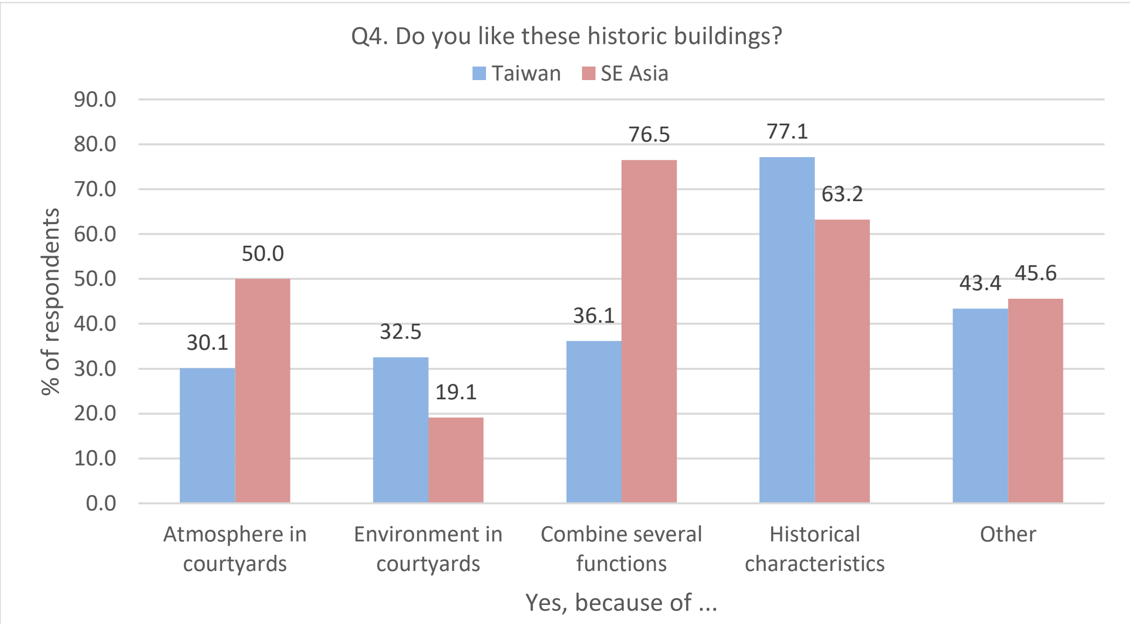


Figure 5.32: Respondents by reasons to like these historical buildings (question Q4).

The results of question Q6: How many times have you been here? The 4 possible responses: 1) Come here daily, 2) Come here regularly, 3) Rarely come here, and 4) First time here.

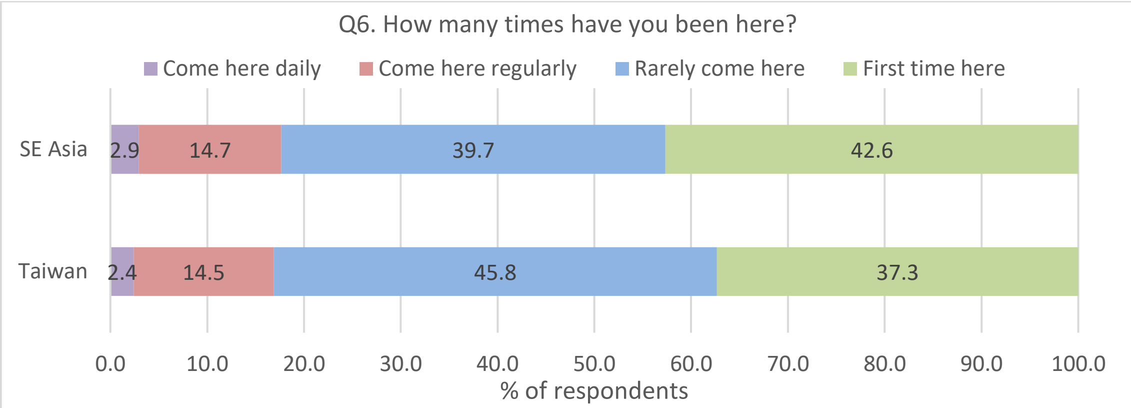


Figure 5.33: Respondents by times for visiting (question Q6).

Figure 5.33 indicates and illustrates that over 80% totally of *rarely come here* and *first time here* respondents came for visiting at least one time. From this results, almost half of them will come back again in the future.

The above 4 questions (Q1, Q2, Q4, and Q6) investigated on-street visitor's perception data. The initial reaction is positive and recognizes the importance of historical blocks. The next is the attitude of the respondents to the environment.

The results of question Q5: Do you think that visitors should have access to inner courtyards? The 3 possible responses: 1) Happy to see, 2) Unnecessary, and 3) unsure.

	Frequency	Percent	Valid Percent	Cumulative Percent
Happy to see	84	55.6	55.6	55.6
Unnecessary	46	30.5	30.5	86.1
unsure	21	13.9	13.9	100.0
Total	151	100.0	100.0	

Table 5.11: Respondent views to access inner courtyard (question Q5).

From Table 5.11, it is easily noted that 84 respondents chose *happy to see* while 46 chose *unnecessary*; furthermore, 21 respondents were *unsure*. The valid percentage show that 55.6% of the respondents answered *yes* while 30.5% answered *no*. Figure 5.34 includes the entire sample in percentage calculations, and illustrates that over 60%

of the respondents in both regions chose *happy to see* while 31.4% chose *unnecessary* in Taiwan. Given these descriptive statistics, it is clear that many respondents appear to enjoy having access to the shophouse courtyards.

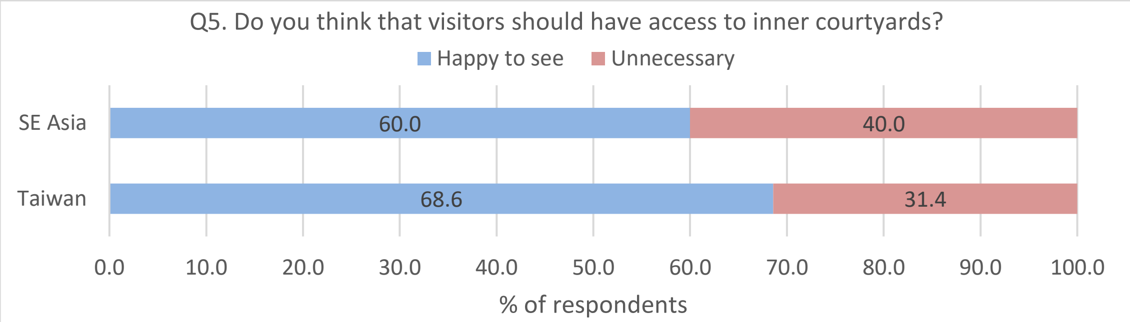


Figure 5.34: Respondent views by different regions to access inner courtyard (question Q5).

The results of open-ended question Q11: What activities and services would you like to see changed, added or improved?

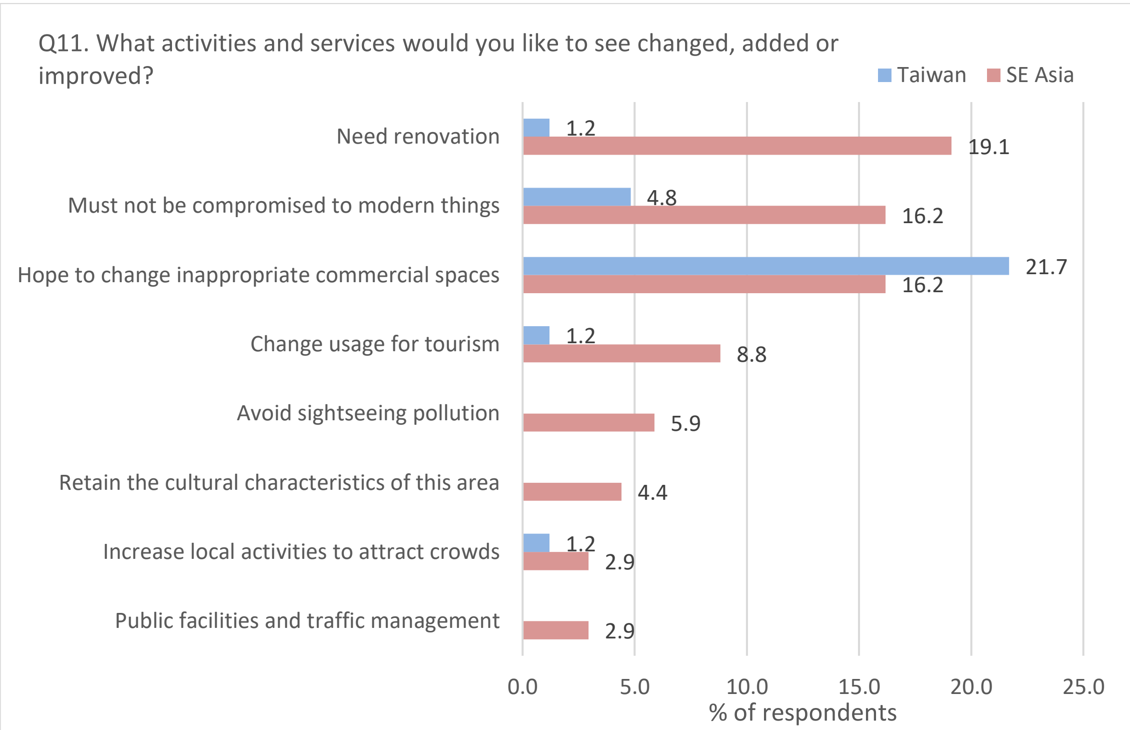


Figure 5.35: Respondents by future expectancy (open-ended question Q11).

This result shows that international tourists have more suggestions on today's historic districts. Figure 5.35 illustrates that over 50% of the respondents in Southeast Asia suggested that *need renovation*, *must not be compromised to modern things*, and *hope to change inappropriate commercial spaces*. In contrast, Taiwan has only had some advice on business activities.

The above 2 questions (Q5 and Q11) are investigating visitor's environmental attitudes. They are highly interested in any new things, such as inner courtyards. Most travelers are looking forward to maintaining the tradition and improving the urban environment. The next and final part is personal data of the respondents by the questions Q3, Q7, Q8, Q9, and Q10.

The results of question Q3: Why did you come to this historic street (please check all that apply)? The 8 possible responses:

1. Business
2. Visiting family or friends
3. Pleasure
4. Atmosphere
5. Shopping
6. Culture
7. Eating and drinking
8. Other

When respondents were asked their reasons to visit these historic streets, Figure 5.36 shows that the *pleasure* comes at the top list with 79.5% and 58.8% of the respondents in Taiwan and Southeast Asia respectively. Beyond the *pleasure*, visitors in Southeast Asia were also interested in the *visiting family or friends*, *eating and drinking*, *culture* and *atmosphere* of the streets.

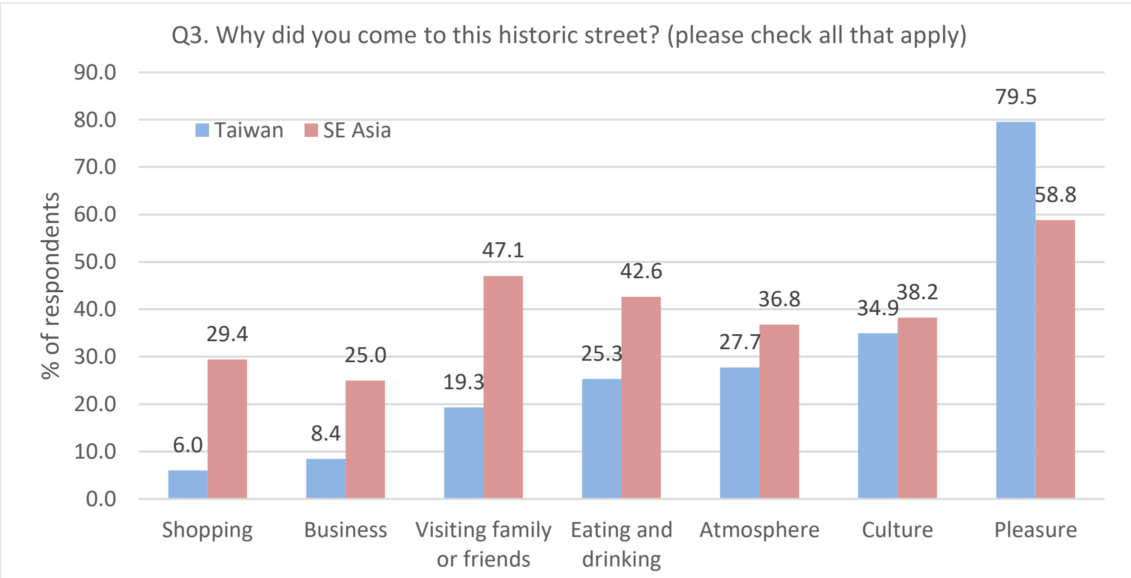


Figure 5.36: Respondents by reasons for coming historical streets (question Q3).

Therefore, enjoyment or satisfaction derived from what is to one’s liking, gratification, and delight. Today's historic neighborhoods already have the above conditions, and it seems to be able to meet the purpose of tourists’ pleasure.

The following 4 questions (Q7 to Q10) resulting their personal background.

Firstly, the gender of the respondents is roughly half on both regions (Q7, Figure 5.37). It was a fact that in the implementation of the on-street questionnaire, as far as possible the interviewers attempt to achieve a gender balance.

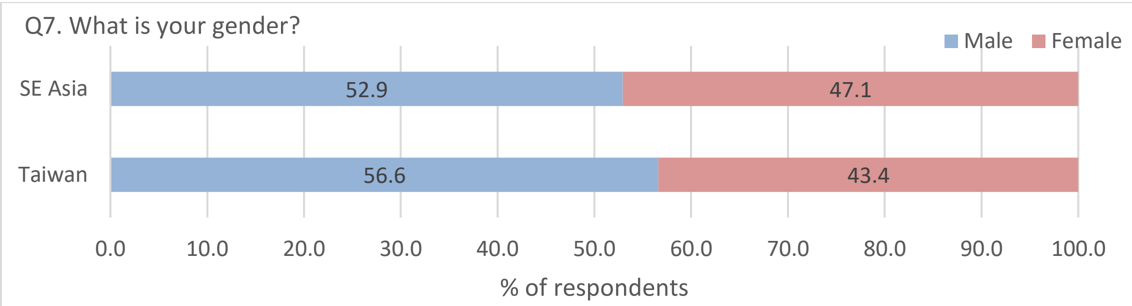


Figure 5.37: Respondents by gender (question Q7).

Secondly, the two regions were different in the distribution of age of the visitor respondents (Q8, Figure 5.38).

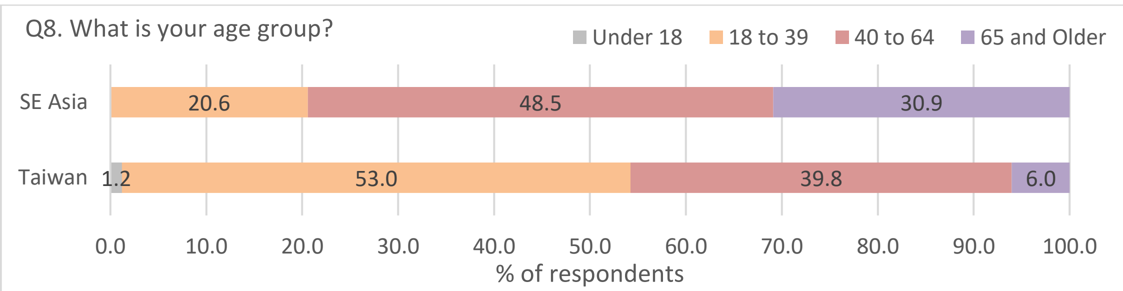


Figure 5.38: Respondents by age group (question Q8).

The responses were coded as 1 for *under 18*, 2 for *18-39*, 3 for *40-64*, and 4 for *65 and over*. Figure 5.38 illustrates that at 48.5%, the majority of visitors in Southeast Asia are between the ages of 40 and 64, while there were two large groups in Northern Taiwan, at 53.0% of 18-39 and 39.8% of 40-64. By the author's understanding, Taiwan's colleges or schools often hold extra-curricular activities in these historic streets.

Thirdly, related to the educational levels of the visitors (question Q9), the responses were coded as *high school*, *university*, *postgraduate*, and *not applicable*.

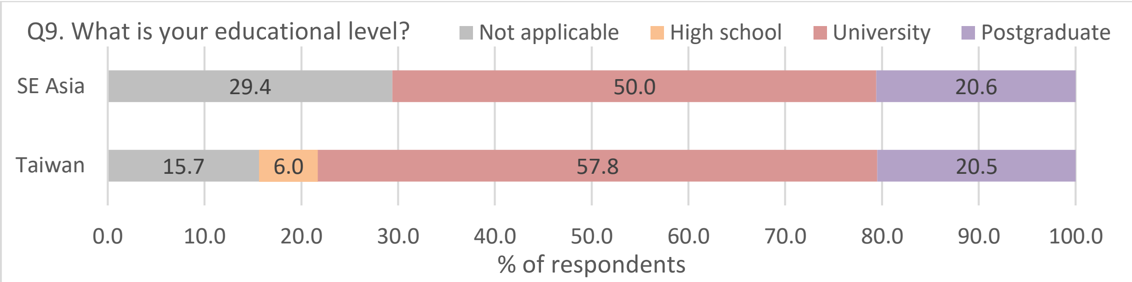


Figure 5.39: Respondents by educational levels (question Q9).

Figure 5.39 shows that the majority of visitors in both regions are between the levels of graduated and post-graduated.

Finally, the results of the origin of visitors (question Q10), the responses were coded as Australia, Europe, Asia, Africa, America, and Nationals. Over half (69.9%) of visitors in Northern Taiwan were Nationals with 19% from Asia. While in Southeast Asia, displayed in figure 5.40, shows a clear pattern of diversity with more respondents from overseas. The chart below displays that from Europe, whilst from the rest of the world, Australians, Americans and Asians accounted for most respondents.

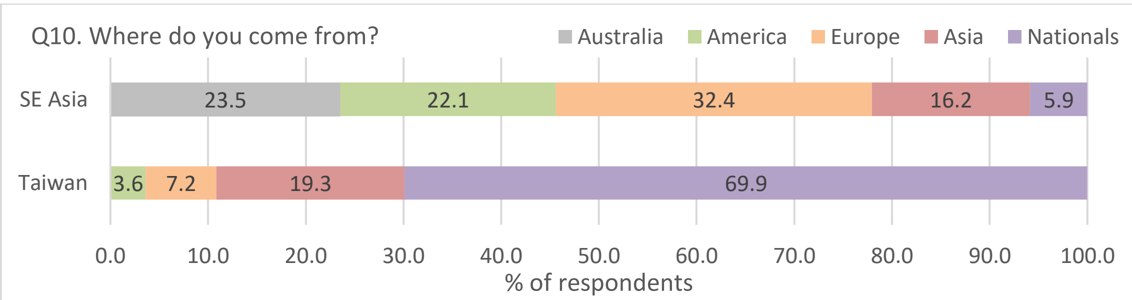


Figure 5.40: Respondents by origin of visitors (question Q10).

5.3.3. Summary of findings

As the preceding discussion evidences, a number of difficulties exist regarding the physical characteristics given to on-street visitors. The majority of respondents expressed their dissatisfaction with unexpected commercial activities taking place in these aged or historical buildings. Of course, visitors may not understand how the old street has developed over time, yet they are likely to be captivated by the story of the building and its layers of history which may be read through the fabric of the street. However, it appears shophouse buildings which are fully owned by the occupants, particularly those in the old or historic districts, were the most affected by a successful business. In general where people go, business follows. Also negatively the secondary matter of respondents expressed dissatisfaction with the lack of maintenance of existing shophouse buildings and this increases with increasing business activities. Most visitors seem concerned about the potential impact of modernisation issues of the historic districts. Positively, the majority of the respondents were happy to visit historic districts. Furthermore, the level of satisfaction rises in relation to good experiences of inner courtyard in traditional shophouses.

From the findings discussed, it can be concluded that the majority of old street visitors were in favour of the integration of the surroundings, thereby making it more attractive to business inflows. As stated in the above, cultural heritage tourism is a very significant generator of earnings for a district economy. The economic attraction of tourism for a historic street is that it leverages an existing set of local 'assets' to generate economic activity in that street. While the above findings are impressive, there is in fact some room for improvement in terms of the impact that tourism could have on the economy of the street. Only approximately 4.6% of visitors have mentioned that they would like to see changes and/or improvement on the space usage for tourism. However, this implies that they couldn't get adequate or suitable facilities on the street for their whole day visiting, especially in lack of travel information, visitor centre, and also the sanitation facilities at such tourist spots.

5.4. Courtyard Physical Survey

A local weather station of CWB (#C0C630-Daxi; 209m; 121.265547E, 24.882853N) was located inside an elementary school approximately 1.73km away from the case study shophouse building (Figure 5.41). It was mostly cloudy during each of the separate visits to collect data: the two-day (8th-9th August 2012) and the three-day (13th-15th August 2012) measurement periods. In addition, an iOS application called DaylightCal (iPhone Daylight Calendar), created by the Bureau for Visual Affairs, was used as a reference tool to show the quantity and quality (BVA 2012) of daylight on any given day and location, and what quality it would be. The live data, including sunrise/sunset, sunlight angle, annual light distribution, and a weather preview were displayed (Figure 5.42).

Figure 5.41: Satellite image showing the locations of Weather Station C0C630-Daxi (WS) and the Case Study Shophouse Building (CS). (Source: Central Weather Bureau, 2012; Google Map, 2015)

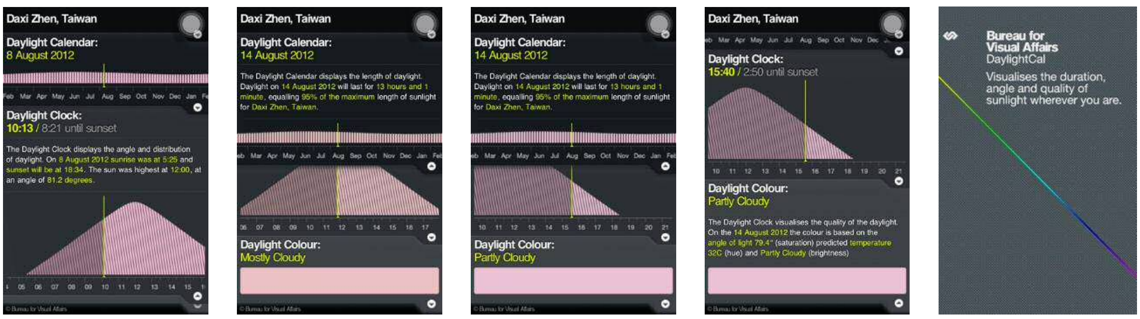


Figure 5.42: Examples of iPhone Daylight Calendar (DaylightCal) for visualizing duration, angle and quality of sunlight. (Source: Bureau for Visual Affairs, 2012, www.bureau-va.com/thoughts/ical)

5.4.1. Evaluation of Thermal Comfort

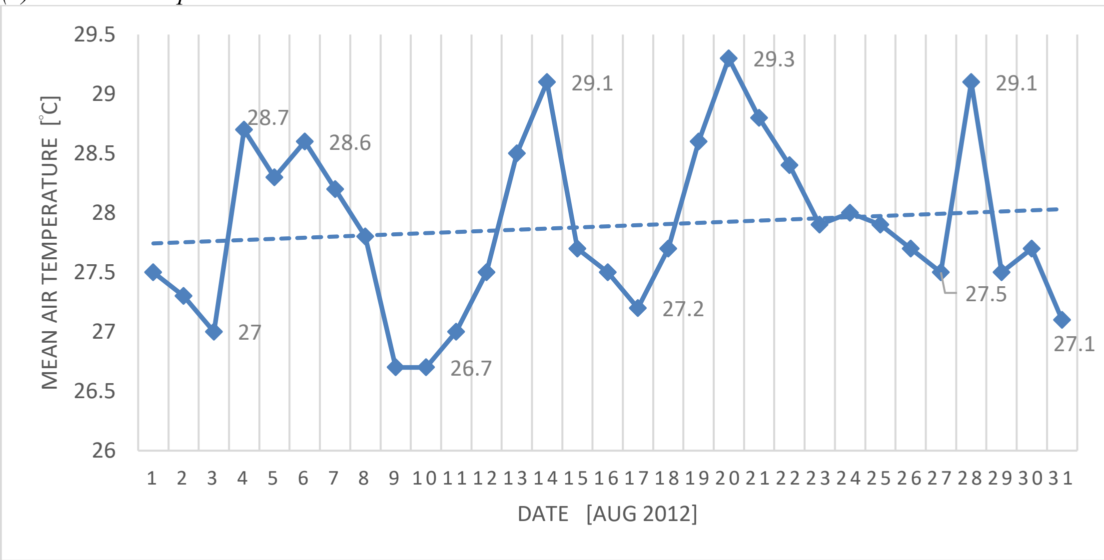
Figure 5.44 shows the temporal variations of major thermal variables that were measured in the front courtyard at a height of 0.7m above the floor (indicated in grey), and on the roof top of first building at a height of 0.3m above the ridge (indicated in red), during the totally five-day measurement period. Figure 5.43 shows the related data of history records in August 2012 from the local weather station C0C630-Dasi. As shown in history records (Figure 5.43.a), the daytime overall air temperature at Dasi Township reached a maximum temperature of approximately 28.6-29.3 ºC, and the air temperature at night had dropped slightly to approximately 26.7-27.5 ºC.

As shown in Figure 5.44.a, the outdoor air temperature in central courtyard was approximately 6-7 ºC lower than the immediate outdoor roof top temperature during the daytime. Any cooling effect caused by the tree in the front courtyard cannot be observed in this figure. The measured relative humidity was high throughout the day in the front courtyard, which is most likely due to transpiration of the tree in the front courtyard. The relative humidity at front courtyard during the day ranged from 45-65%, whereas the relative humidity at roof top was approximately 42-54%.

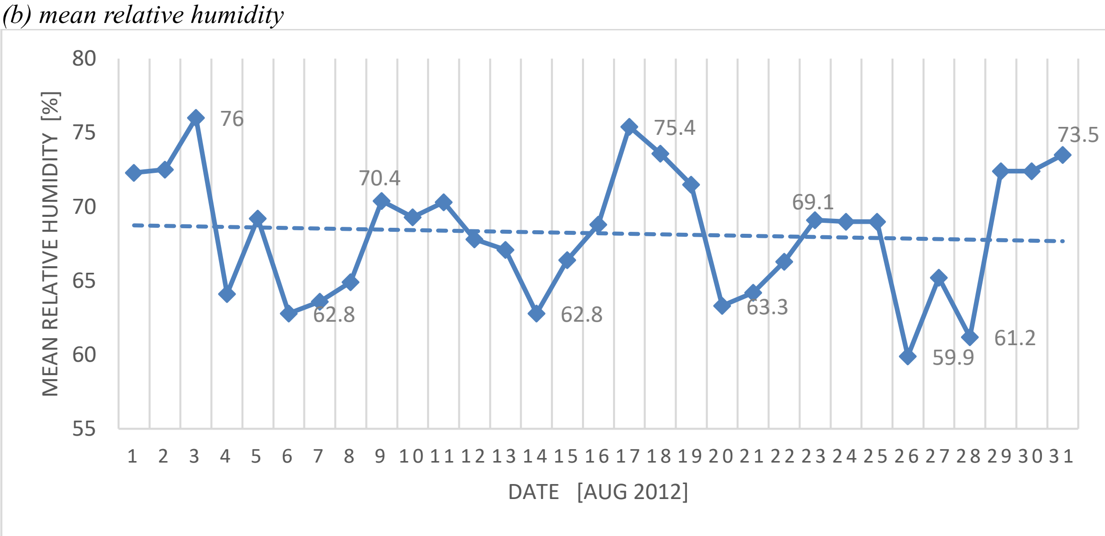
5.4.2. Wind Environment Profiles

The average wind velocities at the local weather station, which was located in an open space 2.1km far from the case study site, were approximately 1.3m/s to 4.5m/s throughout the month (Figure 5.43.c). Despite the outdoor wind velocities, the corresponding environmental air velocities around the shophouse building of both roof top and central courtyard exhibited quite clam conditions (less than 1.0m/s) throughout the daytime, except after 17:00. This result indicates that there was minimal cross ventilation, even if the exterior doors or windows were opened. However, the central front courtyard had steady stream of air flow, whereas the wind velocities at roof top difference in approximately 0.2m/s to 1.2m/s throughout the daytime.

(a) mean air temperature



(b) mean relative humidity



(c) mean wind velocity

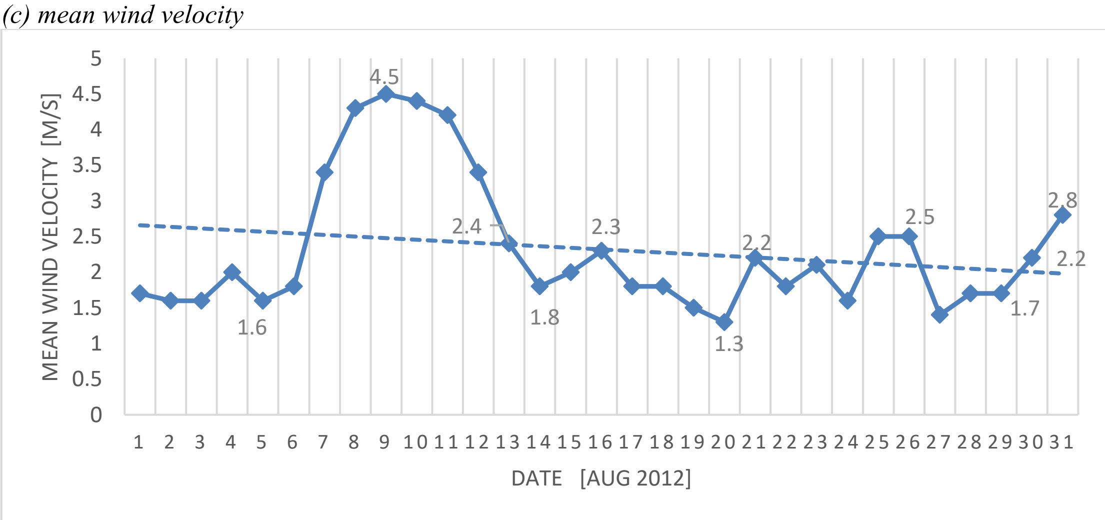
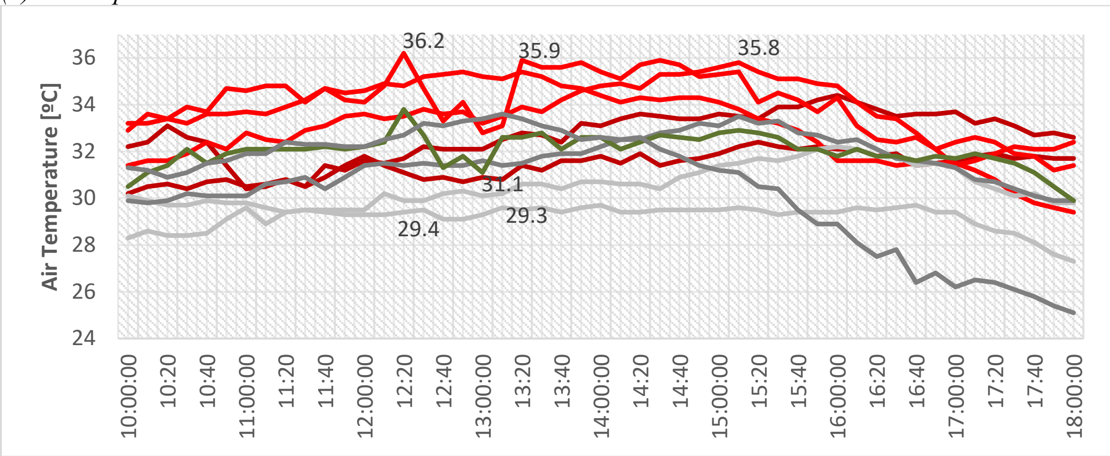
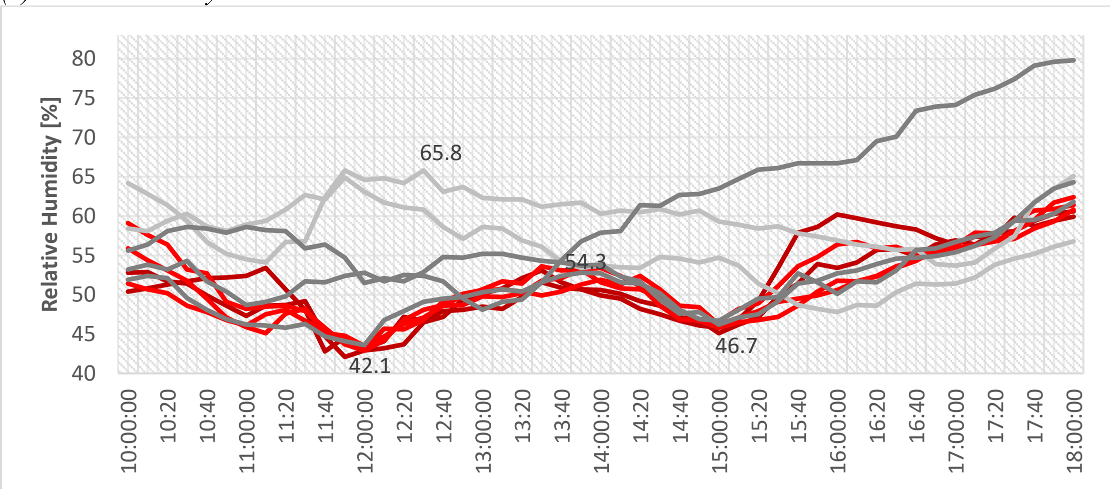


Figure 5.43: History records (August 2012) of major thermal variables from the local weather station C0C630-Daxi: (a) Mean Air Temperature; (b) Mean Relative Humidity; (c) Mean Wind Velocity. (Source: CWB, 2013)

(a) air temperature



(b) relative humidity



(c) wind velocity

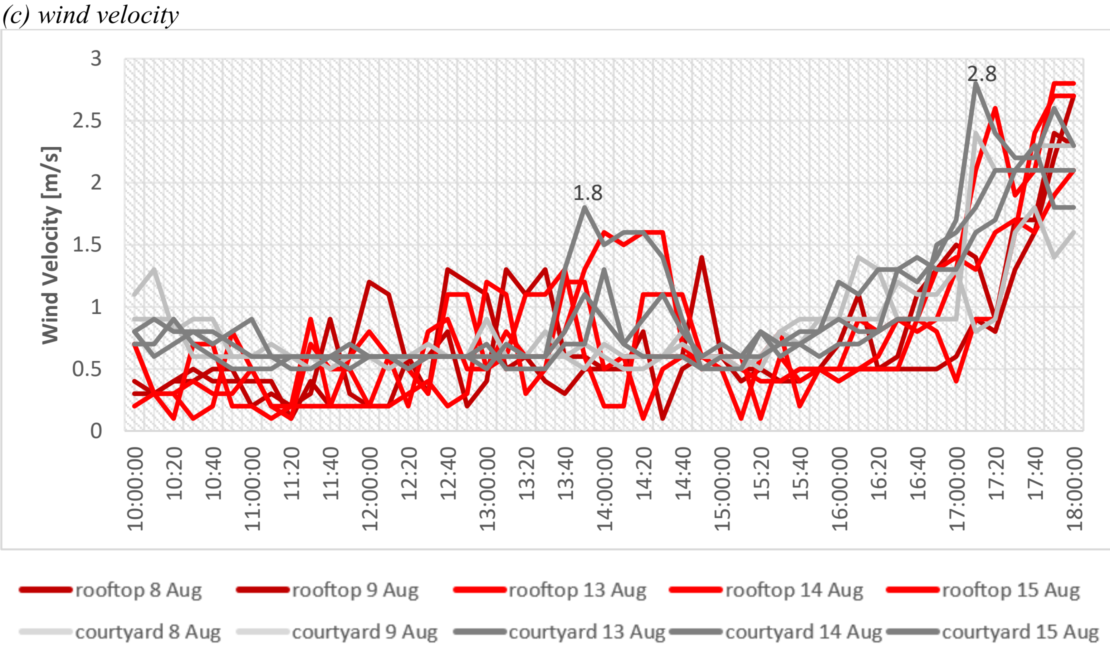


Figure 5.44: Temporal variations of major thermal variables in the area of field measurement: (a) Air Temperature; (b) Relative Humidity; (c) Wind Velocity. (Source: Fieldwork, 2012)

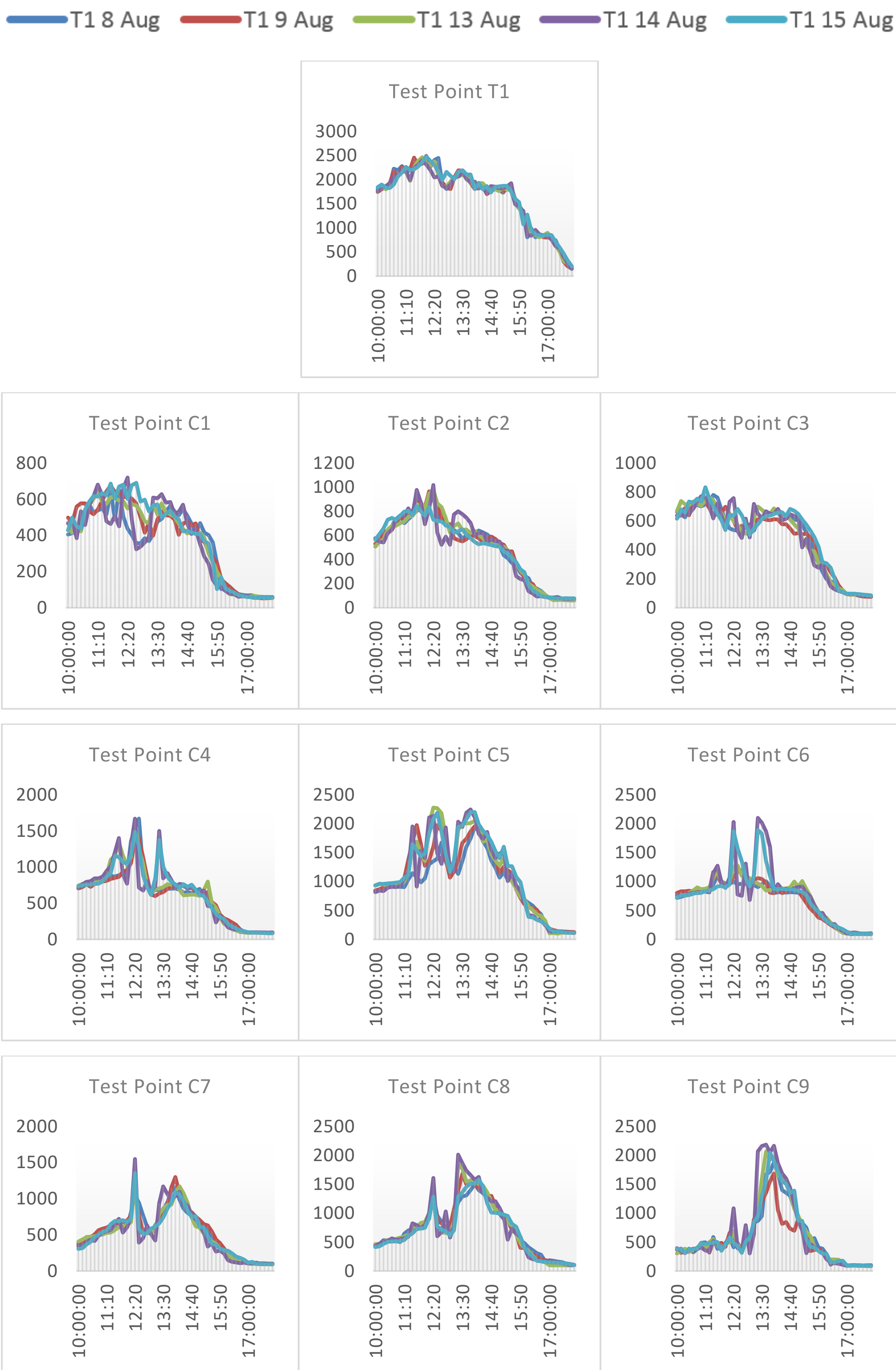


Figure 5.45: Illuminance on measuring points (lux). (Source: Fieldwork, 2012)

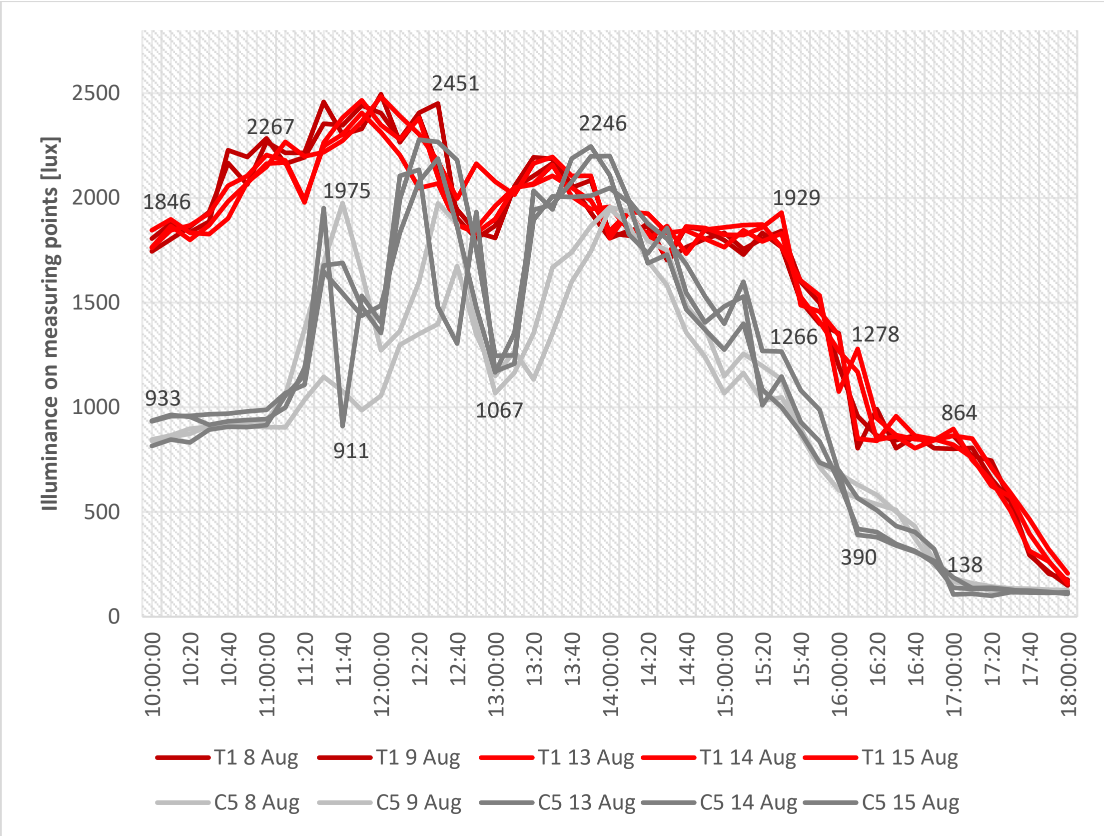


Figure 5.46: Differences of measured illuminance compared with the test points at ridge height (T1) and centre of courtyard (C5). (Source: Fieldwork, 2012)

5.4.3. Illuminance Distribution

The field measurement were conducted on August 8-9 and August 13-15, 2012, which were mostly cloudy days. To obtain the daylighting illuminance distribution in the whole front courtyard space accurately, the measurement grid size was set to be 0.9m by 0.9m (9 points planned in total). To reduce the influence of the changing solar angle during the measurement period, the measurement need to be finished in a short period time as much as possible. The measurement at each position lasted for 10 sec to get a stable illuminance reading and one complete measurement of the whole courtyard need to take about 4 minutes. All the measurements were conducted in the horizontal plane, looking upwards, at a height of 0.7m above the stone floor.

Figure 5.45 shows the outdoor illuminance level on the measurement days. As shown in Figure 5.46, the outdoor illuminance at the ridge height (test point T1) increased gradually from 10:30 to 11:30 and reached maximum of 2.4×10^3 lux between 12:00-13:00. Then the outdoor illuminance remained stable from 13:30-15:30, and decayed rapidly from 15:40 to the lowest value of less than 200 lux at 16:00. Another grid point (C5) in central courtyard was approximately $0.8x10^3$ lux lower than the immediate outdoor roof top (T1) illuminance from 10:00 to 11:00. Then all the 9 test points in front courtyard ramped up and down quickly from $10x10^3$ to $20x10^3$ lux between 11:30-13:30, and decayed rapidly from 14:00 to the lowest value of less than 100 lux at 16:00.

5.4.4. Conclusion of testing results

This study investigated the outdoor microclimatic conditions caused by daylighting and ventilation in a small courtyard space of domestic building by experimental measurements. The related numerical simulations will be established in Chapter 7 and Chapter 8, which focus on the different configurations of traditional shophouse: single-storey, double-storey, and three-storey shophouse architecture.

Outdoor air temperatures in central courtyard were approximately 6-7ºC lower than the immediate outdoor roof top temperatures during the daytime. From this vertical layout, the temperatures at the lower levels were well cooled by the tree and wet ground surface, which presumably augmented the above temperature gradient. This temperature gradient caused thermal stratification in the above courtyard and discouraged vertical air exchange. However, the temperature was not observed at night. The measured relative humidity was high throughout the day ranged from 45-65% in the front courtyard, which is most likely due to transpiration of the tree and/or plant in the front courtyard. This results indicates that the front courtyard functioned as a cooling source to the surrounding interior spaces.

Wind velocities around the shophouse building of both roof top and central courtyard exhibited quite clam conditions (less than 1.0m/s) throughout the daytime. The main problem is that the high density of buildings reduces airflow at the ground plane as compared to that of a rural area. However, the central courtyard had steady stream of air flow in approximately 0.6m/s, whereas the wind velocities at roof top difference in approximately 0.2m/s to 1.2m/s throughout the daytime. In general, in urban areas the wind is divided into an area of free-running air above the average building height and restricted airflow is found at the ground plain. In this way 'wind shadow' occur where wind is forced over buildings (Givoni 1976).

The illuminance level near the centre of the front courtyard is much higher than perimeter area, due to no external shadings are provided to the centre area and daylight directly enters the space. All the horizontal test points at courtyard ramped up and down quickly in difference of $10x10^3$ lux between 11:30-13:30, which is most likely caused by the surrounding height of party walls and buildings. Both test points T1 and C5 had the similar trend after 13:30, whereas the biggest difference appeared from 11:20 to 13:20.

5.5. Summary

It has been found that the courtyard shophouses in this urban fabric were always good examples for the bioclimatic typologies where their residents could enjoy the outdoor daylight and fresh air with a minimum of energy use while not being separated from their climate and culture. A courtyard open to the sky is an interesting design feature in most old town shophouses. However, the occupant survey report shows that traditional shophouse occupants are taking some actions to expand their interior use or changing something for special needs. As well, they are concerned about the impacts of courtyard openings, with greatest worried about strong sunlight and wind. People in Taiwan are also worried about the effects of worse maintenance on their buildings and the quality of lives of future generations. In contrast, the majority of old town visitors were in favour of the integration of the surroundings, especially within the inner courtyards. Over 60% of the respondents in both Taiwan and Southeast Asia were wish to get the inner courtyard access.

6. Methodology – Modelling: Designing and Evaluating Change Responses

As shown in previous chapters, the majority of studies regarding early shophouses have not discussed the implications of changes in the use of the inner courtyards. In order to do this effectively, it is necessary, therefore to consider not only the natural-climatic, but also economic, and functionality factors, as well as to consider the built space that surrounds the courtyard, in terms of its parameters and improvement. The literature, discussed in Chapter 3, has been shown to address the difficulties that surround the future of traditional shophouses more broadly; however, little is known about how the occupants' needs have changed over time, especially in terms of the implication of these changes on the desired or required physical environments. The application area of this study therefore draws together two distinct trends which have, as their basis, fundamentally different disciplines: conventional design and ecological design. This chapter will describe the methods of digital modelling used for both areas and how they will be brought together here to inform this research: to develop a clear understanding of what the requirements are needed for change and what action might be needed to respond to the issues that may arise.

6.1. Research questions

Architectural design is diverse in nature as well as application-oriented, and it is difficult to just discuss it abstractly. The case study allows us to specify the decision processes as well as the multi-faceted and holistic problems, and focus in detail and depth on the domain problem without losing applicability (Hamel *et al.* 1993; Yin 2011; Yin 2013). The case study method used here is a descriptive bottom-up approach of understanding the problem through tracing various regions' designs in traditional shophouses. The descriptive case study looks at the spatial forms and relationships of factors leading to uses. Based on the extensive arguments put forth by Yin (2011) and Hamel *et al.* (1993) for the strength of the general case study, we assume that we can learn and make generalizations from the understanding of designs and decisions from the general case.

The case of traditional shophouses, in general and specifically in Southeast Asia, is used to understand how and why architectural design is done and the characteristics of the problems associated with these cases. The case of old and traditional shophouses in Southeast Asia is chosen because it is an example of design practice that is rich with information about the context, design work, practical thinking, as well as successes and errors in design suitable for the research discussion. Also the understanding derived is applicable to the practice of design in many rapidly developing countries in the region that share similar concerns and conditions of practice.

The case is studied in two parts. The first part of the case is a preliminary case study to review the various paradigms of practice in Taiwan to understand the general practice, the real estate builders' dependency on pre-parametric and qualitative design thinking, and the problems (as discussed in Chapters 1 and 2).

The second part is the case study of a specific building project, which was designed and completed by an architectural practice that is committed to producing responsive tropical design. The findings on the preceding entities and properties, and the analysis of the problems of design errors in relation to possible biases will be discussed in detail in Chapters 7 and 8.

The positive features of daylight and the creation of interesting spatial features, such as the courtyards in shophouses is something that lends itself well to a historic building setting. Notable examples of such buildings throughout Southeast Asia include: George Town of Penang and Malacca Town in Malaysia, Singapore's Chinatown, and the traditional and old town centres in Northern Taiwan.

6.2. Traditional shophouse case studies

Stake (1995) suggests that a case study is useful when the 'opportunity to learn is of primary importance.' A case study approach provides a mode of inquiry for an in-depth examination of a phenomenon. Yin (1994) characterizes case study research as empirical inquiry that:

i) investigates a contemporary phenomenon within its real-life context;
ii) when the boundaries between phenomenon and context are not clearly evident; and
iii) in which multiple sources of evidence are used.

For this study, a multiple case studies method is adopted. The reason for adopting multiple case studies is to add confidence to the emerging theories. Herriott and Firesstone (1983) assert that the evidence from multiple cases is often considered more persuasive, and the overall study is thus regarded as being more robust. Deciding on the number of cases deemed necessary or sufficient for multiple case studies research, Yin (2011) contends that greater certainty lies with large number of cases for theoretical replication purposes (where more cases selected on the basis of predicting contrasting results).

However, if the issues at hand do not demand detailed study as a result of an undue degree of certainty due to an underlying priori themes backed by existing theories, then the selection of two or three multiple cases for literal replication (in which similar conditions or criteria are used to guide the selection of cases in order to predict similar results) could be warranted. Prior to conducting the case studies for this research, exploratory interviews with shophouse occupants were conducted to help strengthen the initial theoretical framework and to augment the case study data collection and analysis.

It was decided to stratify the selection of the case studies based on the following:

A traditional shophouse building, or an attached multi-storey shop or housing unit contained in long building rows of the same variety.

This type of building incorporating at least one open courtyard without any kinds of roofing or covers, and

Access to the full set of construction drawings and material specifications for the whole building, so that accurate digital models in simulation software can be built.

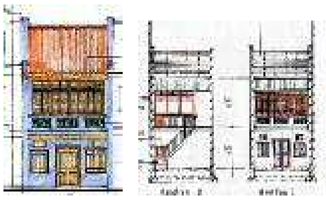
All three buildings should also be real building examples and, as such, their current design or usage should be dictated by the needs of the occupants. Also, the applicability of results obtained from these case studies should be limited to similar type buildings, in term of size, form, construction, and location.

The following buildings (Figure 6.1) were therefore selected as case studies for this work:

1. One-storey shophouse building: 88 Hoping Street, Daxi, Taoyuan, Taiwan (in-situ data collection)
2. Two-storey shophouse building: 26 Church Street, Georgetown of Penang, Malaysia (recorded literature)
3. Three-storey shophouse building: 20 Amoy Street, Chinatown of Singapore (recorded literature)

a) 1-storey: 88 Hoping Street, Taiwan
(Source: on site measured by author, 2007)

b) 2-storey: 26 Church Street, Penang
(Source: Penang Heritage Trust 2009)



c) 3-storey: 20 Amoy Street, Singapore
(Source: URA, Singapore, 2008)

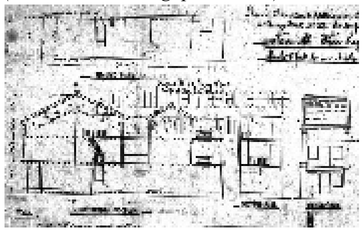


Figure 6.1: Building selections for case studies.

These shophouse occupants, owner occupants, and organizations agreed to participate in the research:

the single-storey building, agreed by Mr. Liu, Qing-Ke (Daxi);
the double-storey building, agreed by Ms. Lin Lee, Loh-Lim, the Council Member of Penang Heritage Trust (Penang);
and the three-storey building, agreed by Ms. Tan, Mee-Ling (Singapore).

The final selection of case studies maximized either the potential for in-situ data collection and/or sources of recorded literature to inform this research. In addition, they were intended to provide the chance for interesting comparative study. This is one of the main thoughts behind including the one-storey shophouse in the selection which, despite its similar function, is obviously different from the other two examples at George Town of Penang and Singapore's Chinatown in terms of its scale. It will be interesting to see how the different scales of the inner courtyards affect the daylight performance and the introduction of natural ventilation.

(a) Dasi

(b) Penang

(c) Singapore

Figure 6.2: Multiple case studies: (a) No.88 He-Ping Road, Daxi Township; (b) front courtyard view of No.26 Church Street, Georgetown in Penang; (c) No.20 Amoy Street, Chinatown in Singapore. (Source: Photographs taken by author, 2008-09)

The three case studies will now be explained in further detail. In each case there is information about the history, function, structure, daylight control and natural ventilation, all of which are key contextual factors that will be used to help draw conclusions from the data obtained from monitoring and computer analysis later in the project.

6.2.1. Case study 1: Single-Storey Shophouse at Daxi Township in Taiwan:

He-Ping Road No.88 (Figure 6.2A) is also the case study building used in section 5.3 for field measurements. As mentioned earlier, the owner occupant contributed to this study in many ways, including the user and visitor questionnaires, measurement of existing building, and field tests. One part of the building was adopted to become a carpenter’s workshop and a showroom of Liu & Liu Studio. The historic building’s interior was re-arranged to combine both the production functions and the sales area at the front hall. This one-storey shophouse building is recorded to have been constructed more than 130 years ago around the 1880’s. In 1919, during the occupation of Taiwan by the Japanese Colonial Government (1895-1945), those in power instituted a city re-structuring plan in Daxi to broaden the roads. As a result, part of the shophouses facing the roads were torn down; therefore, the residents were obliged to build new facades for their houses. Thus, the façades of the arcades (similar to the archways built in temple fairs in the old days) came into being.

6.2.2. Case study 2: Double-Storey Shophouse at Georgetown of Penang in Malaysia:

According to a Penang based architectural firm, the Tan Yeow Wooi Cultural & Heritage Research Studio (Tan and Fujita 2014), Church Street No.26 (Figure 6.3B) is believed to have been constructed more than 140 years ago around the 1860′s. It housed an early-mercantile establishment in the island port settlement, and is especially important as an example of a very early shophouse prototype. As a permanent home for the Penang Heritage Trust, construction was achieved through the fund-raising efforts of its members and friends, as well as generous donations from the Penang State Government, the Malaysian Ministry of Tourism, the Malaysian Ministry of Culture, Arts & Heritage and a supportive corporate sector. This office also provided this study for the full set of constructions drawings.

6.2.3. Case study 3: Three-Storey Shophouse at Chinatown in Singapore:

Approved building plans from 1892 and related images were found and provided by the National Archives of Singapore (NAS 2008). As one who has always had an appreciation for culture and heritage, the owner occupant saw this shophouse building, Amoy Street No.20 (Figure 6.3C), as the perfect place for a renovation and restoration project that would combine modern elements with heritage. Ms. Tan's mother brought the shophouse more than 20 years ago and she took over the property a few years ago. However, in order to increase their household income, she decided to rent out on the ground floor – the shop section.

Figure 6.3: Front elevations and longitude sections of the multiple case studies from: single-storey shophouse at Daxi Township in Taiwan (top); double-storey shophouse at George Town in Penang (middle); three-storey shophouse at Chinatown in Singapore (bottom). (Source: Illustration by author, 2008-09)

These case studies (Figures 6.2 and 6.3) inform the outline questions to consider when testing the performance of the courtyard(s) and described some of the advantages and limitations of the three common types of traditional shophouse architecture.

Figure 6.3A: General plans of single-storey shophouse at Daxi Township, Taoyuan County, Taiwan. (Not to scale drawings)

Figure 6.3B: General plans of double-storey shophouse at George Town of Penang, Malaysia. (Not to scale drawings)

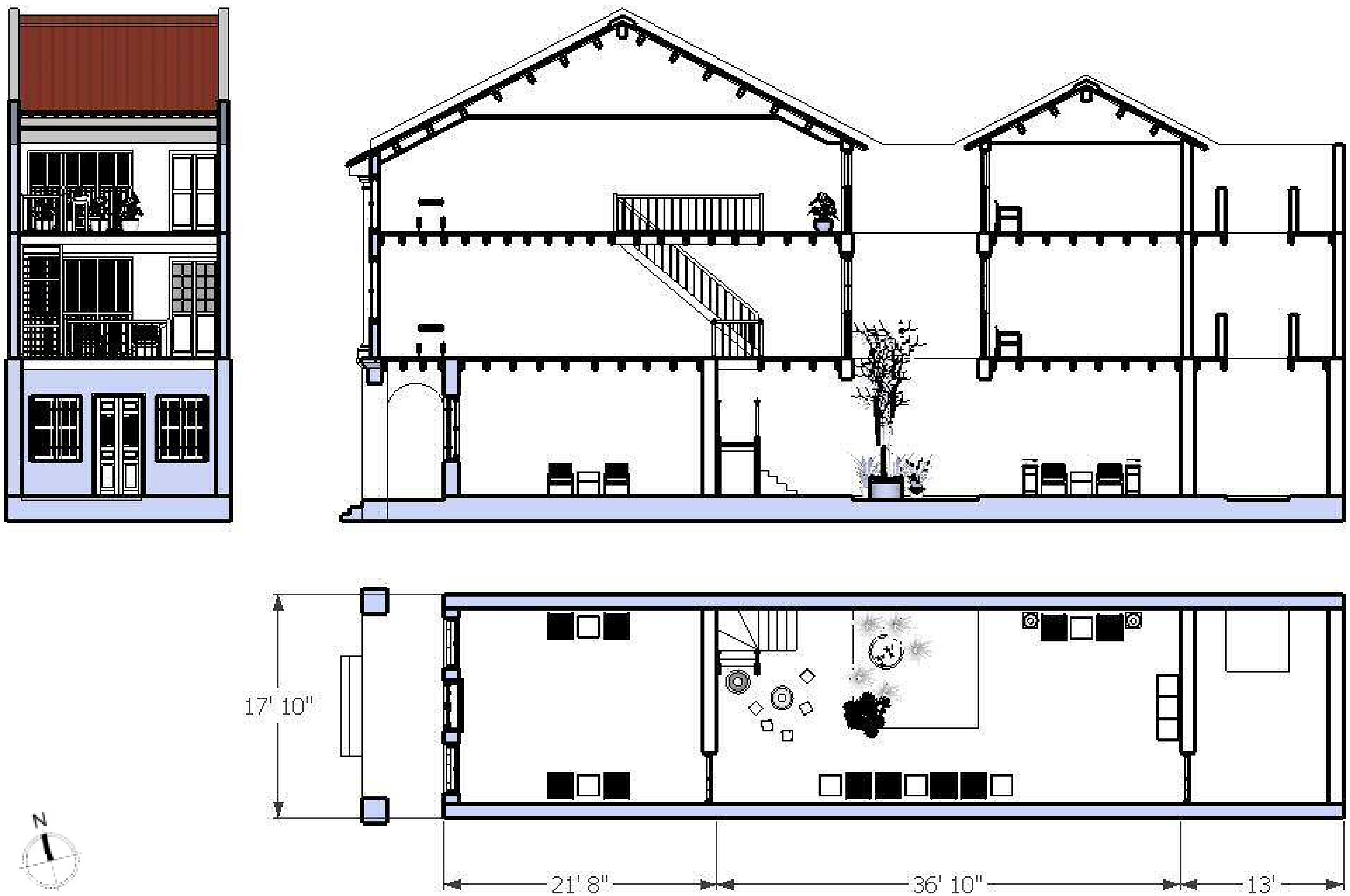


Figure 6.3C: General plans of three-storey shophouse at Chinatown in Singapore. (Not to scale drawings)

6.3. Phase 3: The modelling design and implementation

In this phase of the study, the research was performed through the simulation analysis of the selected shophouse physical environments in order to create data on the mechanisms of natural lighting (Chapter 7) and ventilation (Chapter 8) focused on each of the shophouse case studies' first courtyards. Following the review of the traditional functions, this study was interested in how occupants make sense of their lives, interpret experiences, and structure their social world within the courtyards. This approach was exploratory and focused on discovery. It collected data through a variety of techniques and then used a modified inductive analysis, in conjunction with the courtyard model as an analytical tool, as well as to identify and characterize important interrelationships in the phenomenon. The results of this synthesis of ideas are presented in Chapter 9.

6.3.1. Solar analysis and illuminance modelling

In order to conduct the natural lighting analysis Radiance lighting model was used. Radiance is a freely available radiosity-based lighting simulation programme that uses a backward ray-tracing process for simulation. It was developed by Lawrence Berkeley Laboratory (Ward *et al.* 2011) and its accuracy in lighting illuminance modelling is well established as it has been validated in 20 years ago (Ochoa *et al.* 2012; Clifford and King 1993). Radiance requires the 3D geometric information of a model to be provided as a text file, usually derived from other software. Radiance is capable of handling complex geometries and there are no limits imposed by the software on what can be modelled.

In this study, SketchUp Pro was used as the primary modelling tool and Autodesk Ecotect Analysis was used to setup the geometries to be utilized by the software. Autodesk Ecotect Analysis provides a comprehensive exporter for Radiance and also allows the importing of Radiance results back into Ecotect Analysis for visualization. Furthermore, it allows for the specification of custom grid points for calculating lux levels in a room and it is not bounded by any geometrical limits.

6.3.2. Computational fluid dynamics simulation

In this study, DesignBuilder was used as the primary modelling tool. DesignBuilder offers a rapid model-building OpenGL interface combined with a 'full-featured user interface to EnergyPlus HVAC' (EnergyPlus Energy Simulation Software 2012). The key to DesignBuilder's simulation capabilities is the integration of the EnergyPlus calculation engine. Critically for this analysis, DesignBuilder also offers true 3-D CFD capability tailored specifically to the needs of the construction industry, but at a fraction of the cost of the leading general purpose CFD codes, and with an easy-to-learn and easy-to-use interface (EnergyPlus Energy Simulation Software 2012). This made this a viable and repeatable method for application in this study. Various aspects of building design can have a significant effect on local wind velocity and in some cases can result in unacceptable levels of pedestrian comfort.

External wind analysis can be conducted with DesignBuilder CFD, which uses ASHRAE wind profiles to determine wind velocities at different heights above ground (EnergyPlus Energy Simulation Software 2012). CFD results can be displayed within rendered images of the building model. The display tools include 3D velocity vectors, linear and filled contours, and 3D contours.

6.4. The role of courtyards

As mentioned in the Introduction, early shophouses are currently understood to be struggling between traditional and modern approaches to their environmental functioning, with those approaches having significant normative outcomes. These opposing approaches are supposed to reflect how the reuse of inner courtyards. Nowadays, people are more concerned about the image of the house than the integration of spaces within it. The reorientation of the house to the street has caused a shift in the focus from the central space to the front facade. In this way the courtyard becomes less useful as a symbol of status and may potentially be perceived as an unwanted and wastes space. Therefore, what should the role of traditional shophouse courtyards be in the future?

6.4.1. Specification of the courtyard function

Traditionally, the courtyard appeared as a result of the necessity to protect the human body from the harmful effects of thermal factors. These factor, especially in Northern Taiwan, enable the shophouses to promote benefits from the cool northern winds and protect the adjacent spaces from direct solar radiation. The introduction of such an element creates the comfortable and suitable conditions for any activities. The courtyard circulates the air protecting the inhabitants from harmful effects of stormy winds and hot weather. The courtyard also casts shadows from all sides and is surrounded by a shaded pathway, which shades the walls and the spaces arranged behind them by preventing them from overheating. Through simulation of lighting and ventilation, we can review and rethink the functions of a courtyard in the micro-climate of the shophouses.

6.4.2. Addressing the valuation of the *change* aspect of the motivations

Next to physical factors, flexibility in design is essential for successful housing, such as provided by a shophouse. Flexibility in the use of architectural styles or in the application of personal taste is made possible within the framework of the structural system and layout of the shophouse. Flexibility also includes the ability to personalize one's dwelling. Creative and intelligent design can allow individual units to be added to (vertically or horizontally) or be modified over time as the occupant's needs change.

Due to the change from joint to nuclear families, the new space for 'family living' shifts to the bedrooms or in some cases the living room. The housing policies have imposed small plots where the introduction of the courtyard is difficult and cuts out space from other functional spaces which are may valued today. In addition, the individualization of rooms, as a modern way of living, weakens the need for an internal space for a collective family life. In terms of comfort, people refuse to cross the open space – the courtyard – in order to move from one place to another, preferring shorter, sheltered, air-conditioned transition spaces provided in modern houses.

This study was therefore concerned with the 'what' and 'how' questions about the *change*.

6.5. Approach

In that hypothetical situation, this study is interested in using the knowledge gained from the simulations of lighting and ventilation, and the inferences inductively learned from the case studies of Southeast Asia, to make a prediction that a subsequent sample – a design selection. Various specific events were examined to determine the underlying commonality in all of them. The study supposed an explanation that could account for the various phenomena, such as solar access and airflow pattern, and then examines each phenomenon to determine if it supports or refutes the hypothesis: which is visual comfort and thermal comfort.

The findings of this study will be evaluated for their reliability, implications to practice and architectural design education. It will also be evaluated across other design disciplines to explore whether the theoretical interpretation holds and where the limits are. Suggestions will also be made for further investigation into the various aspects of the domain of cognitive psychology and architecture. The details of these will discussed in the final chapter (Chapter 10). The step-by-step procedure of the entire study is referred to in Chapter 2.

7. Courtyards in Daylight: Solar Analysis and Illuminance Modelling

The visual environment plays a significant role in the health, mood and productivity of occupants. Le Corbusier (1957) strongly advocated that, 'Each dwelling must have a set amount of hours for daylight to enter'. Daylighting is the most pleasant, economical and ecological source of energy for buildings (Ander 2003) and is an important measure of building comfort. However, people of Southeast Asia have successfully adapted themselves to the stresses and strains imposed upon them by the region's harsh environment: they have adjusted their daily life cycle so as to avoid unnecessary activity during hot periods of the day. Users in this context would therefore benefit from a daylighting system designed to provide enough daylight without any undesirable side effects (ABSIC/CBPD 2004); heat transfer through the window; glare; and variation in daylight level shall be carefully balanced.

As explained in the previous chapter, three major types of traditional shophouse courtyards have been theoretically examined, using computational tools, Radiance-based simulation with Autodesk Ecotect Analysis, solar tools, and weather tools to conduct daylighting analysis. Measurements made during field work from the Daxi case study helped to inform an understanding of how the different forms impact on architectural daylighting. With the help of these results, suggestions are made in the following Chapters on how to reform existing courtyards in a corresponding architectural language to provide modern daylighting needs of occupants: in response to lifestyle; and modifications suggested and informed by both the occupant surveys and literature.

7.1. Introduction

Unwanted solar gain can be one of the tradeoffs associated with using natural light, and should be considered in any complete daylighting analysis. It has the greatest potential of all other climate responsive strategies to affect the thermal performance of vernacular buildings. Wyon (2000) said that '*the user must understand the way that the building works and the consequences of their actions, so they must be given insight*'. This being the fact in most shophouse courtyards, it is not difficult to find similar modifications of the original (Figure 7.1), to better meet the occupants' lighting needs. Leaman and Bordass (2007) argue that occupant comfort and comfort-related behaviour can impact on building energy and environmental performance, particularly in green buildings which are thought to be '*more fragile in their performance*,' where it is '*more important that everything works all together.*' Further, Cole and Brown (2009) state that '*while the availability and use of personal controls was found to be higher in green buildings, the quality of personal control in terms of responsiveness, the absence of immediate and relevant feedback, and poor user comprehension may have lead to sub-optimal comfort conditions.*'

(a) side courtyard *(b) movable device*

Figure 7.1: Example of modification: mechanical device installed at the side courtyard in the building of Penang Teochew Association, George Town of Penang, Malaysia. (Source: Interview and photographs taken by author, 2011)

There are three main desirable impacts resulting from allowing people to adjust illumination (Boyce *et al.* 2002). People's preference to be able to lower the illumination level rather than working under fixed lighting contributes to energy savings and reduced utility costs. Different illumination levels required for different tasks can be met by user manipulation. Boyce *et al.* (2002) also showed that users' moods may be improved by being given illumination control. Compared to the late 19th century, the nature of courtyards in traditional shophouses has changed dramatically, especially in the context of the proliferation of modern and powerful mechanical facilities. The courtyard lighting environment must now continue to meet a variety of needs based on the nature of use and/or work, e.g. living-based, dinning-based, small group gathering, and other type of tasks.

7.1.1. Climate conditions in Peninsular Malaysia and Taiwan

In order to explore the lighting context in Shophouses in greater depth it is necessary to understand the climate conditions in which they occur, where Southeast Asia (Figure 7.2) is particularly vulnerable to weather and climate extremes.

Differences in economic level, population density, urbanization, technological capacity and physical geography mean that some regions may experience more severe impacts than others. Within the next century, increased temperature and, in many regions, extreme rainfall events are expected on a sub-regional scale (Met Office 2015). According to the Köppen-Geiger Climate Classification (Wikipedia 2014), all three study locations have a humid climate. Both Penang and Singapore are in equatorial fully humid (Af) classification, and Daxi Township at Northern Taiwan is in the warm temperate fully humid and hot summer (Cfa). The following presents a brief description of the climate conditions in the three study locations.

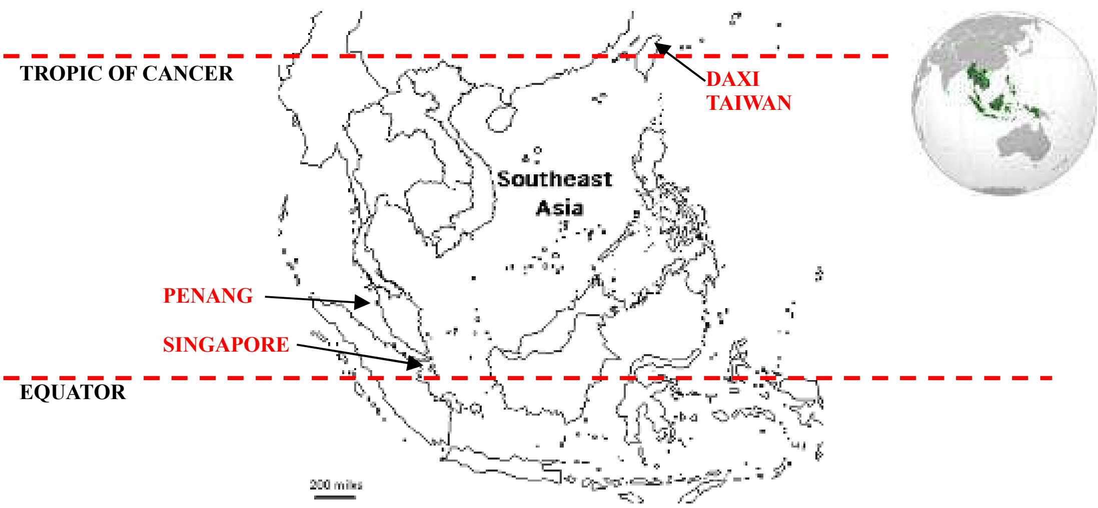


Figure 7.2: Map of Southeast Asia and the three study locations of the traditional shophouse.

The island of Penang is located off the northwest coast of Peninsular Malaysia. The climate in George Town, Penang, is generally hot and humid throughout the whole year. However, being on an island, the temperature within the city is often higher than on the mainland; sometimes reaching as high as 35°C during the day. Temperature ranges from 29°C to 35°C during the day and from 26°C to 29°C during the night, with the months June to August being the hottest (Figure 7.3a). Sunshine levels average at around eight hours per day for most of the season. Due to its proximity to Indonesia, all of Malaysia is prone to the phenomenon known as 'the haze', as winds carry over ash particles from the forest fires of Sumatra, where the sun can hide behind a muggy grey sky for days (MMD 2014).

Singapore lies between Malaysia and Indonesia, the weather is warm and humid all year round. Due to its geographical location and maritime exposure, its climate is characterized by uniform temperature and pressure, high humidity and abundant rainfall. The average temperature is between 25°C and 31°C. Thunderstorms occur on 40% of all days (Figure 7.3b). Relative humidity is in the range of 70% – 80%. April is the warmest month, January is the coolest month and November is the wettest month (NEA 2014).

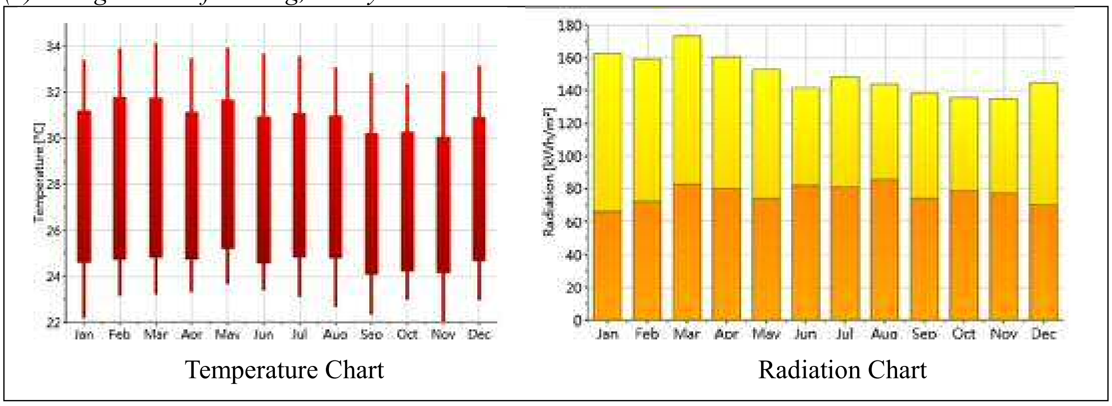
The weather in Southeast Asia is also somewhat predictable: due to the relative proximity to the equator. Thus, in summer the sun moves slightly to the north and in the winter slightly back to south, but without much change in the distance: while most places experience two distinct seasons: wet and dry. Further, times for sunrise and sunset in Peninsular Malaysia don't differ much throughout the year, with up to 12 hrs 20 mins at the longest days, in June. While in December a night in Kuala Lumpur lasts almost 13 hours.

The Tropic of Cancer runs straight through the middle of Taiwan bringing with it tropical and subtropical weather. It typically presents an average temperature of 22°C all year round (Figure 7.3c). There is no severe cold in winter and no brutal summer heat. The annual average temperature of the northern part is around 21.7°C while is around 24.1°C in the southern part. The coldest months are from January to March with the lowest temperature to about 10°C. In some rare cases, there will be frost or snow on the high mountain. The hottest months are from June to August with the highest temperature up to around 38°C. The average temperature of the rest months is around 25°C. Taiwan is a humid region. The northern part, middle mountain area and western plain are abundant with rainfalls in different periods. June to October is the typhoon season in Taiwan, with July to September offering the most activities to experience. The months with the most rainy days are in plum rain season in May and June while thundershower mostly came in the afternoons in summer (CWB 2014). The times of sunrise and sunset in Taiwan are influenced by the country's moderate northern position in the hemisphere. The days in summer are long and in winter short. With just over 13 hours on the longest days are in June; while the longest dark nights happen in winter, where in December a night in Taipei lasts almost 14 hours.

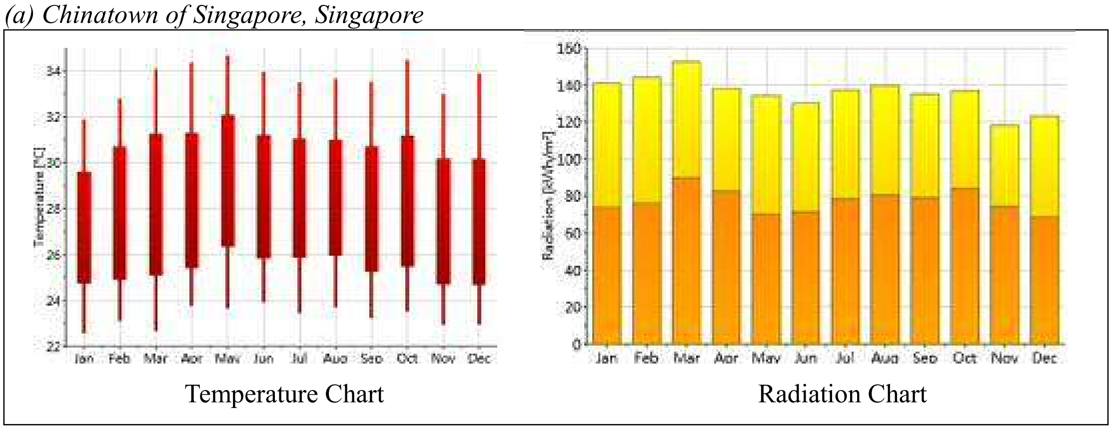
All the three locations' sunshine levels average at almost 13 hours per day during the summer time. Rainfall is almost an everyday phenomenon in Peninsular Malaysia, even during the non-monsoon period. These brief showers are usually quite refreshing, as they provide respite from the sun.

In comparison, Taiwan is always in a warm to hot environment during daytime. The number of hours of sunshine has an inverse relationship with the degree of cloudiness. That is, the accumulation of clouds shortens the day. Less sunshine is seen in the mountains than on the plains, and less on the east coast than the west. While rainy days prevent Taipei from getting much sunshine, the southwestern city of Tainan enjoys 2,649 hours of sunshine a year, seven hours a day on average (CWB 2015).

(a) George Town of Penang, Malaysia



(a) Chinatown of Singapore, Singapore



(a) Daxi Township, Taoyuan County, Taiwan

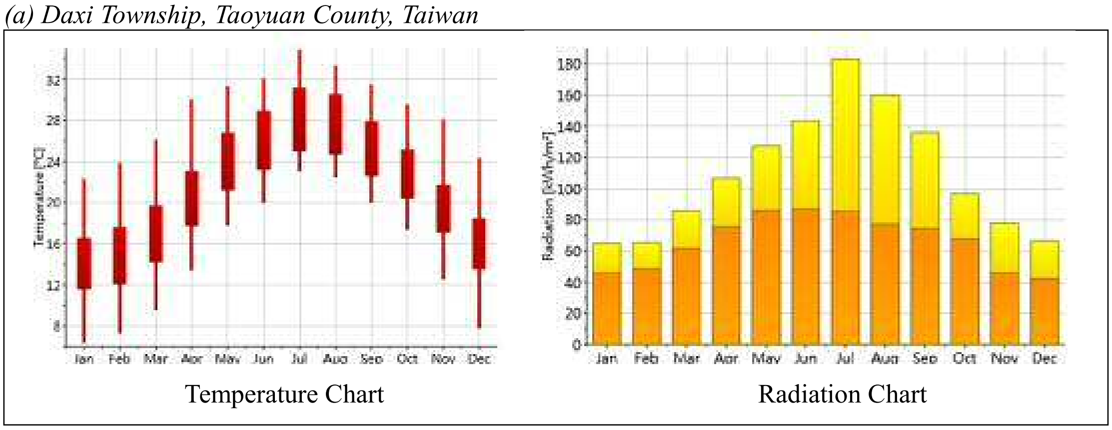
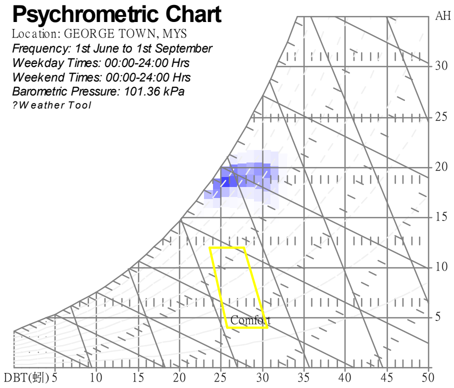


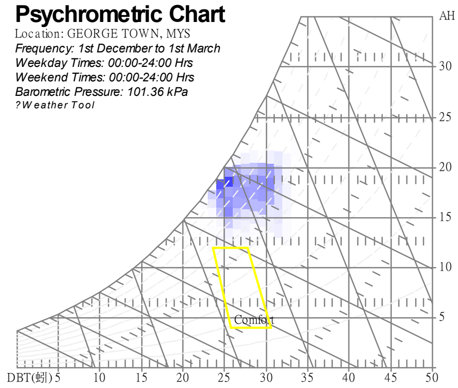
Figure 7.3: Data charts for the three study locations: (a) George Town of Penang; (b) Chinatown of Singapore; and (c) Daxi Township in Northern Taiwan. (Source: Meteonorm, 2014)

Psychrometric charts describe the relationship between dry-bulb temperature, and relative humidity, on the horizontal and the vertical axes respectively. The Thermal Comfort Zone is defined according to temperature and relative humidity, as well as the occupants' characteristics such as clothing and activity level. The psychrometric charts reproduced below reflect the natural absence of outdoor comfort zones, where the climates can be seen to lie outside the comfort zone when plotted for both summer and winter (Figures 7.4).

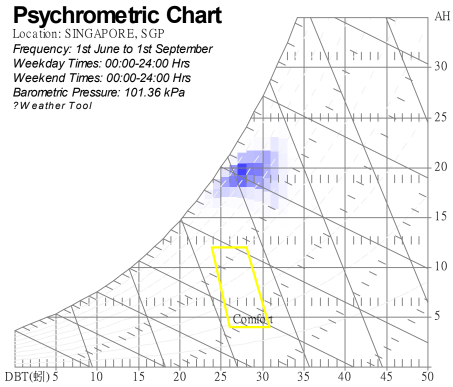
(a-1) Georgetown in summer



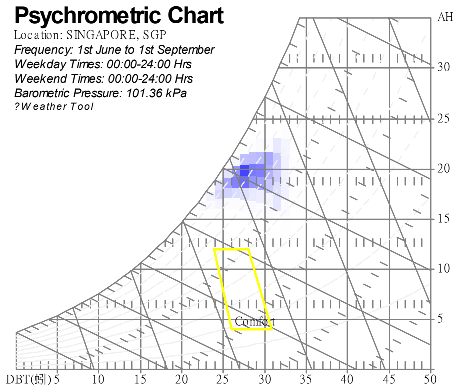
(a-2) Georgetown in winter



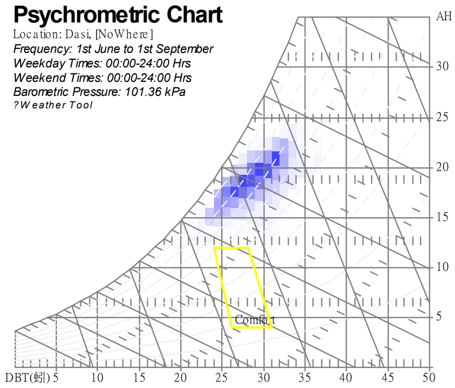
(b-1) Singapore in summer



(b-2) Singapore in winter



(c-1) Daxi in summer



(c-2) Daxi in winter

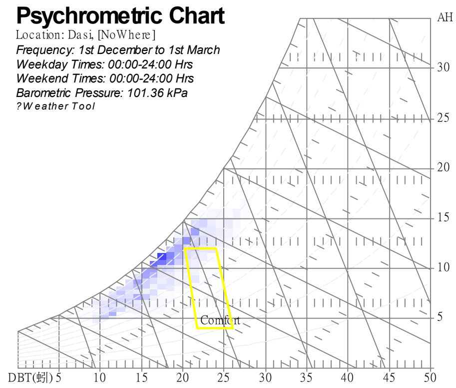


Figure 7.4: Psychrometric charts the three study locations in summer and winter.
(Source: Ecotect Weather Tool)

7.1.2. Literature review on previous studies

A courtyard, as found in the traditional shophouses that form the focus of this study, is a common architectural feature that has been applied for thousands of years in many parts of the world. Courtyards were often the primary meeting places for specific purposes including gardening, cooking, working, playing, sleeping, or even in some cases as places to keep animals (Edwards 2006). As an open space within a cluster or urban fabric, courtyard fulfils various functions, social, leisure and microclimate. One of the important factors of such a space was their location, providing private outside spaces in central sites within the urban fabric or building. Surrounded by arcades and colonnades, paved, landscaped with water bodies, various plants, shade and light, all played an important role in the associated social and working life (Meir 2000).

A wide range of investigations relating to the design form, concept of courtyard have been done. It is clearly noticed that the design form can be seen as a microclimate modifier to the environment. Many researchers have investigated the typical rectangular courtyard form in hot or temperate climate and its effect on the environmental performance. Aldawoud (2008) and Tablada *et al.* (2005), have recommended protection of the surface form and its surroundings from intense solar radiation and hot dusty wind as well as the capacity to promote cross ventilation which can have a direct impact on thermal comfort.

Meir *et al.* (1995) studied the effect of three sided courtyards on the microclimate. The courtyard created better microclimate condition; particularly when some variables are taken into consideration such as the orientation, attached volume and ventilation. Muhaisen (2006) studied the effect of a rectangular courtyard proportion (ratios and heights) at four different climate locations. This simulation study explored the relationship between the courtyard form and shading performance and sun location and exposure. The optimum courtyard height to obtain a reasonable effect in summer and winter was found to be three storey in hot humid climate, double storey in hot dry and temperate climate and one storey in cold climate. Hence, taller walls should surround courtyards in hotter climates (such as Penang and Singapore) and courtyards in colder climates could function with lower surrounding walls (such as Taiwan in winter).

Muhaisen and Gadi (2006) found that the deep courtyard form produced more internal shadow in summer while shallow form performed better in winter. The study has recommended an annual calculating ratio. However, for the daylight aspects, this solution is not recommended. The potential of courtyards with less exposure to the sky (narrow) to act as passive cooling can be correlated with a building composition in terms of airflow rate and pattern in warm humid climates. The microclimate condition could be improved through naturally ventilated high mass residential buildings with internal courtyards (Rajapaksha *et al*. 2003).

Moreover, Muhaisen and Gadi (2006) studied the polygonal courtyard forms (non-typical form) and it's shading performance to develop a shading calculation tool for courtyards. The study concluded that courtyard geometry and proportions have a significant influence on the shading produced on the internal surface. The sun location in the sky and the geometry of the courtyard can affect the shading condition within the courtyard. However, the research presented a computer based mathematical model but did not cover all the multi-sided courtyards.

Aldawoud (2008) has attempted to investigate the thermal behavior of courtyard buildings under different design conditions of glazing type and window to wall ratio. The courtyard wall enclosure materials (Sadafi *et al.* 2011; Li 2007), colours and shading devices (Wang and Liu 2013) are other options to look into when trying to improve the microclimate condition of the courtyard and the surrounding spaces. Placing natural elements within a courtyard would produce environmental benefits. For instance, Safarzadeh and Bahadori (2005) found that trees, shrubs and flower plants (as a garden elements) within a courtyard can significantly affect the thermal comfort as they provide shaded area with the wall of the courtyard. Al-Hemiddi and Megren (2001) studied the effect of using water body (pond) and water spray within the courtyard on the thermal performance with control tent above the courtyard. It was found that the internal courtyard with a pool, tent and water spray during sunny hours provided significant cooling effect for the internal spaces surrounding the courtyard.

The study of daylight in courtyards has developed from the analytical formulae of classic treatises (Hopkinson *et al.* 1966) right up to the most recent research which uses computer simulation (Miguet and Groleau 2002; Tsangrassoulis and Bourdakis 2003), since courtyards, which are essential architectural elements, let daylight and ventilation into buildings.

The study of the variables develops a cycle tuning the shophouse building structure. As the configuration alters in shape and orientation, the built up area shape follows and adapts, which consequently modifies the front courtyard configuration in terms of dimension shape and location, effecting and altering the surrounding façade, hence affecting the amount and position of the window and door openings. Amid testing each shape with regards to location, all the affects representing the cycle are going to be explained thoroughly. Each configuration of each courtyard is designated with its own code. Figure 7.5 presents a legend to explain each configuration code.

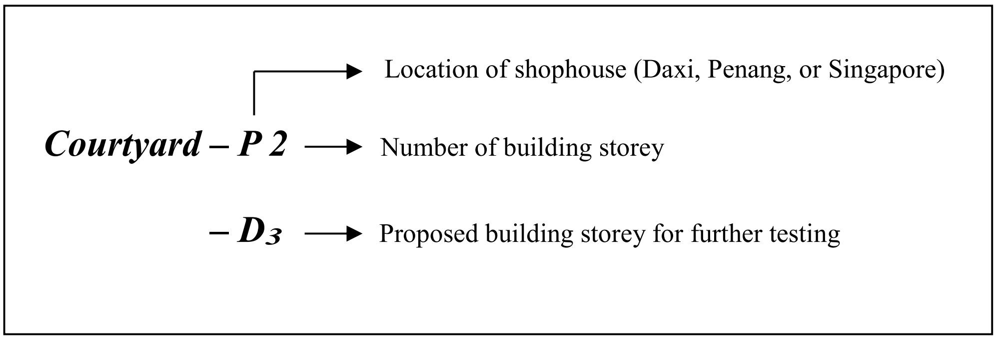


Figure 7.5: Configurations proposed legend.

7.1.3. Review of solar access study

Solar intensity affects the shophouse courtyard's micro-climate which determines the visual environment. Its presence at the courtyard's surface is necessary for the provision of lighting for general lifestyle. Thus, it is important to be able to understand the impact of solar radiation, and in particular, to determine the amount received by the courtyard's surface. This has been explored through a brief thermal study of solar radiation which is presented below.

Nowadays, building regulations around the world states that provisions should be made for the conservation of fuel and power in buildings, by limiting heat gains and/or losses. In the climatic context of this study, unmanaged solar heat gain affects both a building and its occupants, resulting in the long-term use and maintenance of air conditioning as the environment requires cooling in order to deliver occupant thermal comfort. This energy consumption has a detrimental effect on carbon dioxide emissions and building running costs. Extensive research has shown that natural daylight plays an integral role in influencing productivity and mood for building occupants so it is important that this is optimized when introducing external solar shading. The range of control systems - also available as motorized shading can enable individuals to manage the effects of solar glare in their own area or in some cases systems can be designed to track the sun automatically.

In warm humid tropics overheated building interiors are common due to solar penetration through the buildings envelope and windows (Rajapaksha *et al.* 2003) and shophouses as one of the most common typologies of residential buildings in Southeast

Asia are also facing these problems. As a result of the high density of the building blocks and crowded dwellings, a large number of buildings do not fulfill the requirements for thermally comfortable environment. So far many bioclimatic design strategies have been proposed in different studies and some of them are also used in practice (Budaiwi 2007).

One of the common strategies is to include internal courtyards in houses, in order to introduce the outdoors into the heart of the buildings core as well as optimizing the climate source. Solar radiation which is received directly onto the courtyard surfaces will affect the thermal performance of the building especially in the internal areas adjacent to the courtyard. The amount of heat gain through radiation depends on climatic conditions, the time of year, configuration of the courtyard and thermal properties of the construction materials of partition walls (Muhaisen and Gadi 2006).

Moreover, thermal performance of courtyard buildings has been investigated by many researchers such as; Hemiddi and Saud (2001), Rajapaksha *et al.* (2003), Ratti *et al.* (2003), Muhaisen (2006), Sadafi *et al.* (2011), Kavan *et al.* (2011), Wang *et al.* (2014) and Acosta *et al.* (2015). However, typically, these studies have evaluated buildings such as bungalows without the limitation for land size and openings as experienced in the shophouse typology and in different countries including Japan, U.K., U.S., Saudi Arabia, and Iran.

This section therefore intended to provide an initial investigation as to the influence and effectiveness of internal courtyards on the thermal performance of shophouses, in order to identify potential advantages and offer recommendations.

In this research for ongoing daylight simulations, all three case study shophouses have been considered for modelling and evaluation of thermal conditions (Figure 7.6).

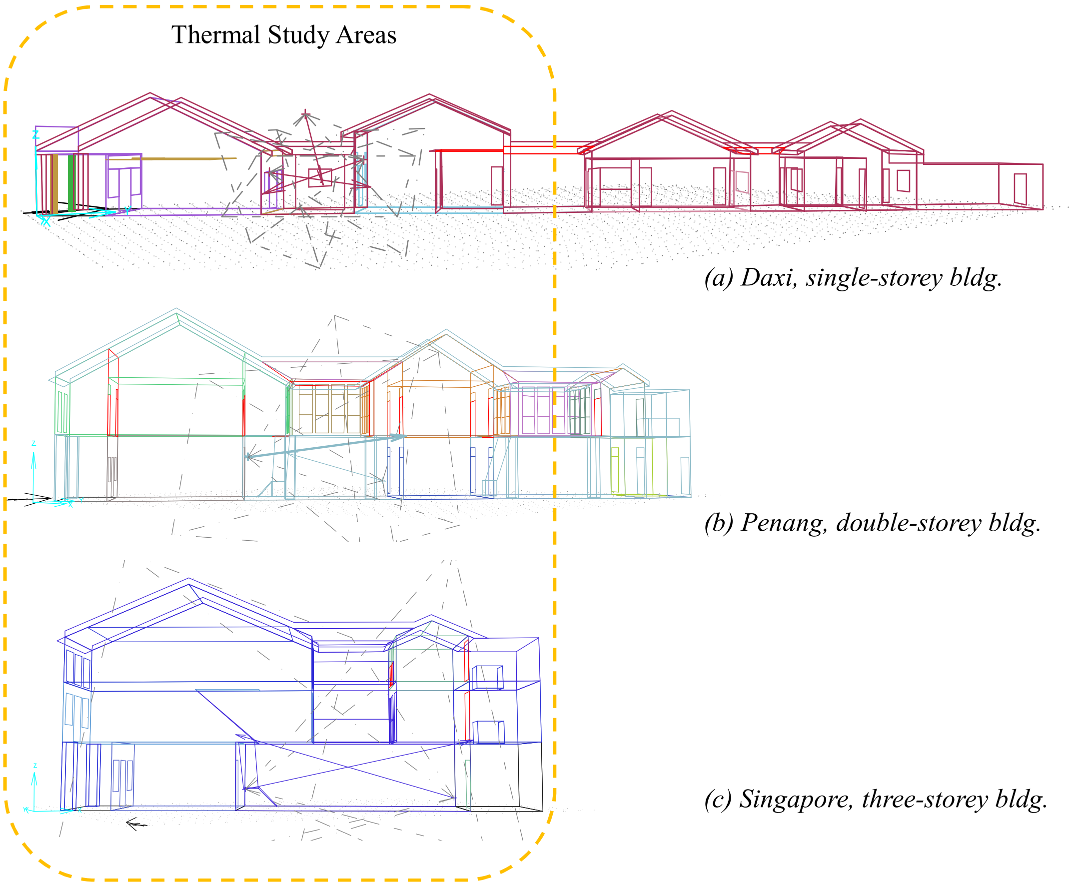


Figure 7.6: Case study shophouse buildings in Ecotect format model.

The levels of the shophouses have been modelled with the following functionality in mind as illustrated in Figure 7.7:

Ground Level: This level is mainly for business unit on the front. The thermal zones were divided into several zones: (1) shop unit, (2) living area, (3) dining area and/or kitchen, and (4) the front courtyard which considered as outside zone.

First Level: Where present, this level is for family area in the Singapore case and for public meeting area in the Penang case. The created zones are for: (1) living area and study room, (2) conference rooms, and (3) spaces for corridor.

Second Level: Where present, this level is for family area and the created zones are for: (1) master bedroom, (2) living area, and (3) bedroom.

The first investigation for thermal performance of the shophouses as it exists was conducted for two different months of the year, June and December, the hottest and coldest day in Northern Taiwan.

In the next step after investigating common typologies of shophouses with courtyard, all the three different rectangular shape courtyards with 4.6 x 5.5m *(Courtyard-D1)*, 6.0 x 9.6m *(Courtyard-P2)*, and 5.0 x 11.6m *(Courtyard-S3)* dimension, have been introduced in the shophouses. Figures 7.7 show the case study shophouse building models after including the front courtyards in the family area. As could be seen the courtyard zone are adjacent to the shop unit and the living, dinning, and/or kitchen zones.

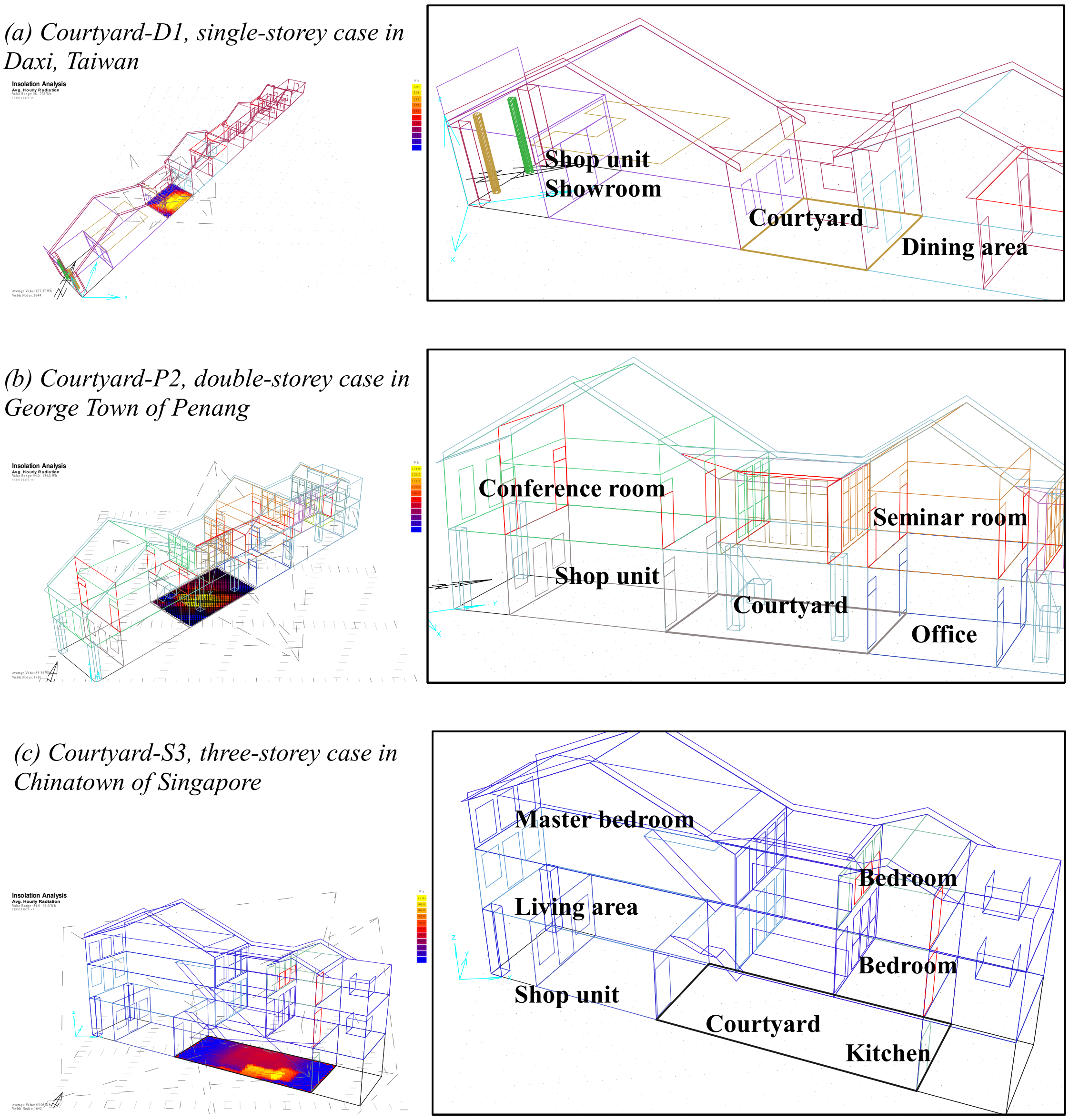


Figure 7.7: 3D models of case study shophouse building after introducing the front courtyard.

To inform the Ecotect Analysis model, the following materials for the buildings were either chosen from Ecotect Analysis library or created from user library (Table 7.1). The property values for these materials are calculated from Ecotect Analysis material property. The materials of the shophouses are considered as follows:

	Material Description	U-Value (W/m^2k)	Admittance (W/m^2k)
Floor	100mm thick suspended concrete floor plus ceramic tiles and plaster ceiling underneath	2.90	5.21
Wall			
Internal	40mm thick hollow core plywood partition	2.98	0.65
	100mm brick with 10mm plaster either side	2.72	4.32
External	130mm brick with 10mm plaster either side	2.44	4.46
Roof	130mm thick Terracotta clay tile cover	3.10	3.10
	130mm thick clay tile cover with foil	1.82	2.00
Ceiling	10mm suspended plaster board ceiling, plus 50mm insulation, with remainder (150mm) joists as air gap	0.50	0.90
Door	40mm thick hollow core plywood door	2.98	0.65
Window	Single pane of glass with wooden frame	5.00	5.00

Table 7.1: Material description for the case study building. (Source: Ecotect Analysis)

The insolation analysis simulates the average hourly total, direct, and diffuse solar radiation on the courtyard surfaces. The simulation is carried out between 05:00 to 19:00 in June, and 06:00 to 17:00 in December for Daxi Township in Taiwan; and 07:00 to 20:00 in June, and 07:00 to 19:00 in December for Penang and Singapore. The timing for Daxi is set as stated is based on the Direct Solar Gain analysis calculation as it calculates the month for June till 7 p.m. and in the month of December till 5 p.m. due to the early sunrise and late sunset in summer and early sunset in winter.

In Daxi, *Courtyard-D1* average hourly incident solar radiation value in summer (June) is 127.37Wh, and in winter (December) is 34.61Wh. The solar radiation distribution within the courtyard in June, presents the South-East side of the courtyard receiving higher solar radiation than the North-West side, and the South corner of the courtyard receives the lowest solar radiation. In winter (December), the distribution is different, as the middle of the courtyard receives the higher solar radiation in comparison to all the other sides. Figures 7.8a and 7.8b demonstrates the average hourly incident solar radiation for *Courtyard-D1* in summer and winter.

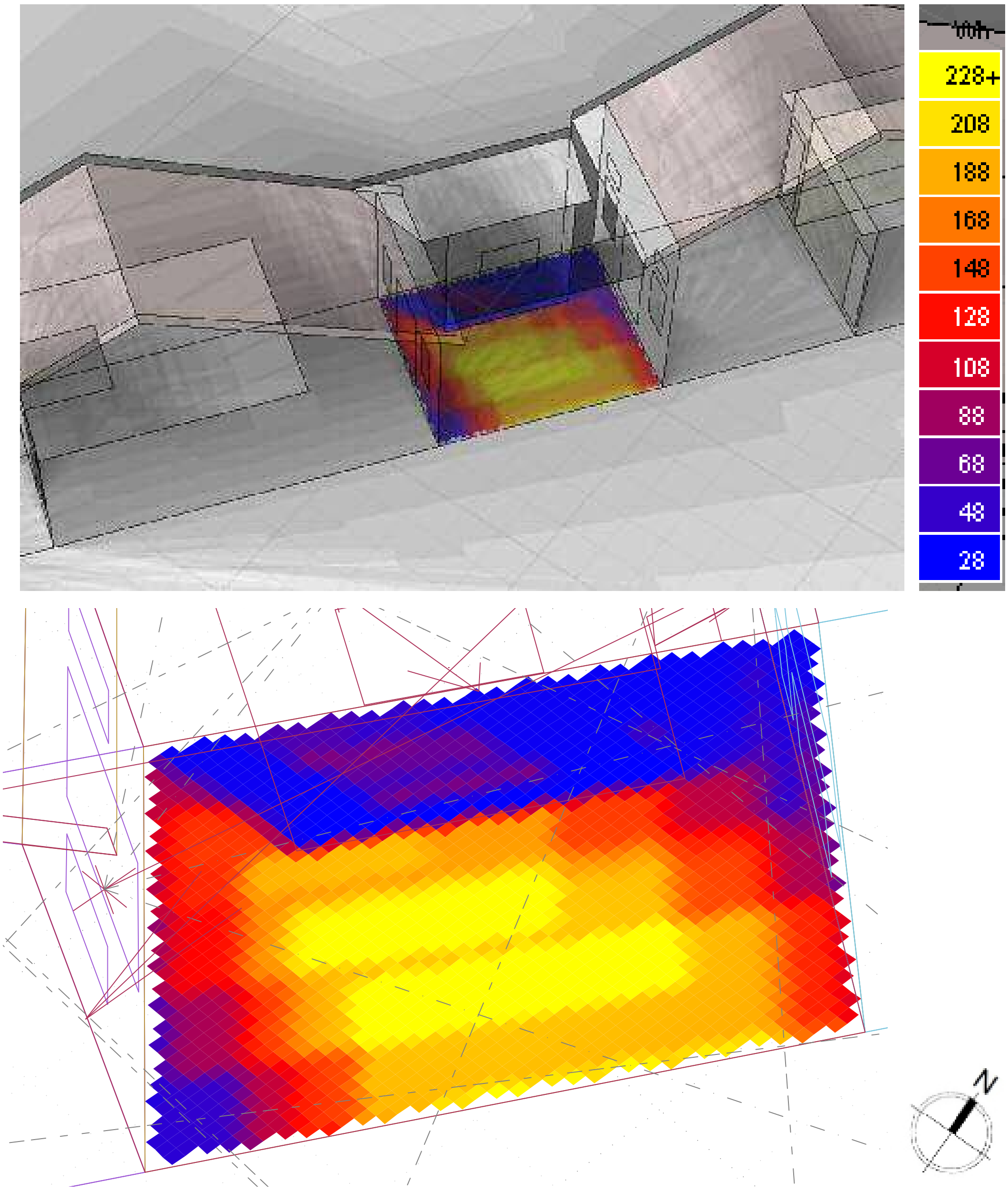


Figure 7.8a: Average hourly incident solar radiation for *Courtyard-D1* in June.

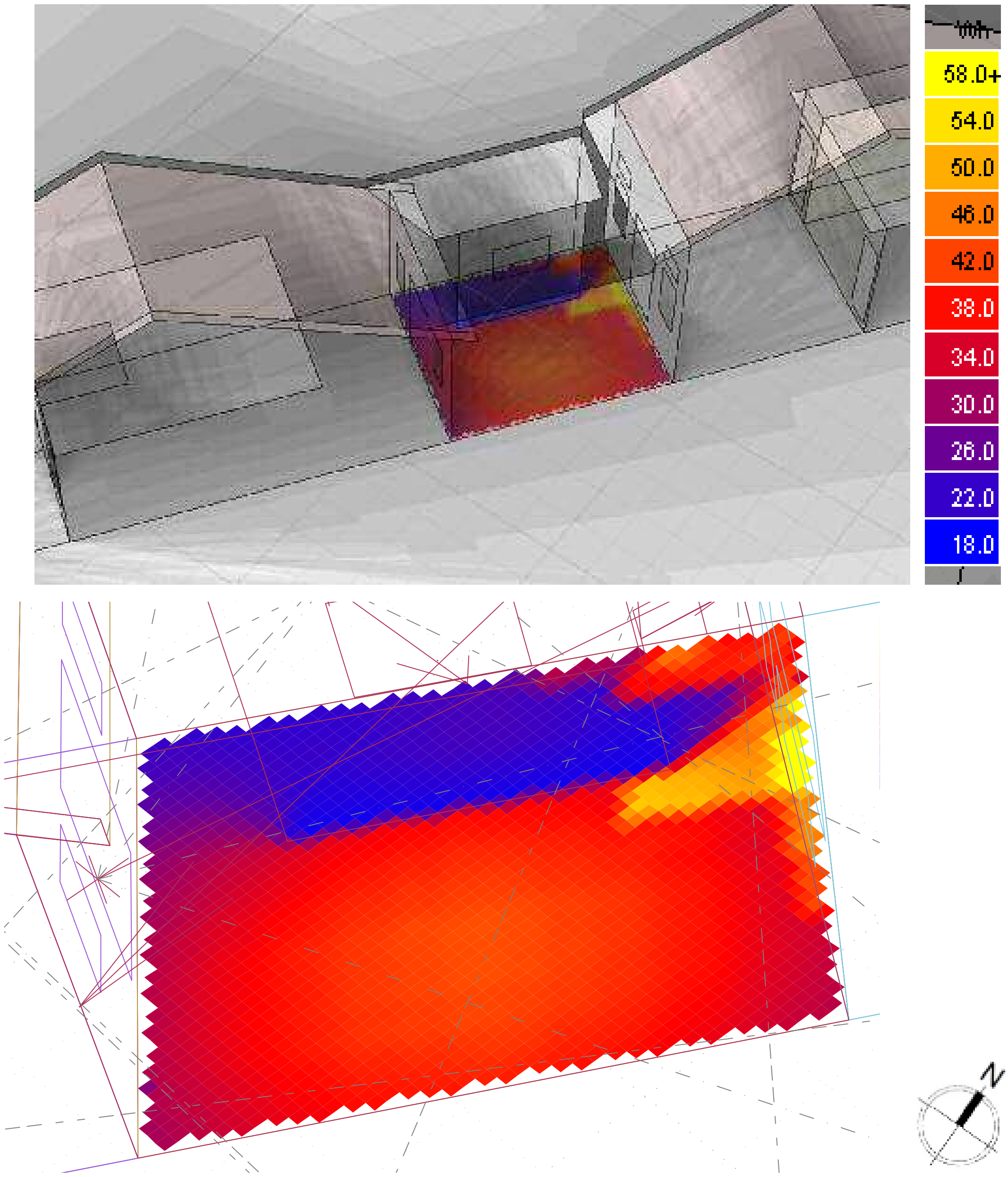


Figure 7.8b: Average hourly incident solar radiation for *Courtyard-D1* in December.

In a comparison between summer and winter, the difference in average hourly incident solar radiation value is almost 90Wh within this one-storey shophouse *Courtyard-D1*. This variation is due to the changes in the angle of the sun throughout the year, as well as the low party walls that do not effectively shade the sunlight. This may be one of the factors to cause the large proportion of these first courtyards to be closed in Daxi Township up to 33.3% (as established through the visual records of occupants' survey, 2011).

In Penang, *Courtyard-P2* average hourly incident solar radiation value in summer (June) is 83.34Wh, and in winter (December) is 77.26Wh. The solar radiation distribution within the courtyard in June, presents the South side of the courtyard receiving higher solar radiation than the North side, and the four corners of the courtyard receive the lowest solar radiation. In winter (December), the distribution is different, as the North corner of the courtyard receives the highest solar radiation in comparison to all the other sides. Figures 7.9a and 7.9b demonstrates the average hourly incident solar radiation for *Courtyard-P2* in summer and winter.

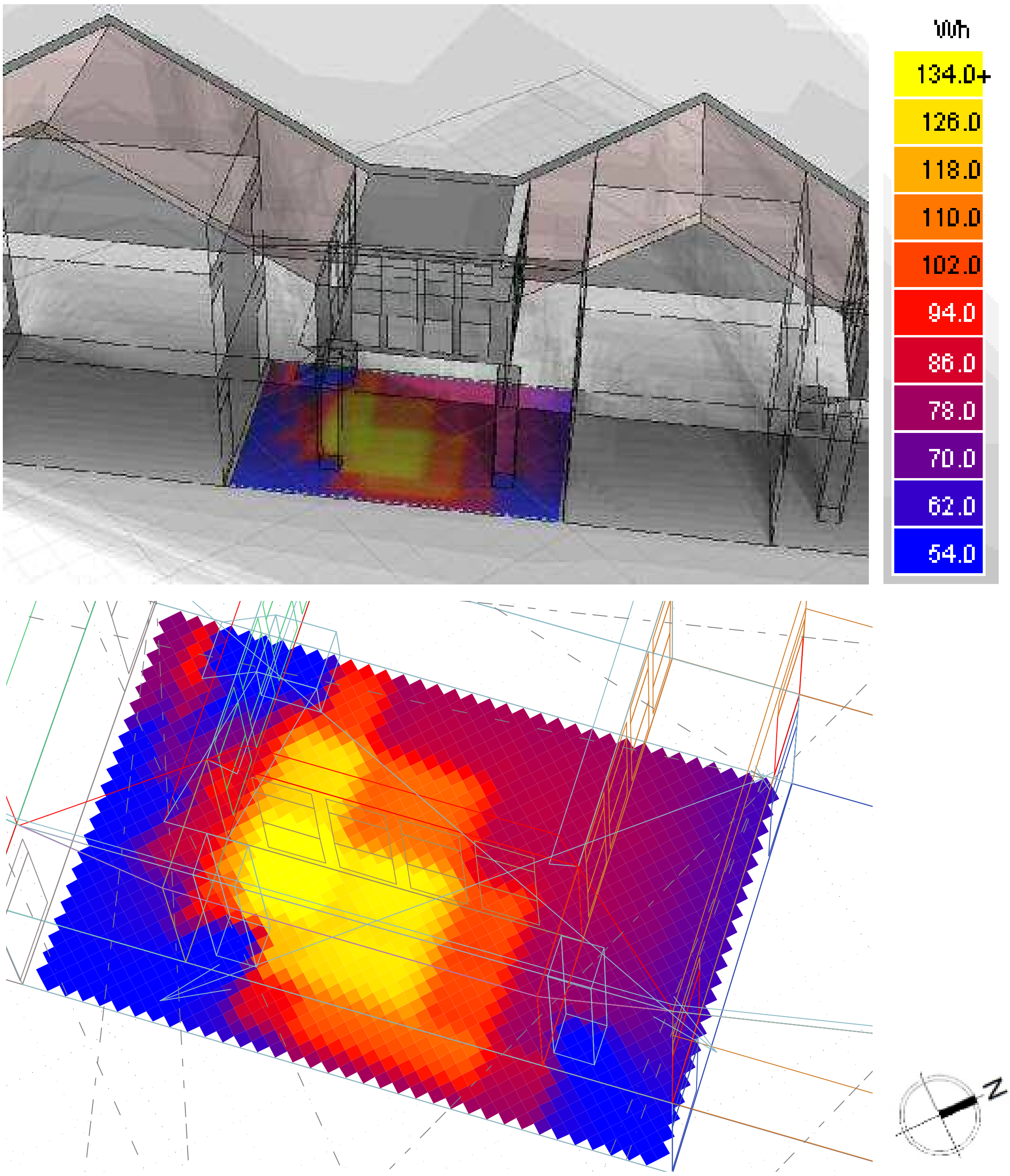


Figure 7.9a: Average hourly incident solar radiation for *Courtyard-P2* in June.

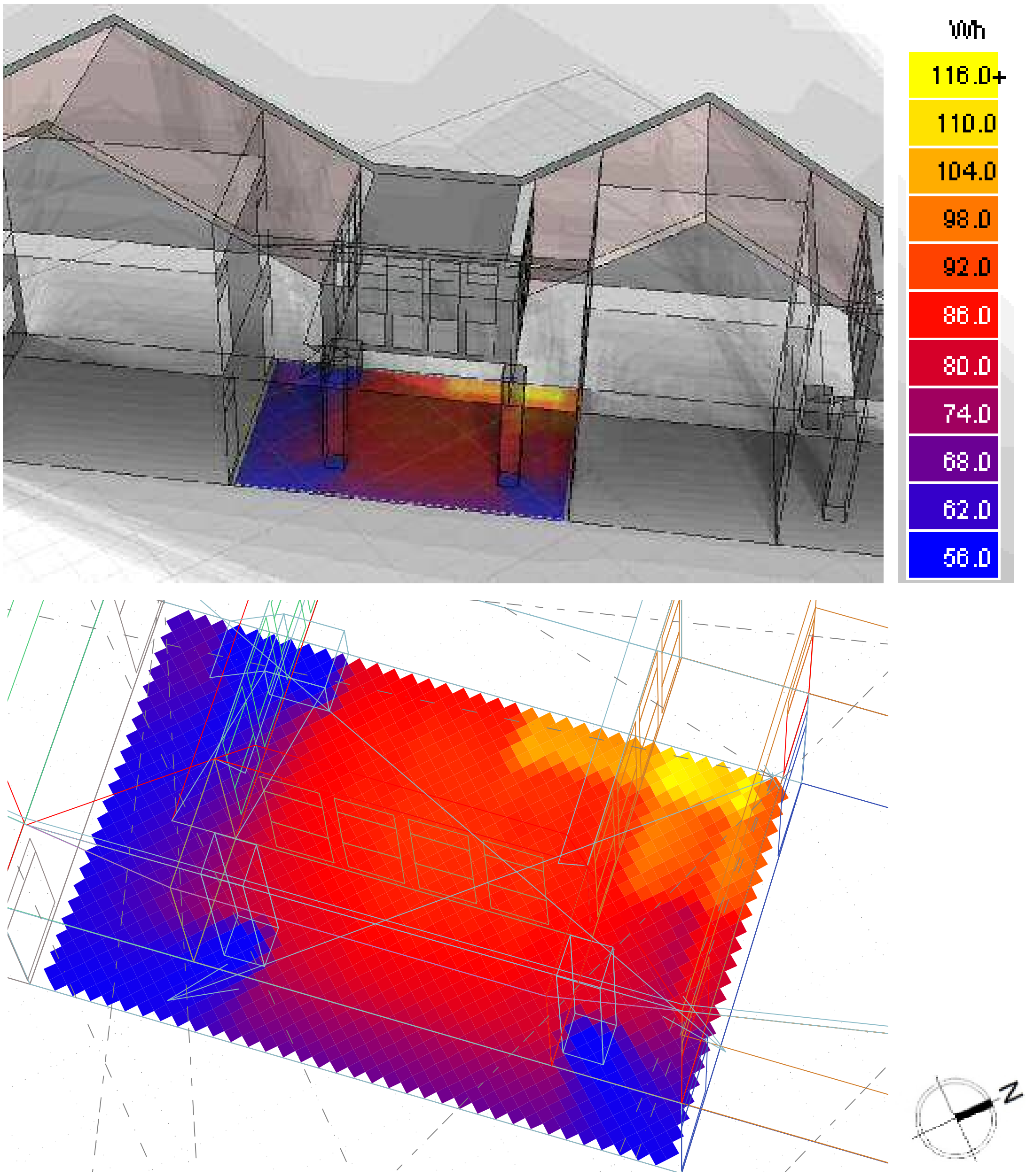


Figure 7.9b: Average hourly incident solar radiation for *Courtyard-P2* in December.

In a comparison between summer and winter again, the difference in average hourly incident solar radiation value is approximately 6Wh within this two-storey shophouse *Courtyard-P2*. Where the height of the party walls and deep overhanging eaves can be seen to have played a role in providing enhanced shading; where the sunlight penetration is found to be concentrated in a single spot, even when the sun is almost directly overhead. Beyond a slightly high and small area of distribution at Southwest end corner, both end sections of courtyard have an equal amount and distribution of solar radiation.

In Singapore, *Courtyard-S3* average hourly incident solar radiation value in summer (June) is 63.96Wh, and in winter (December) is 63.30Wh. The solar radiation distribution within the courtyard in June, presents the South side of the courtyard receiving higher solar radiation than the North side, and the four corners of the courtyard receive the lowest solar radiation. In winter (December), the distribution is different, just the North end corner of the courtyard receives the highest solar radiation in comparison to all the other sides. Figures 7.10a and 7.10b demonstrates the average hourly incident solar radiation for *Courtyard-S3* in summer and winter.

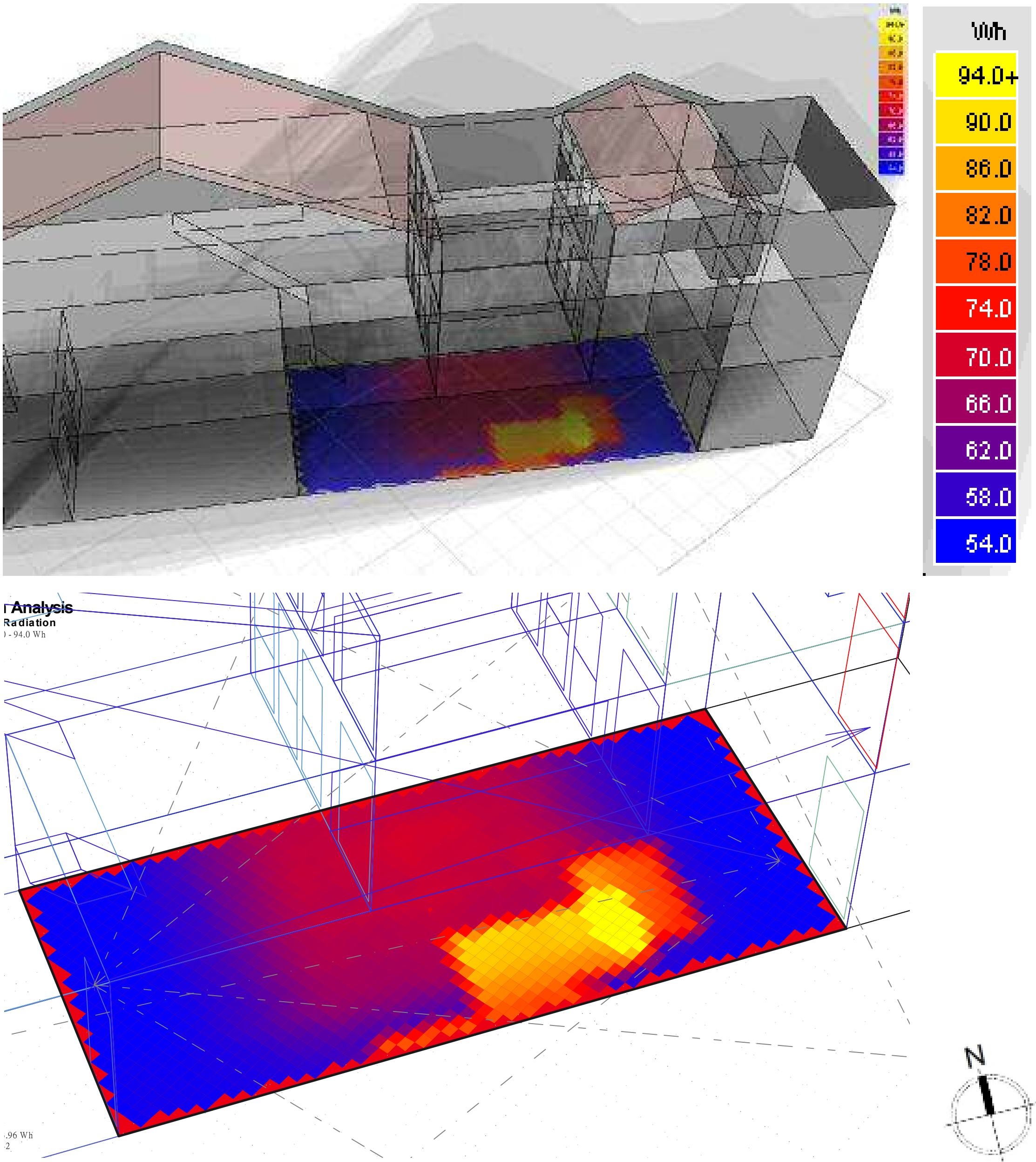


Figure 7.10a: Average hourly incident solar radiation for *Courtyard-S3* in June.

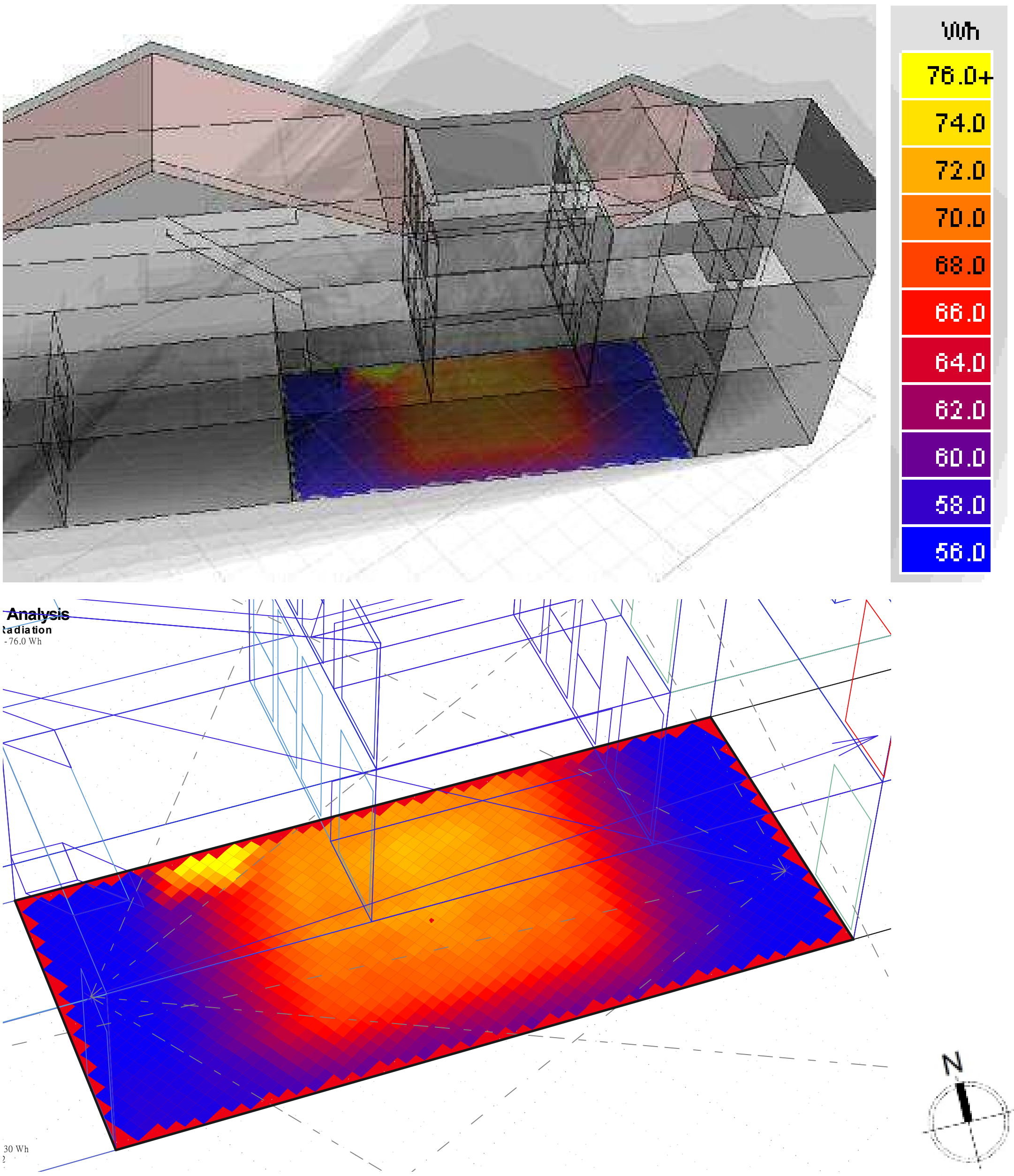


Figure 7.10b: Average hourly incident solar radiation for *Courtyard-S3* in December.

In a comparison between summer and winter for this three-storey shophouse *Courtyard-S3*, there is almost no difference in average hourly incident solar radiation value. Moreover, the height of party walls, the deep overhanging eaves, and the balconies have narrowed the spot of sunlight focused to a smaller area: where both end sections of courtyard have an equal amount and distribution of solar radiation. The average radiation level is well distributed within the courtyard.

In December, all courtyards have the best well distributed solar radiation, as light is distributed North and South equally. On the other hand, in *Courtyard-D1* spaces such as the semi-outdoor pantry, within the courtyard along the North-West side where reflected light causes discomfort, as well as there being spaces by the walls that receive low exposure. In comparing to the other 2 courtyards: *Courtyard-P2* has higher solar exposure levels during both season's summer and winter; while *Courtyard-S3* receives the least solar radiation. This is directly associated with the courtyard shape and small opening size that decreases the courtyard surface in receiving radiation.

Comparing all three courtyards, *Courtyard-S3* receives the least solar exposure than *Courtyard-P2* and *Courtyard-D1* during the month of June. This is due to the fully enclosed structure that provides more shade. Yet, in December, it receives higher solar radiation than *Courtyard-D1* with almost half of values.

Figure 7.11 illustrates a comparison of average hourly incident solar radiation in summer and winter. In *Courtyard-S3*, the difference between them in June and December are 63.96Wh and 63.30Wh respectively. On the other hand, in June, a lower solar exposure level in *Courtyard-D1* is needed to modify the courtyard by decreasing the warmth levels to provide a more comfortable outdoor space. Therefore, *Courtyard-S3* provides more comfort levels than *Courtyard-P2* and *Courtyard-D1* in two seasons.

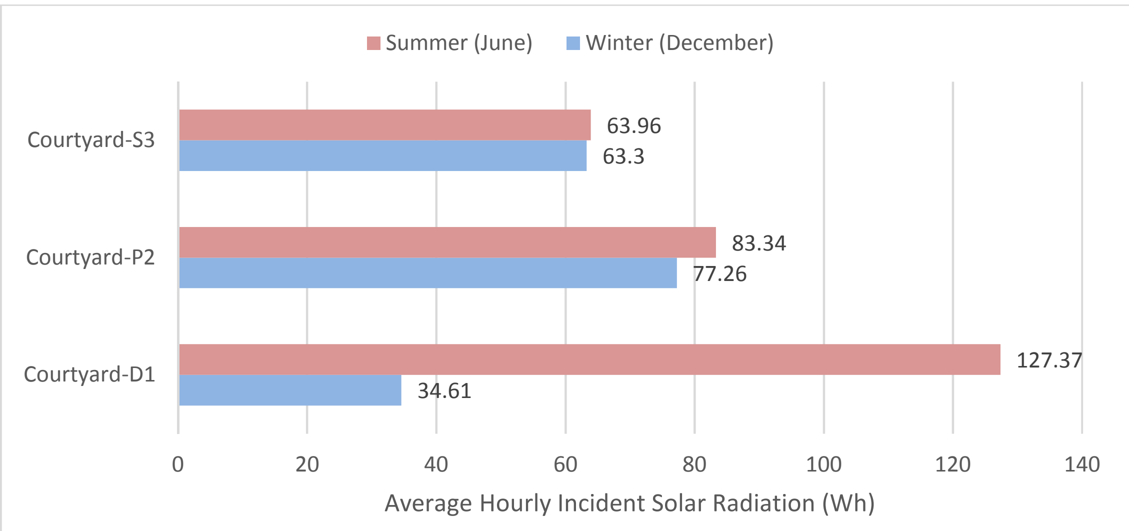


Figure 7.11: Comparison of solar access on the first courtyards for the three locations.

However, in terms of total monthly available direct and diffuse solar radiation on the courtyard surface, throughout the year, *Courtyard-D1* presents a surprising result with respect to percentage of available incident solar radiation received.

According to the manual of Ecotect Analysis (2004 and 2010), it uses the solar radiation data provided by the weather file, in combination with the term by 'shading masks'. Shading masks are very important in Ecotect Analysis, as they assess how much shading a particular object surface receives. Once that calculation is done, it can multiply the shading percentage of that surface by the amount of solar radiation it would have received without any shading, to provide a more realistic assessment of the amount of solar radiation that surface would receive. Ecotect Analysis is able to provide this for both the direct (from the sun) and diffused (from the sky dome) radiations. Because solar radiations from the weather files are typically taken from horizontal planes, Ecotect Analysis uses the angle of target objects and that of the sun at the particular time to determine the incident angle on the object. That incident angle will be used to calculate the total amount of solar radiation on that surface.

Figure 7.12 illustrates the comparison between the three courtyard surfaces to the total monthly available direct and diffuse solar radiation (upper part of line chart), and that available incident solar radiation received (lower part of line chart).

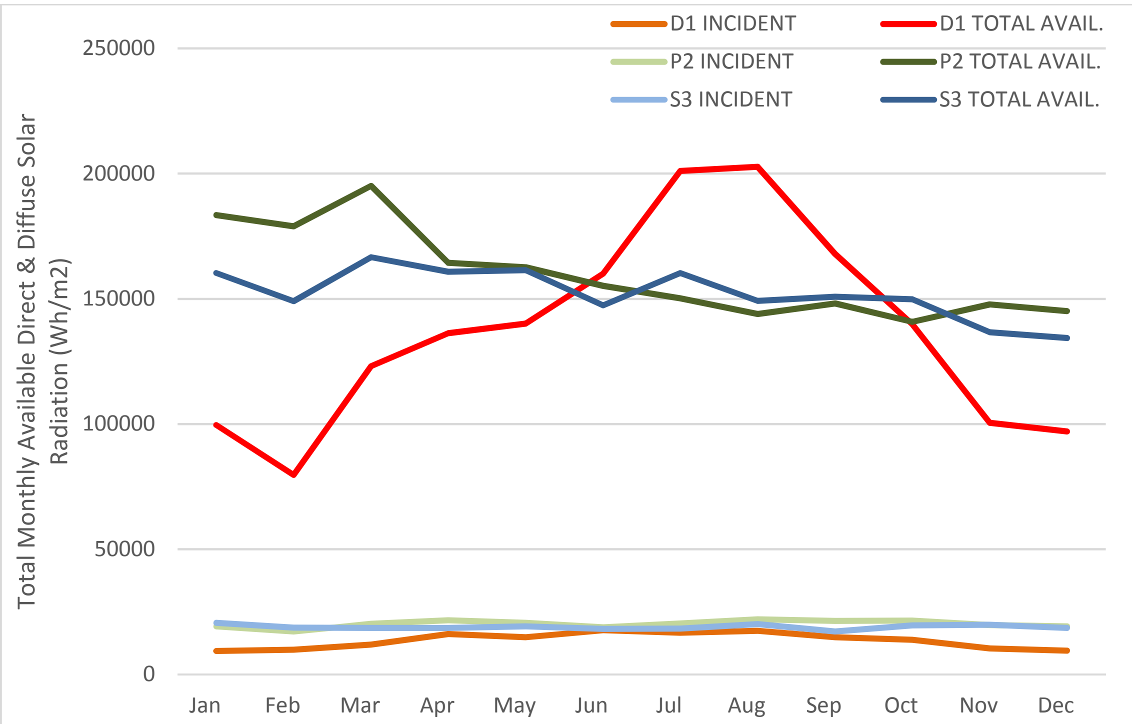


Figure 7.12: Comparison of total monthly available that incident solar radiation received for the three courtyards. (Source: Ecotect Analysis for Solar Exposure)

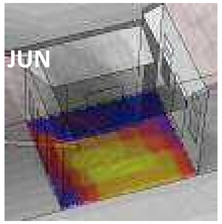
Table 7.2a (refer to Figure 7.12) highlights both the total and the percentage of available solar radiation incident on the three different courtyards. Table 7.2b also lists the value of total incident solar radiation in single day. The coloured values represented the most critical single days for cross-section analysis.

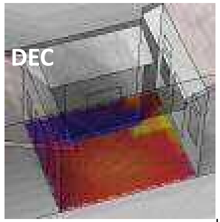
From the upper part of Figure 7.12, it is apparent that the trend lines of both *Courtyard-P2* and *Courtyard-S3* are similar and close to each other, as well as their values of solar radiation. Due to different climate base, *Courtyard-D1* had highest values in summer with the difference of approximately 50kWh/m^2 over another two courtyards. Again, from the lower part of this figure, total incident on the courtyards, all three locations resulted much more closely, while both *Courtyard-P2* and *Courtyard-S3* were almost overlapping.

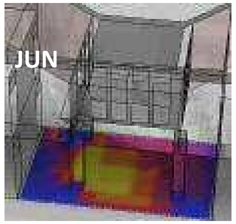
In terms of the single brightest sunny day (highlighted in colour yellow), Table 7.2a calculated and indexed the lowest monthly percentage of available incident solar radiation is *Courtyard-D1* with 8.29%. By contrast, *Courtyard-S3* tops the list with 12.86%, and *Courtyard-P2* with 10.41% in the middle of them. Then, in terms of the single most overcast day (highlighted in colour grey), the lowest one is *Courtyard-D1* again with 9.43%, while Courtyard-P2 tops the list with 15.35%, and Courtyard-S3 with 12.37%.

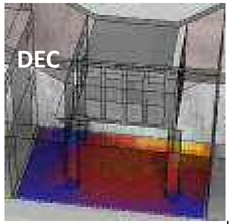
In theory, the courtyard shape and small opening size would affect the courtyard surface in receiving solar radiation. The case of *Courtyard-D1* here does not have the above conditions. The lowest and just one storey height of party walls in *Courtyard-D1* are unable to block such a strong sunlight in summer July. The only thing that can be explained is the relatively lower effect of the solar angle in Northern Taiwan against in Southeast Asia.

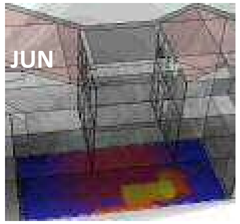
From the other side of thinking, the double or three storey height of courtyards in Northern Taiwan should be able to effectively control the sunlight as well.

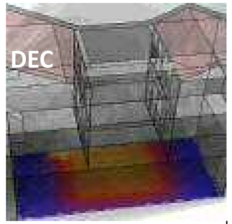








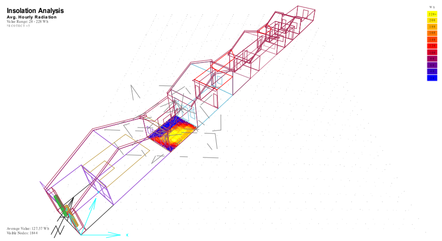


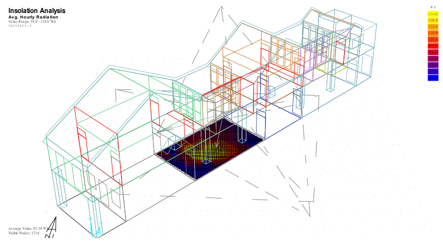


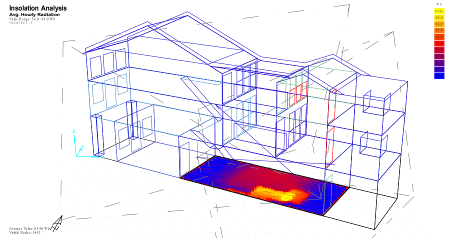
	Courtyard-D1			*Courtyard-P2*			*Courtyard-S3*		
MONTH	AVAIL. Wh/m2	INCIDENT Wh/m2		AVAIL. Wh/m2	INCIDENT Wh/m2		AVAIL. Wh/m2	INCIDENT Wh/m2	
JAN	99669	9402	**9.43%**	183495	19273	10.50%	160304	20621	**12.86%**
FEB	79681	9976	12.52%	179012	17134	9.57%	149048	18769	12.59%
MAR	123135	12009	9.75%	195113	20316	**10.41%**	166629	18658	11.20%
APR	136239	16241	11.92%	164440	21707	13.20%	160771	18598	11.57%
MAY	140120	14920	10.65%	162631	20618	12.68%	161428	19214	11.90%
JUN	160122	17637	11.01%	155156	18923	12.20%	147460	18247	**12.37%**
JUL	201015	16670	**8.29%**	150160	20450	13.62%	160299	18358	11.45%
AUG	202710	17400	8.58%	143990	22096	15.35%	149168	20210	13.55%
SEP	167953	14863	8.85%	148121	21451	14.48%	150824	17165	11.38%
OCT	139851	13844	9.90%	140785	21610	**15.35%**	149790	19582	13.07%
NOV	100457	10492	10.44%	147787	19709	13.34%	136705	19843	14.52%
DEC	97127	9585	9.87%	145129	19313	13.31%	134338	18590	13.84%
TOTALS	1648079	163039	**9.89%**	1915819	242600	**12.66%**	1826764	227855	**12.47%**

Average	Max. Temp.	Min. Temp.
	Brightest Sunny	Most Overcast

Table 7.2a: Comparison of total monthly solar exposure for the three locations.
(Source: Ecotect Analysis for Solar Exposure)







	Courtyard-D1				***Courtyard-P2***				***Courtyard-S3***			
	Date	Solar Angle degrees	Total Incident W/m2	Absorbed W	Date	Solar Angle degrees	Total Incident W/m2	Absorbed W	Date	Solar Angle degrees	Total Incident W/m2	Absorbed W
Hottest Day (Peak)	**21st JUL**	81	674	17042	**14th MAR**	**85**	243	13985	**23rd APR**	**97**	724	41980
Hottest Day (Average)	**22nd JUL**	81	494	12498	**7th MAY**	**101**	690	39756	**10th JUN**	**112**	581	33675
Coldest Day (Peak)	**6th JAN**	49	255	6457	**20th JUL**	**101**	634	36541	**8th SEP**	**89**	720	41748
Coldest Day (Average)	**18th FEB**	57	212	5374	**19th JUL**	**101**	612	35251	**7th DEC**	**66**	366	21205
Brightest Sunny Day	**29th JUL**	81	305	7706	**14th MAR**	**85**	243	13985	**29th JAN**	**73**	306	17736
Most Overcast Day	**12th JAN**	49	163	4124	**24th OCT**	**77**	453	26070	**24th JUN**	**112**	316	18328
Strongest Wind Gust	**23rd FEB**	57	281	7099	**30th DEC**	**62**	707	40723	**22nd AUG**	**97**	716	41540
Most Windy Day	**4th SEP**	65	657	16622	**30th DEC**	**62**	707	40723	**15th JAN**	**73**	715	41493
Least Windy Day	**31st MAR**	65	267	6760	**2nd SEP**	**85**	737	42463	**2nd MAR**	**89**	363	21031

Table 7.2b: Comparison of single day solar exposure for the three locations.
(Source: Ecotect Analysis for Solar Exposure)

7.2. Daylight simulations

As emerged in previous section, shophouse courtyards strive to obtain a maximum amount of daylight and to make strong visual connection with the surrounding environment. The typology of buildings were chosen to perform adequately in Penang, Singapore and Daxi (Taiwan) during the studies. The simulations were hence realized for George Town in Penang (5.40°N and 100.23°E), Chinatown in Singapore (1.30°N and 103.80°E) and Daxi Township in Taiwan (24.88°N and 121.27°E): these three cities have a humid tropical and subtropical climate and hence, similar daylight duration throughout the year. However, the climate data reveal different clear sky patterns.

Ecotect and Radiance were used to simulate the daylight throughout the year. Shophouse courtyards have a slightly more complicated geometry than regular box building considering the properties of the surrounding textures and their different heights, and thus, Radiance produced more reliable results than the daylight simulation function of Ecotect. For this reason, Ecotect was used only as a modeling and visualization tool.

Radiance is a free backwards ray-tracing programme, considered as one of the most powerful and popular among lighting simulation software (Laouadi *et al.* 2008; Ochoa *et al.* 2012). Radiance is able to predict internal illuminance and luminance distributions under any sky condition, and has been extensively validated in the last 20 years (Ward *et al.* 1988; Mardaljevic 1995). Its algorithm is based on the daylighting coefficient method to remarkably shorten the simulation time. This method, also known as 'Three-Phase Daylight Coefficient' method, was developed by Ward *et al.* (2011), and it is based on the concept of daylight coefficients (Tregenza and Waters 1983). In this method, the sky is divided into 145 patches and the sun is assigned to nearest patches. Once the courtyard geometry and the materials are defined, the contribution coefficient of a sky patch to a sensor point is kept the same no matter what absolute radiance value the sky patch may have. The illuminance or luminance values are obtained by the product of the view matrix, the transmission matrix, the daylight matrix, and the sky vector (Reinhart 2005).

The resolution for the number of analysis grid cells was 60x60, whereas its height was set at 0.6m above the floor. The following material property values were used for the simulation: Brick wall finished with lime plaster or lime wash reflection factor 0.6; wood partitions reflection factor 0.4; traditional terracotta clay floor tiles reflection factor 0.25; granite sink reflection factor 0.25. A low reflection value (0.2) was assigned to the floor to take into consideration the clay tiles installed in the courtyard. Finally, the reflection values were the same used in all simulation studies (Wienold 2009), in order to facilitate the comparison of the results.

Among the different simulation parameters that were used in this study, the Daylight Autonomy and Useful Daylight Index were considered. These two dynamic metrics need to define a time frame for the simulations. Two general approaches of selecting this time basis exist: (a) including all daylight hours during the year; (b) including only the time in which the space is occupied. The latter is generally used for commercial and office building. However, since Shophouse is a residence, the first approach was used.

7.2.1. Daylighting in front courtyards

Daylight in shophouses is the natural illumination experienced by the occupants of any man-made construction with openings to the outside, e.g., dwelling and workplace. The quantity and quality of daylight in courtyards is continually varying due to the natural changes in sun and sky conditions from one moment to the next. For any given sky and sun condition the quantity and character of daylight in a courtyard will depend on the size, and orientation of the building apertures; the shape and aspect of the building and its surroundings.

Daylight Factor (DF) is one of the most common indices for measuring the daylight availability in a building. It is the ratio of indoor illuminance level at a point inside the building to the unshaded outdoor horizontal illuminance level under an overcast CIE sky. Shortcomings of daylight factor include that it is independent of the location, the orientation of the shophouse, front courtyard, and the hour or day of the year; but since it is based on a single sky condition, it has limited ability for reporting annual daylight availability (Reinhart and Walkenhorst 2001).

Daylight Factor in all three front courtyards was found to be unsurprisingly high (Figures 7.13, 7.14 and 7.15). Simulations in all three courtyards revealed values below 2% are in about 15%-25% of the courtyard area. From the following figures, it is apparent that average values within Penang were 53.06% in the double-storey case (*Courtyrd-P2*) followed by 49.82% from Daxi single-storey case (*Courtyard-D1*), and 29.65% from Singapore three-storey case (*Courtyard-S3*). As is evident, the adoption of external sun shadings guaranteed lower daylight factors in the shaded area than on the sky openings.

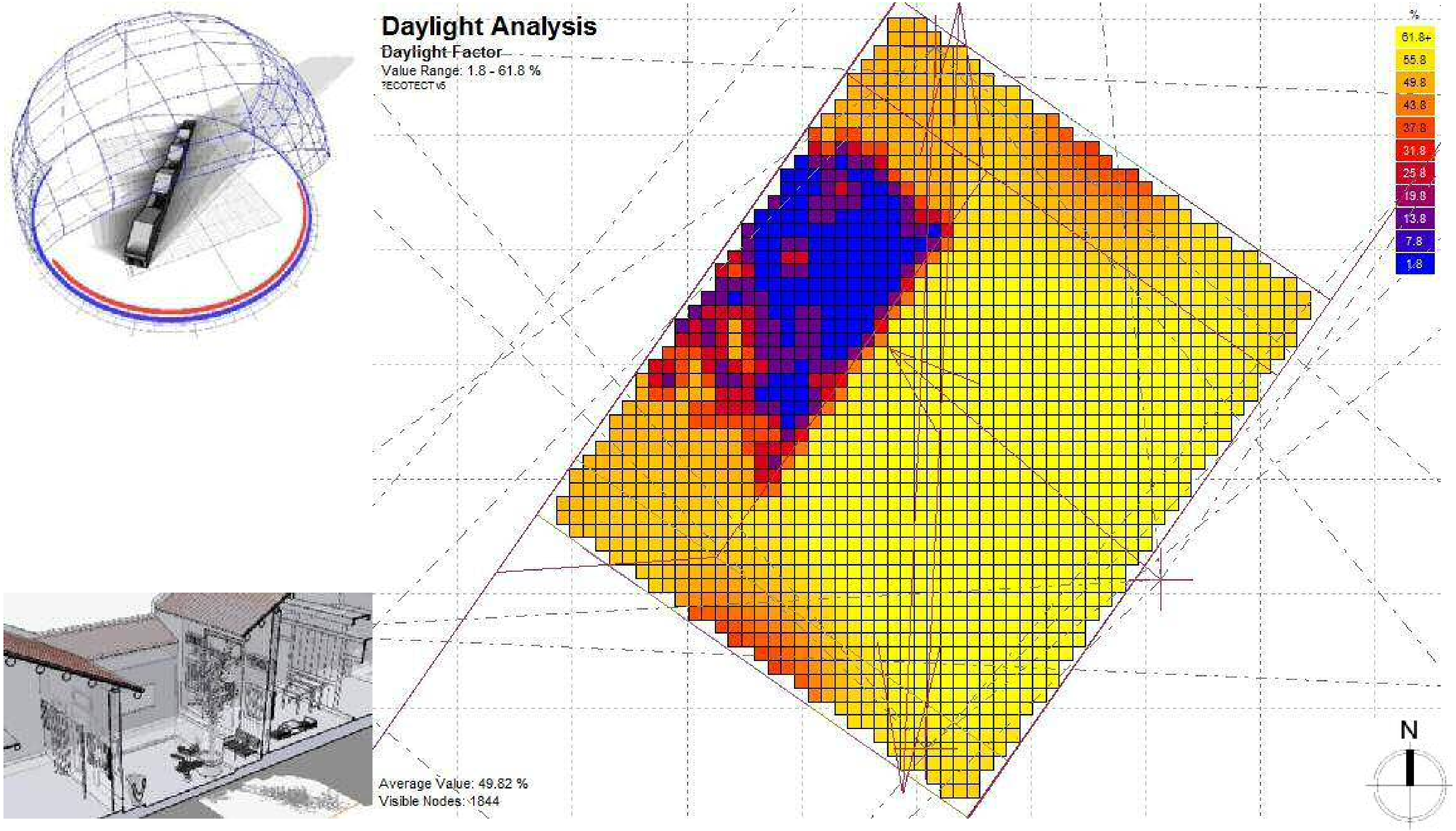


Figure 7.13: *Courtyard-D1* Daylight Factor of single-story shophouse in Daxi Township, Taiwan.

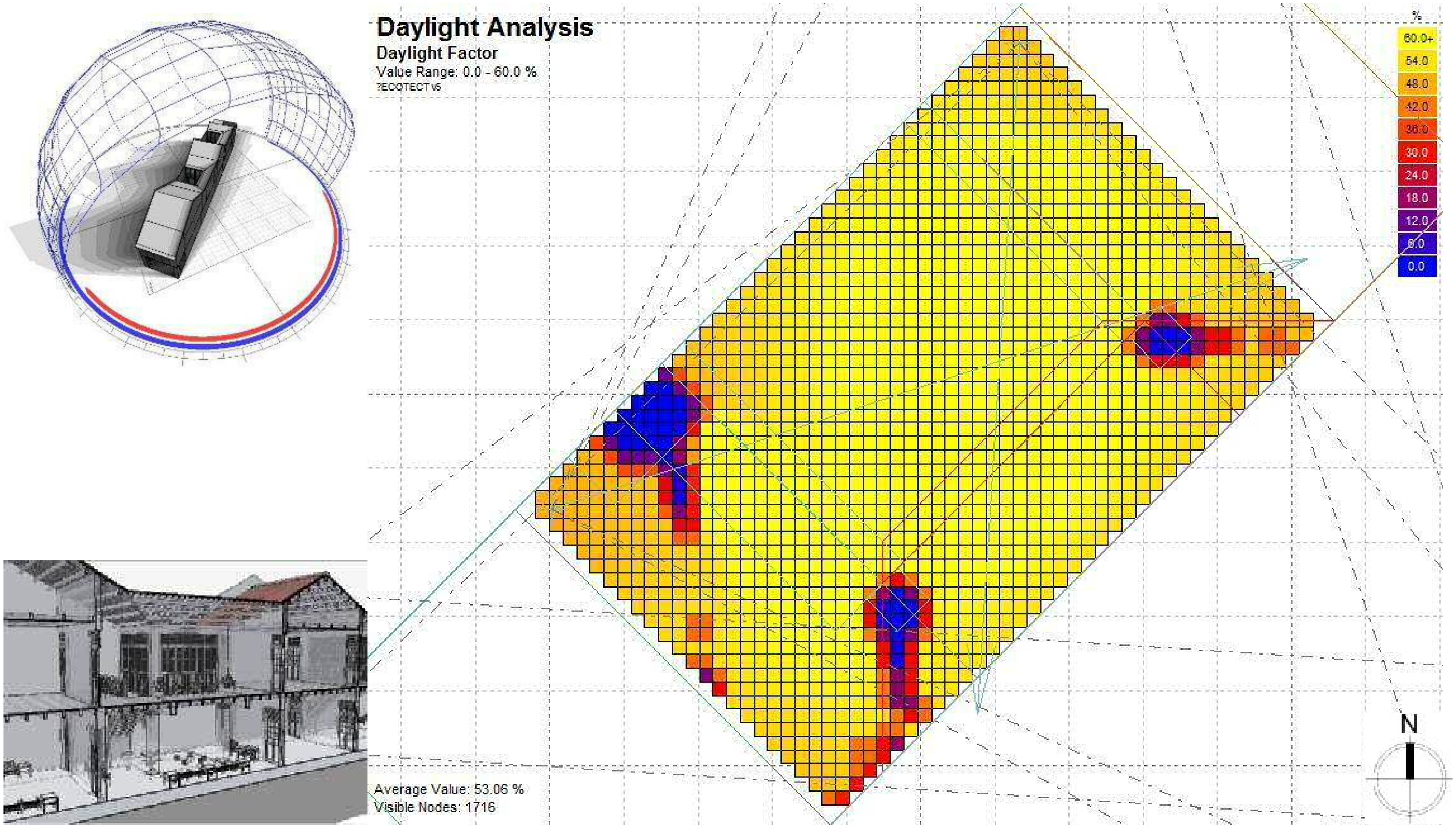


Figure 7.14: *Courtyard-P2* Daylight Factor of double-story shophouse in George Town of Penang, Malaysia.

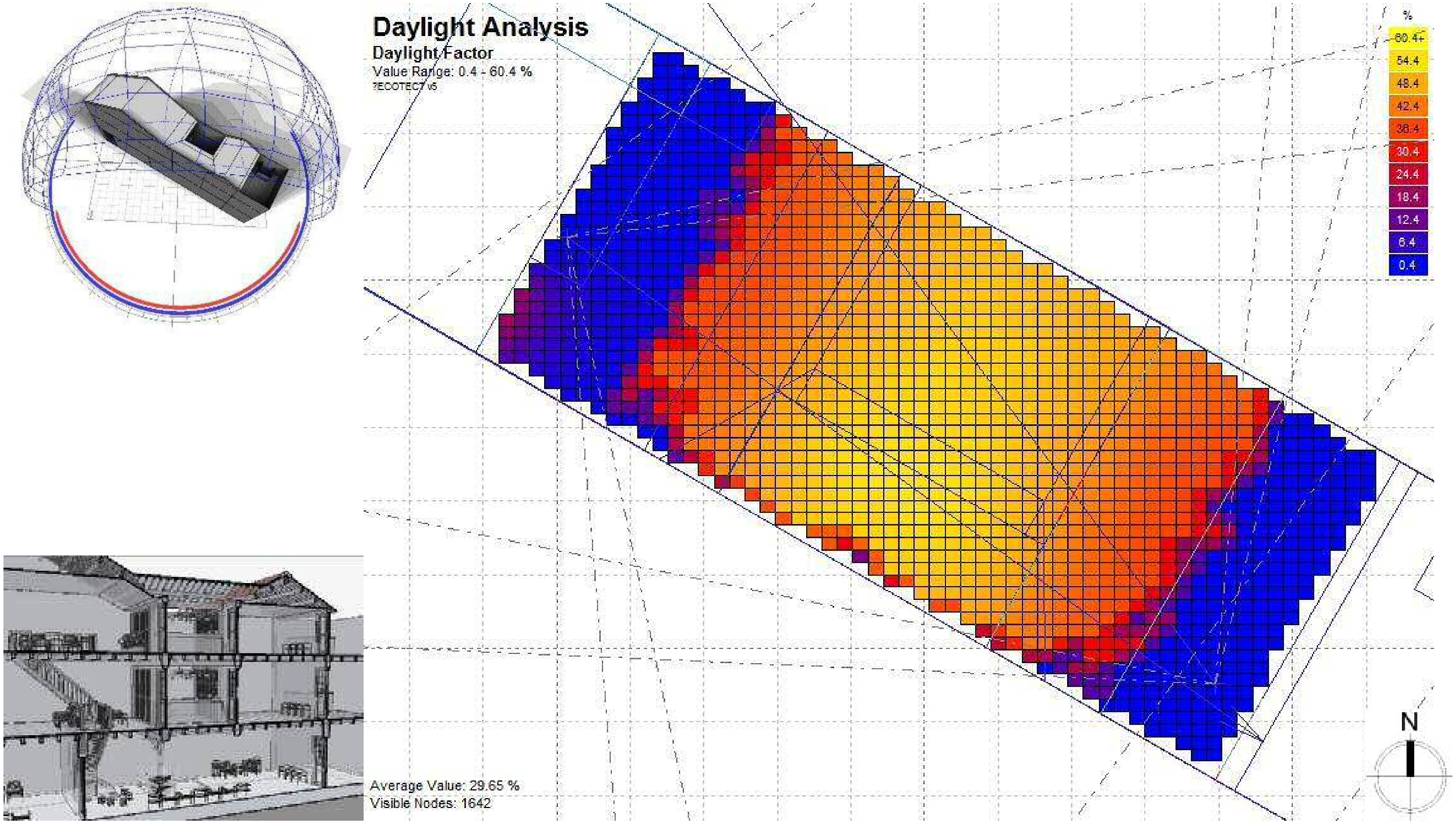
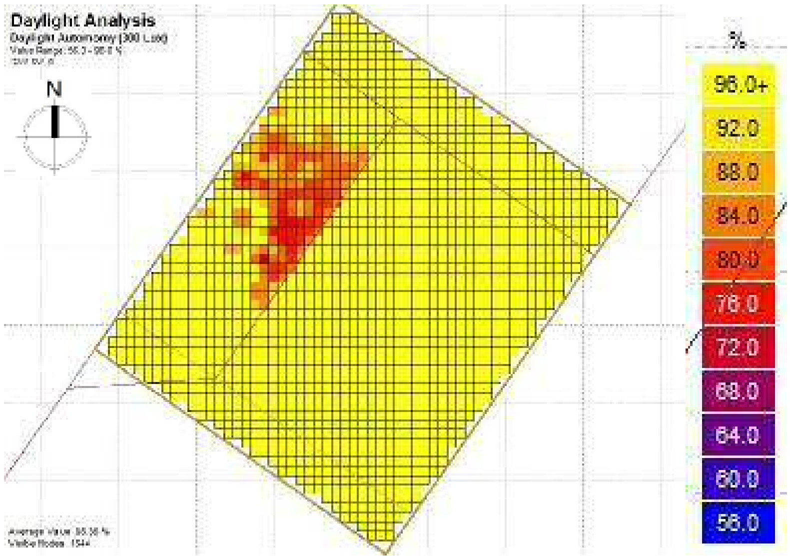


Figure 7.15: *Courtyard-S3* Daylight Factor of three-story shophouse in Chinatown of Singapore.

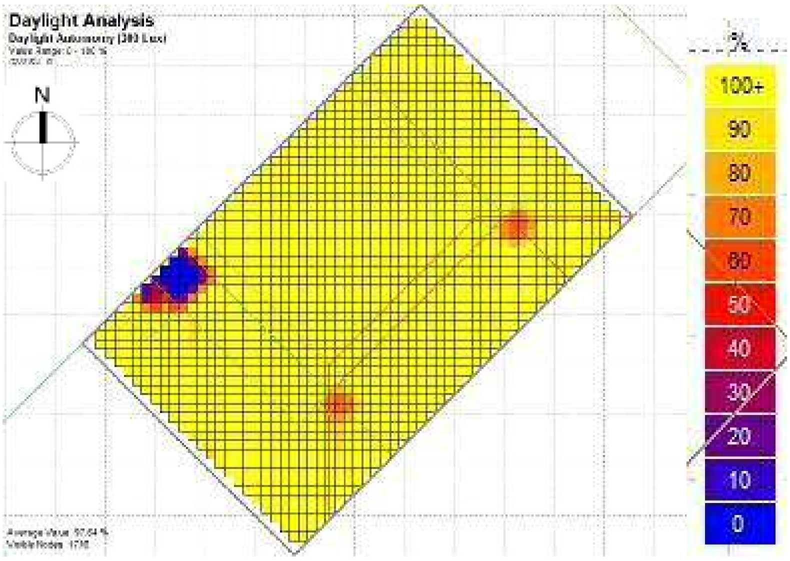
Daylight Autonomy is another useful index for evaluating daylight quantity. It is a dynamic index, defined as the percentage of the occupied hours of the year when a minimum illuminance threshold is met by daylight alone. Compared to the Daylight Factor (DF), which considers only overcast sky, the Daylight Autonomy takes into account all sky conditions throughout the year according to the weather file. The Daylight Autonomy threshold in the following analysis was assumed to be 500 lux: this target was approximated from the IES lighting handbook (IESNA 2014), and confirmed in recent literature (Reinhart 2005).

As shown in Figures 7.16, the Daylight Autonomy for most of the sensors resulted higher than 85% in Daxi, Penang and Singapore. This means that for more than 85% of all the daylight time, occupants will be able to perform tasks using daylighting that require 300 lux (recommended by Ecotect Analysis). Generally, when the majority of the sensor points have values above the threshold limit for over half of the occupied time that shophouse is considered a well day-lit space (Reinhart 2011). In particular, based on the solar radiation profile of *Courtyard-D1* and *Courtyard-P2*, occupants can perform activities that require 500 lux for over 80% of the daylight time throughout the year. Simulations in *Courtyard-S3* (Figure 7.16c) resulted in slightly lower overall values than *Courtyard-D1* and *Courtyard-P2*. As expected, due to the effect of courtyard proportions, Daylight Autonomy values are lower in *Courtyard-S3* than in the rest of all shophouse typologies. This result agrees with the recent study which assumes that the effect of solar heat gain on the energy demand of courtyard building form with different proportions (Muhaisen and Abed 2015)

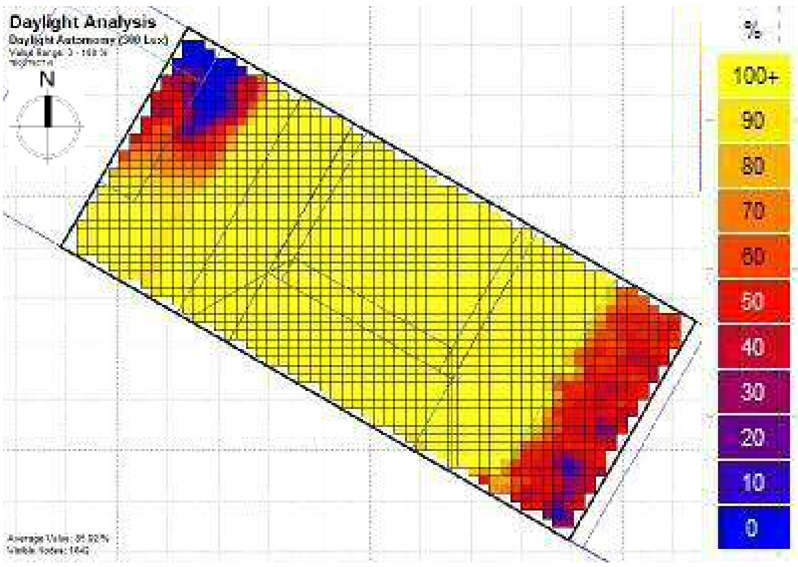
Another considered index is the Sky Component (SC). This represents the ratio of the direct sky illuminance falling on the vertical wall at a reference point, to the simultaneous horizontal illuminance under an unobstructed sky (Littlefair 1991). The amount of sky actually visible from a particular point is an important indicator of its exposure to both daylight and solar radiation. The resulting percentage is calculated by multiplying the layers in each segment together and then summing the product of all segments. Deep inside a room, on the other hand, there may be no view of the sky at all. Figure 7.17 shows that the potential of daylight in *Courtyard-D1* worked properly with 19.25%, while 8.25% is *Courtyard-P2* and 3.13% is *Courtyard-S3*.



(a) DA in *Courtyard-D1*

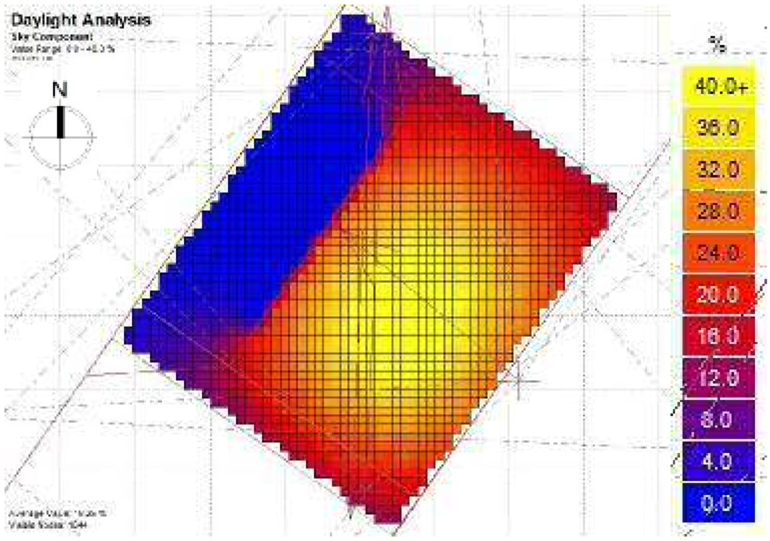


(b) DA in *Courtyard-P2*

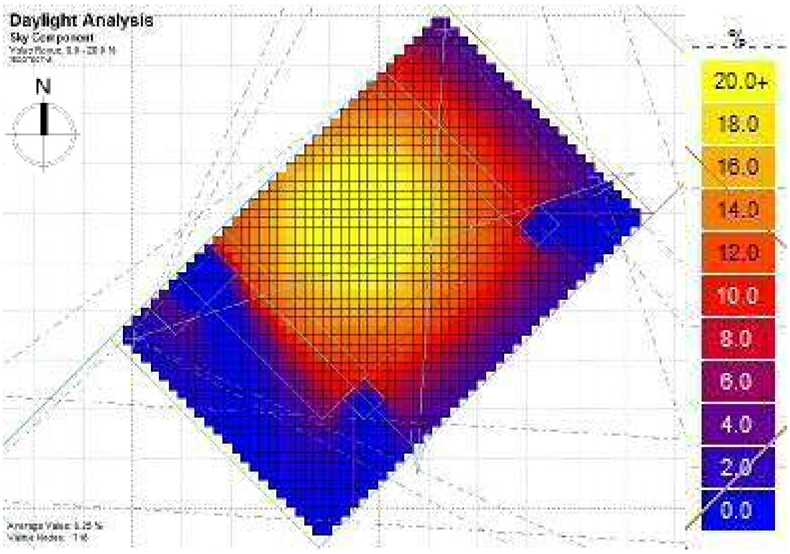


(c) DA in *Courtyard-S3*

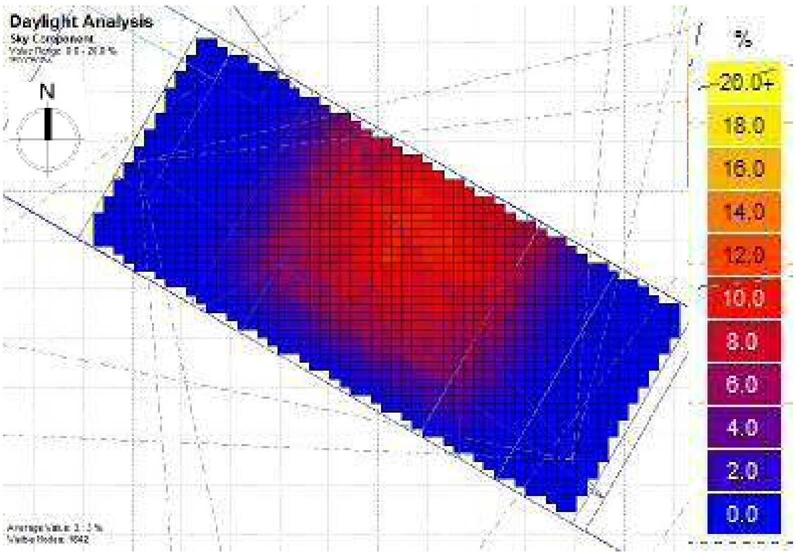
Figure 7.16: Front courtyards Daylight Autonomy in three case study locations.



(a) SC in *Courtyard-D1*



(b) SC in *Courtyard-P2*



(c) SC in *Courtyard-S3*

Figure 7.17: Front courtyards Sky Component in three case study locations.

7.2.2. Glare effects and problems

The previous section predicted the illuminance level within the shophouse courtyards based on a horizontal work plane illuminance levels and compared these findings with standards and requirements as defined by literature and informed by occupant surveys. One of the desires during the shophouse courtyards study was to explore an energy-efficient daylit building; however, maximizing daylight can also result in a high glare risk. Glare is a measure of the physical discomfort that may be caused by excessive light or contrast in a field of view (IESNA 2014). It is dependent on the luminance distribution seen by an observer, and it may correlate very poorly with the horizontal work plane illuminance metrics.

Perception of glare is subjective, positive and view direction dependent, making it difficult to assess compared to conventional illuminance-based metrics (Jakubiec and Reinhart 2012). As glare analysis should be focused on the view of an observer, vertical illuminance level is often particularly important predictor for this.

Glare can be categorized in several different types according to its effects:

Direct glare is caused by directly viewing a light source, such as a bright window or an unshielded high-brightness lamp.

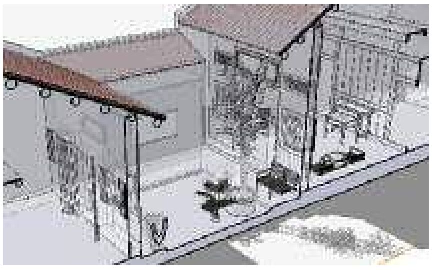
Reflected glare is caused by light reflected from a surface, such as a veiling reflection on a glossy magazine or computer screen (DiLouie 2011).

Disability glare is particularly problematic because it prevents occupants from seeing objects and impairs vision.

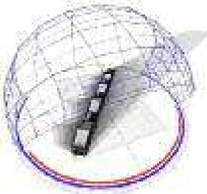
Discomfort glare is more subjective and has different effects on different observers, but it is generally considered irritating. As the brightness, size and prominence of a glare source increase, discomfort glare turns into disability glare, so that preventing discomfort glare precludes the possibility of experiencing disability glare. This is assumed in most glare metric calculations which predict the probability of experiencing discomfort, rather than visual disability (Jakubiec and Reinhart 2012).

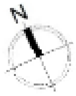
One of the difficult aspects of evaluating glare in residential buildings relates to the different functions and tasks performed in different rooms, in different positions, and at different hours of the day. Four days (22nd of March, June, September, and December) were selected to consider different sun locations, whereas three hours of day (9:00, 12:00, and 15:00) allowed assessment of the effects in the morning, noon, and afternoon.

To study in detail the discomfort glare, several false colour renders representing the surrounding luminance were done facing both ends of the shophouse courtyards while the sky condition was set as sunny in Radiance. Aside from using isoline diagrams, these renderings given a quick idea of the lighting distribution within the space by graduating them on an illuminance or luminance scale and representing them in different colors and/or gray tones.



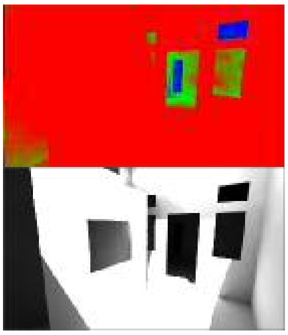
***Courtyard-D1**, single-storey case*



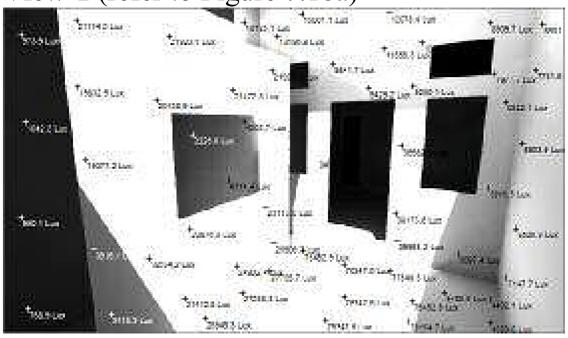


Judging from the images of *Courtyard-D1* in Figures 7.18a to 7.18d, glare is intensive in the northeast side, but thanks to additional shades for the open space of the outdoor pantry, sunlight only extends across almost half of the courtyard. Through these frames, it emerges that the highest risk of glare, especially at noon, when the luminance values above 2000 lux are found in almost 70% of the field of view.

22 Sep **12:00**

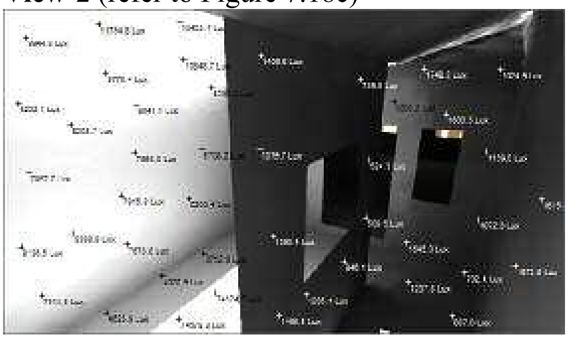


View-1 (refer to Figure 7.18a)

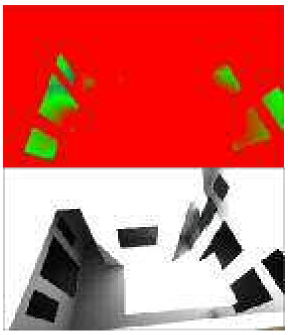


22 Sep **12:00**

View-2 (refer to Figure 7.18c)



22 Sep **12:00**



Upper-view (refer to Figure 7.18b)

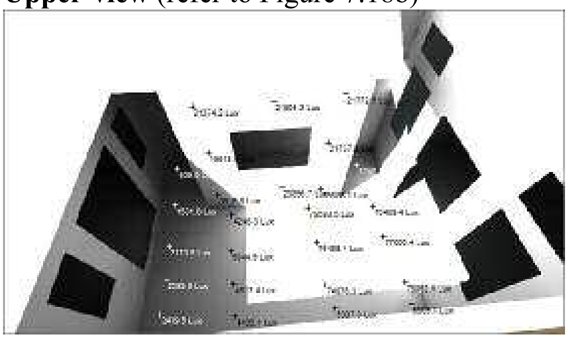


Figure 7.18a: Selected grayscale rendering of luminance (in lux) in the equinox days at noon in three different positions of view, *Courtyard-D1*, Daxi, Taiwan.

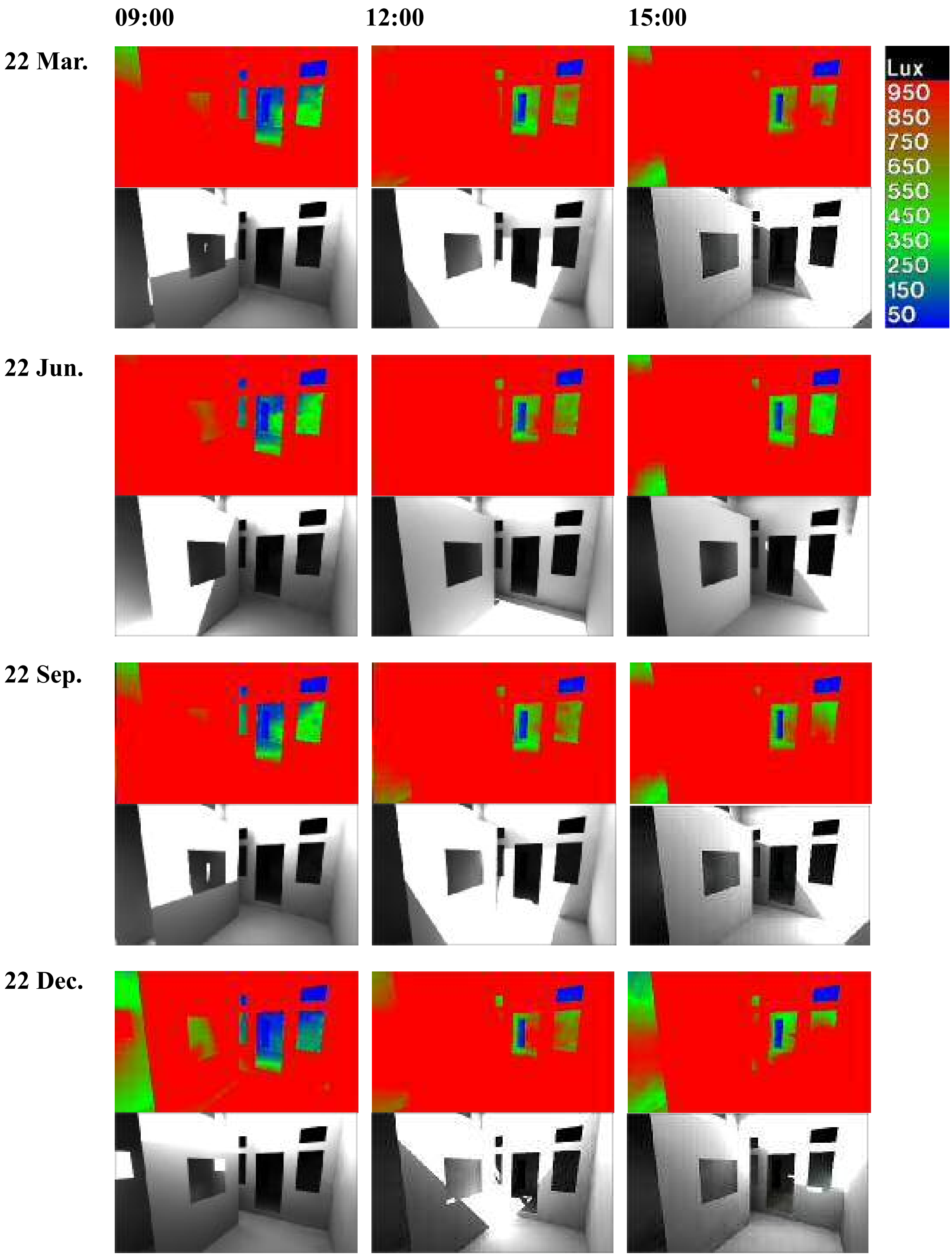


Figure 7.18b: False colour rendering of luminance (in lux) in the solstice and equinox days at three different hours at View-1, in *Courtyard-D1*, Daxi, Taiwan.

From the images of View-1, brightness is focused on the walls of the outdoor pantry and the second building (northeast side of courtyard) and sometimes fall on the ground level of the courtyard. On the whole, the false colour renders indicates that the experience of glare across the courtyard is likely and therefore it seems that one cannot make use of much of the courtyard during the daytime.

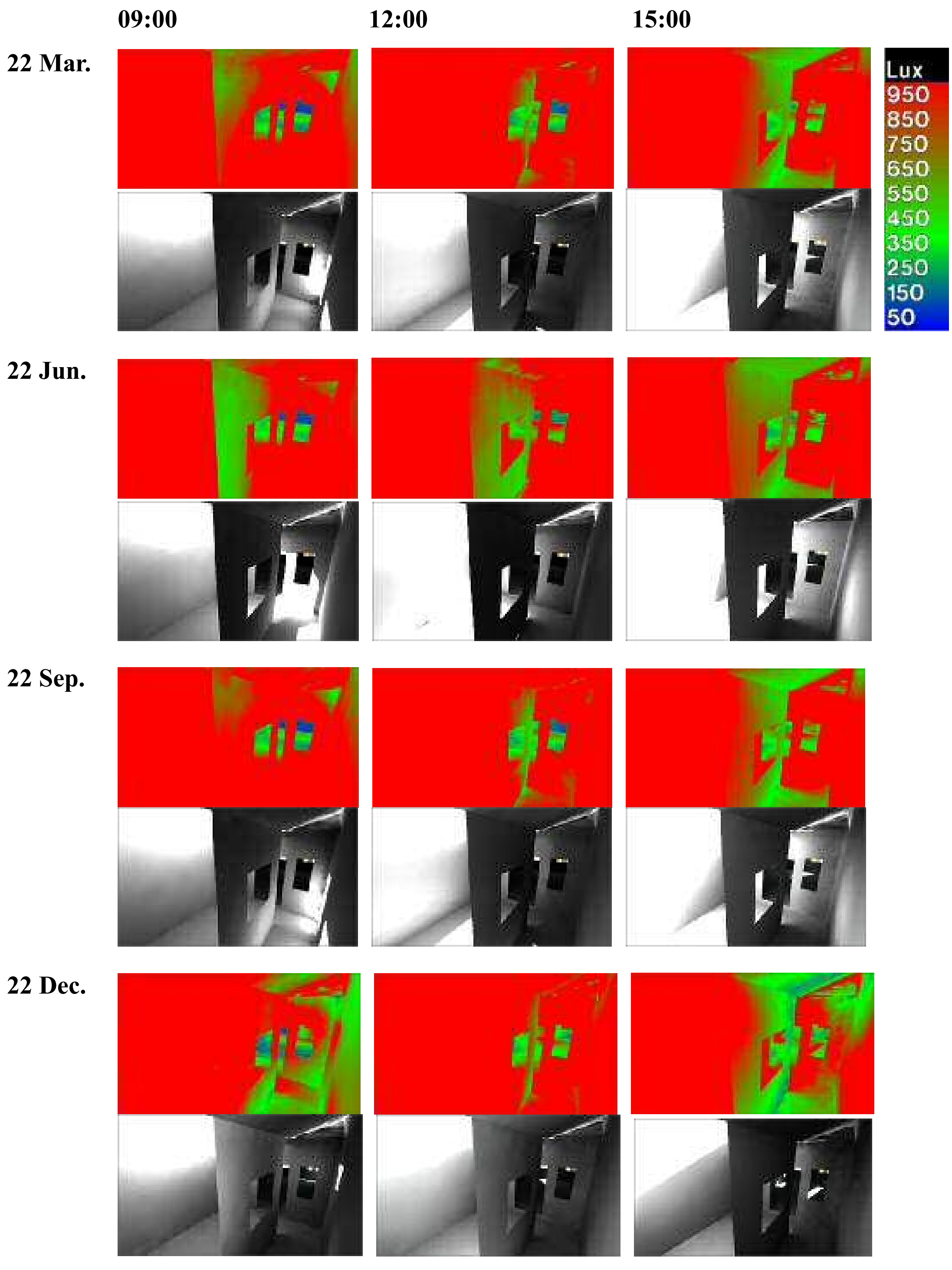


Figure 7.18c: False colour rendering of luminance (in lux) in the solstice and equinox days at three different hours at View-2, in *Courtyard-D1*, Daxi, Taiwan.

It is more comfortable by standing at View-2, because of the free standing wall of the outdoor pantry. In original planning, there is no such wall along the side of existing covered pathway between the first two buildings. Perhaps it is evident that the owner occupants really need something changes in their courtyards.

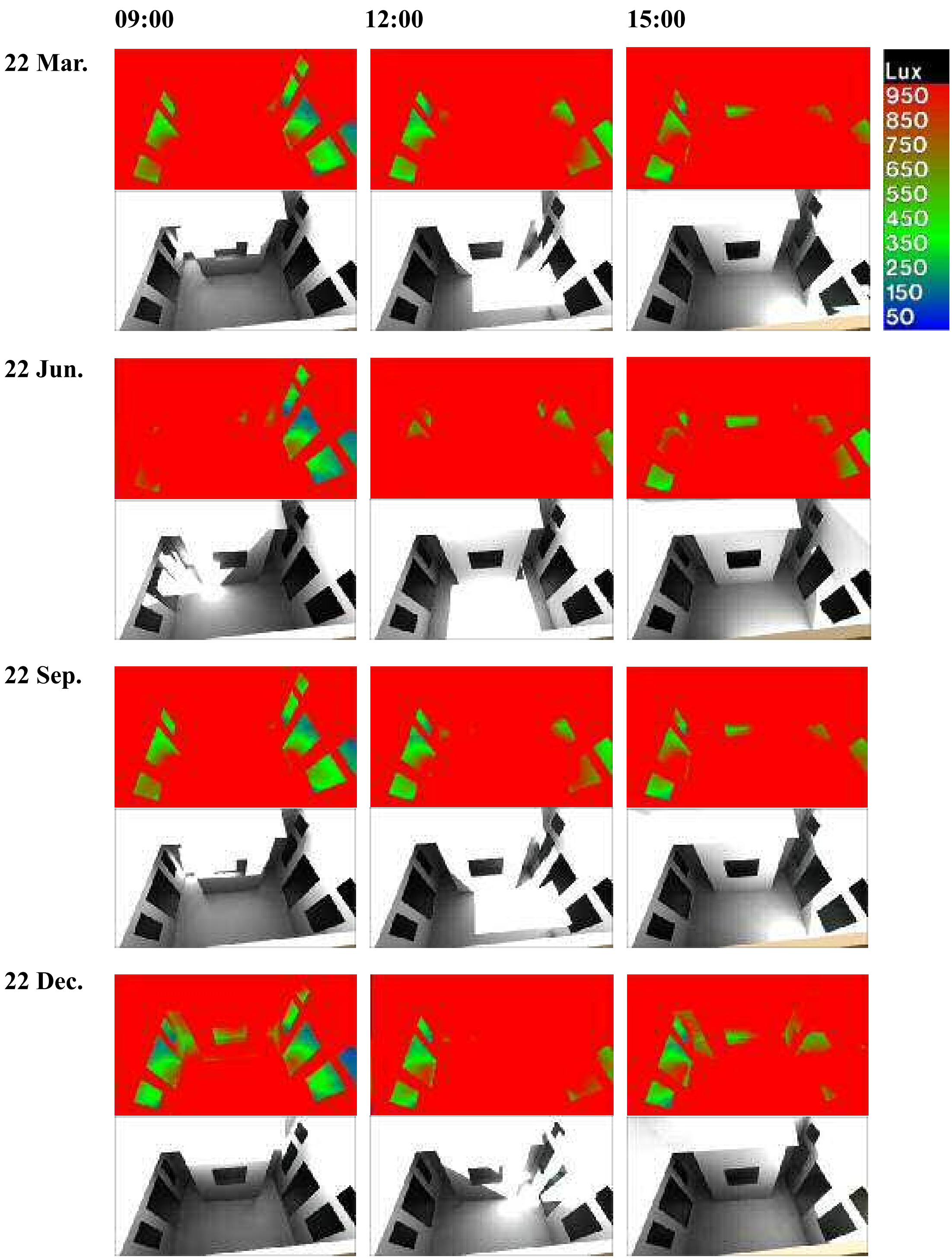
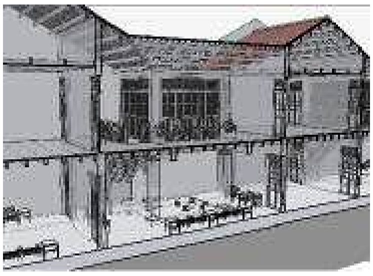


Figure 7.18d: False colour rendering of luminance (in lux) in the solstice and equinox days at three different hours at Upper View, in *Courtyard-D1*, Daxi, Taiwan.

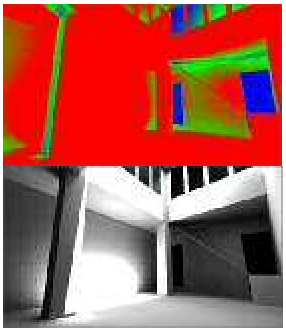
Continuating from the View-2, these Upper Views show the additional wall of outdoor pantry is providing a convenient space that can be used flexibly. This wall has blocked most strong sunlight during the daytime.



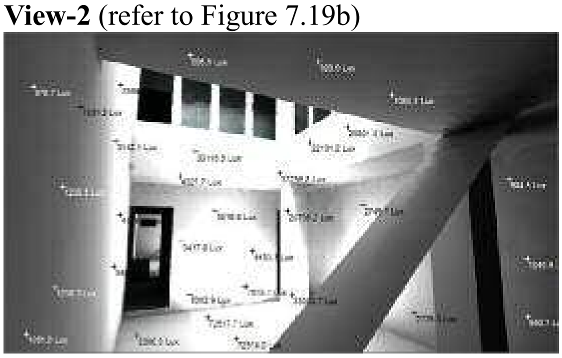
***Courtyard-P2**, double-storey case*

The same tests to *Courtyard-P2,* glare is expected less than Daxi but more intensive in the surrounding walls of the first courtyard. Through these frame again, it is evident that the summer solstice represents the time of the year with the highest risk of glare, especially starting from noon to afternoon. Figures 7.19a, 7.19b and 7.19c show that the experience of the movement of the 'spot' of sunlight.

22 Jun **15:00** **View-1** (refer to Figure 7.19a)



22 Mar **15:00** **View-2** (refer to Figure 7.19b)



22 Dec **15:00** **View-2** (refer to Figure 7.19b)

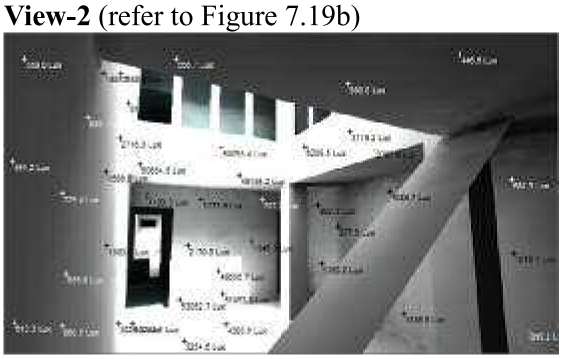


Figure 7.19a: Selected grayscale rendering of luminance (in lux) in the solstice and equinox days at afternoon in both ends of view, *Courtyard-P2*, Penang, Malaysia.

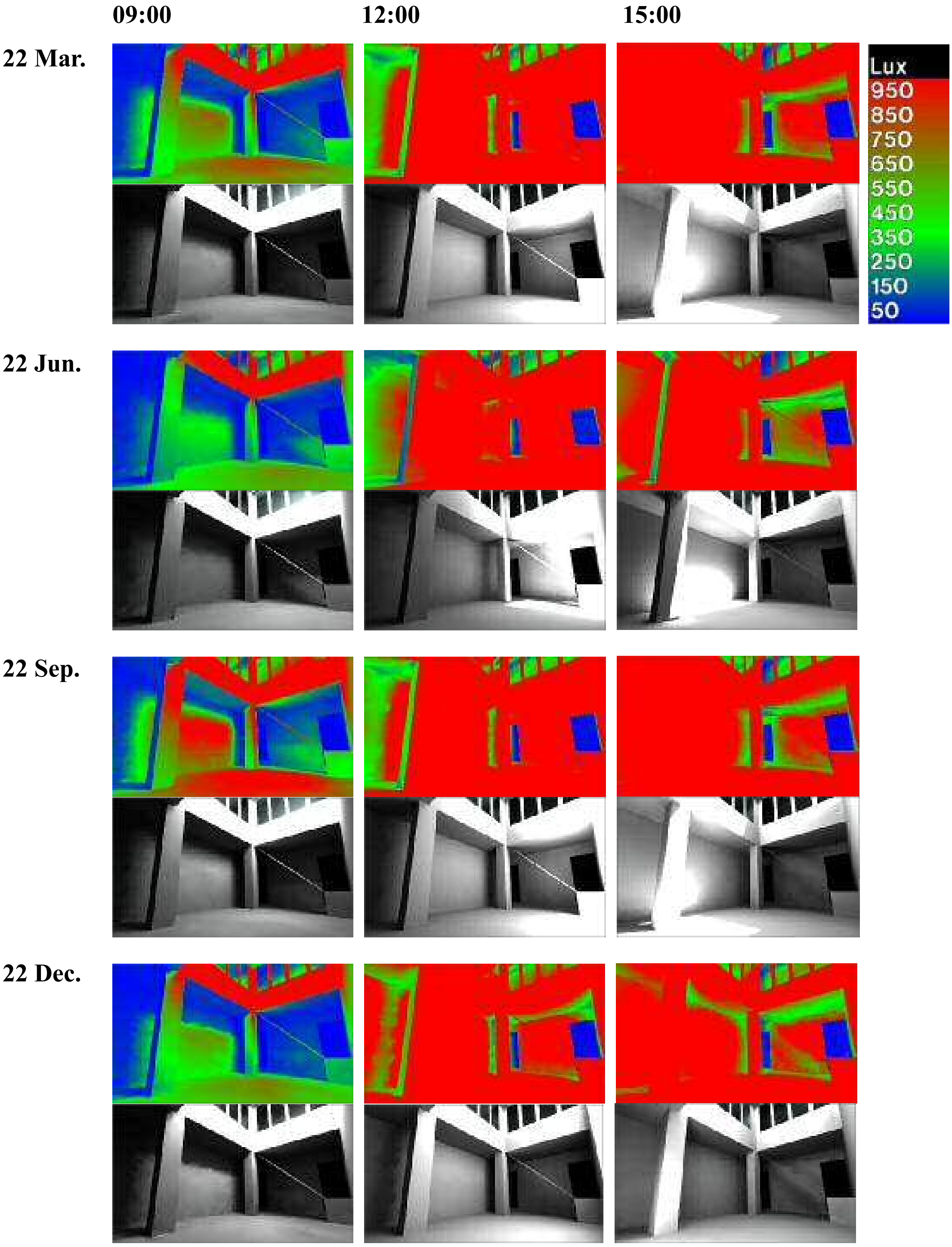


Figure 7.19b: False colour rendering of luminance (in lux) in the solstice and equinox days at three different hours at View-1, in *Courtyard-P2*, Penang, Malaysia.

From the images of View-1, glare is focused on the party wall and the wall of the shop section (southwest side of courtyard). The balconies provide another overhang to avoid direct solar radiation as well as rainy crosswinds. This is one of the design elements of a typical traditional shophouses.

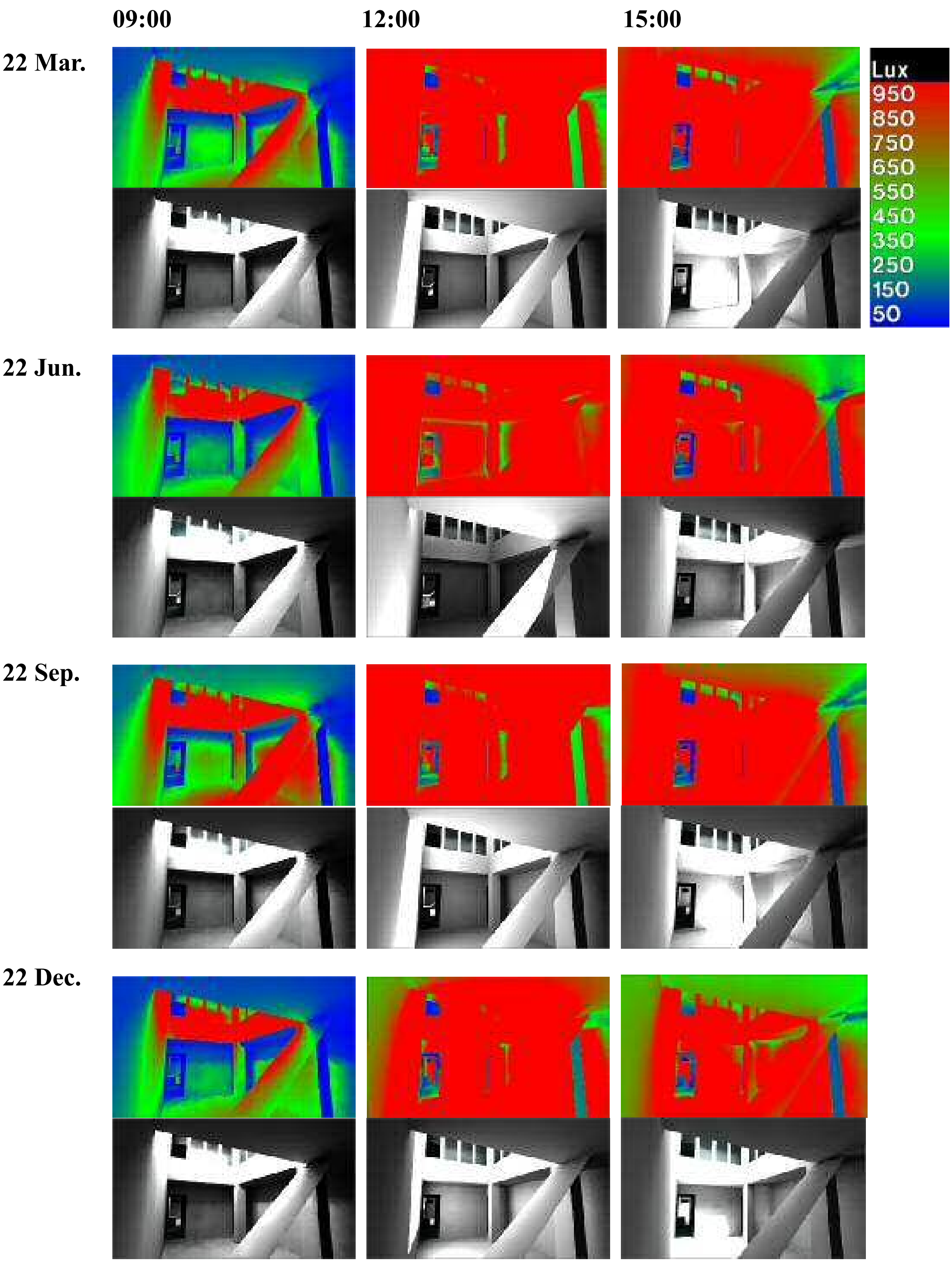
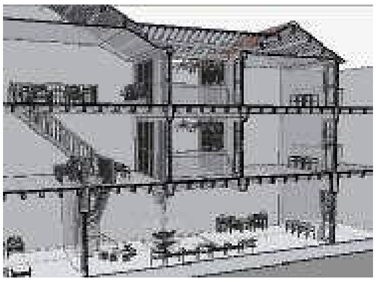
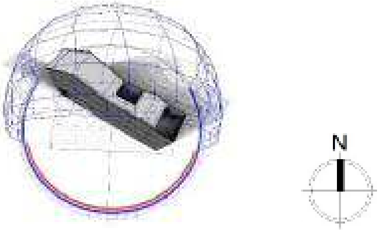


Figure 7.19c: False colour rendering of luminance (in lux) in the solstice and equinox days at three different hours at View-2, in *Courtyard-P2*, Penang, Malaysia.

Looking at courtyard from the beneath the balcony, the images of View-2 show the increased visual comfort, due to the full overhang reducing the glare effects effectively. Through these false colour renders again, however, it is evident that throughout the year, the space is still at high risk of glare starting from noon.

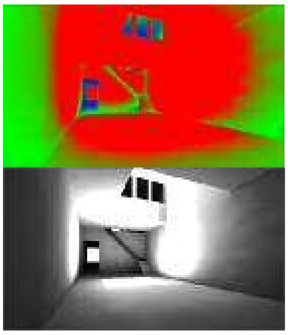


***Courtyard-S3**, three-storey case*



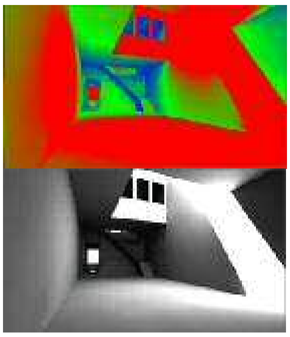
Because there are no any supporting pillars within *Courtyard-S3*, it looks much larger than the Penang one. The three-storey building height of walls can almost narrow the bright sunspot just onto the surrounding walls at most times. However, as the brightness remains towards one side of the ground floor courtyard, while the opposite side remains relatively dark. The luminance is found to reach high levels where the direct sun enters the spaces, with to the range between 30,000 lux and 70,000 lux.

22 Sep **12:00**

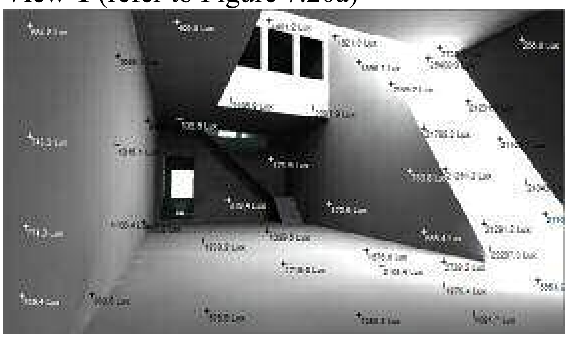


View-1 (refer to Figure 7.20a)

22 Sep **15:00**



View-1 (refer to Figure 7.20a)



22 Sep **12:00**

View-2 (refer to Figure 7.20b)

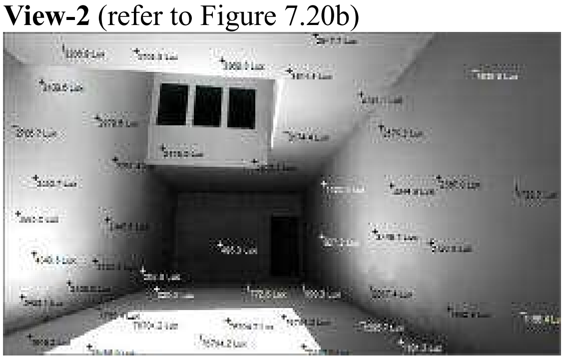


Figure 7.20a: Selected grayscale rendering of luminance (in lux) in the equinox days at noon and afternoon in both ends of view, *Courtyard-S3*, Singapore.

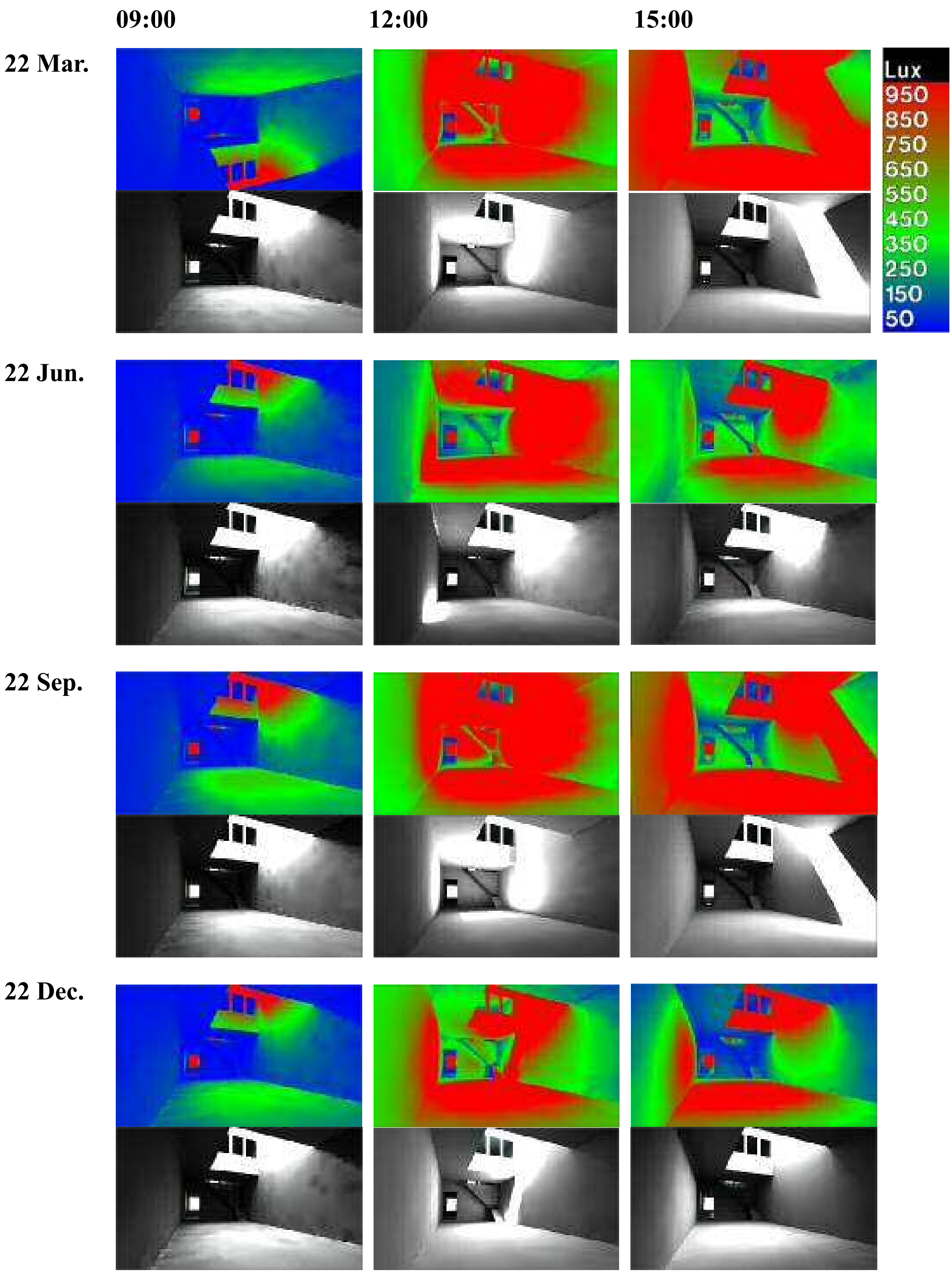


Figure 7.20b: False colour rendering of luminance (in lux) in the solstice and equinox days at three different hours at View-1, in *Courtyard-S3*, Singapore.

From the images of View-1, the brightest areas are found spreading onto the party walls and falling down to the floor of the courtyard without being blocked at most times. Such spatial arrangement seems to intensify the difference between shadow and light, and is likely to be experienced as glare.

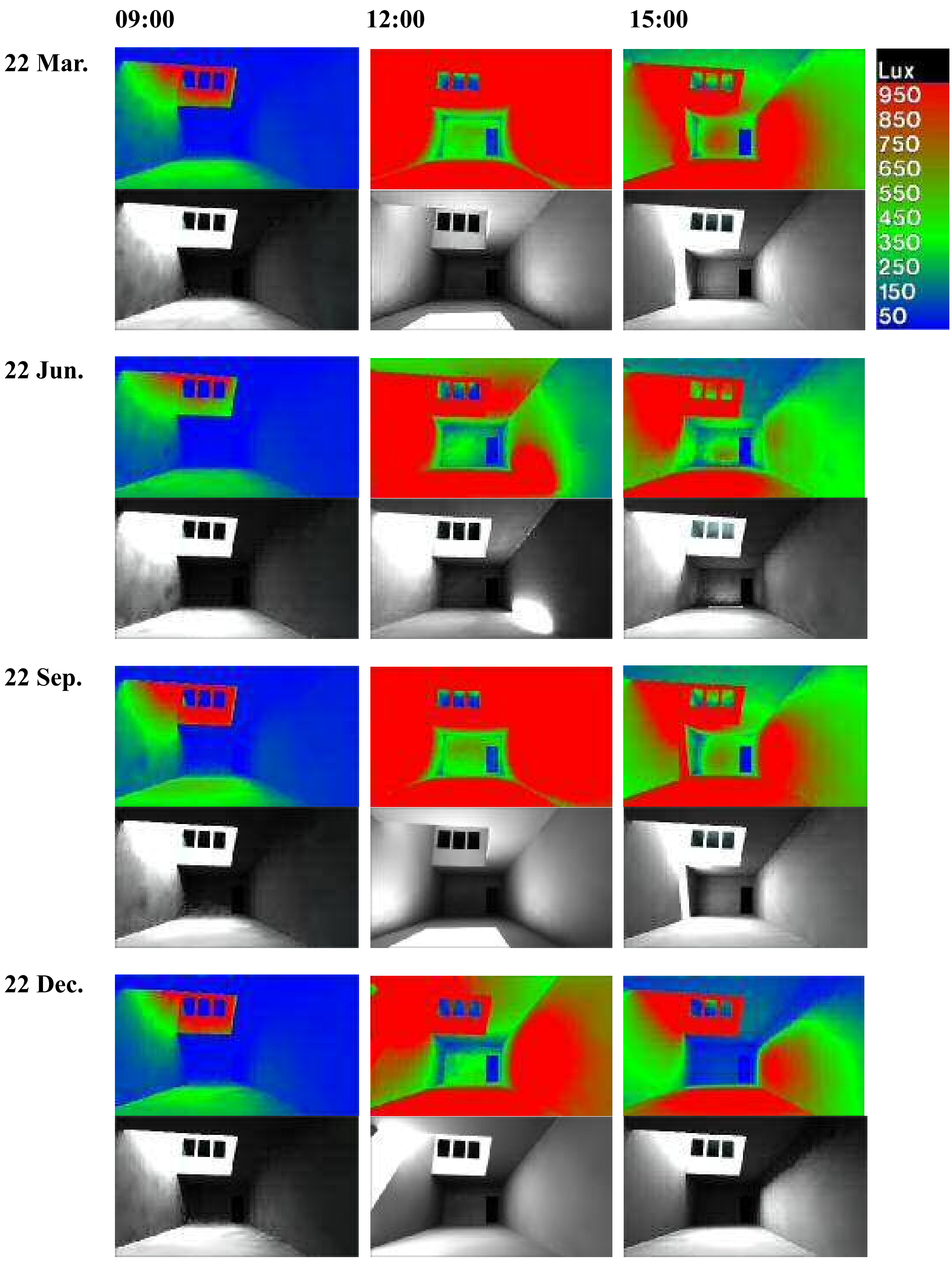


Figure 7.20c: False colour rendering of luminance (in lux) in the solstice and equinox days at three different hours at View-2, in *Courtyard-S3*, Singapore.

Both View-1 and View-2 showing a high-contrast daylight environment within the space of courtyard. It is apparent that the traditional design elements, such as deep overhang, balconies, and staircase, generate a basic living environment in which it is possible to find visual comfort, where households are able to use the space flexibly, avoiding the direct penetrating sun.

Among these three case study shophouses, it was unsurprising that a multi storey courtyard building showed better daylight factor performance when compared to a single storey one. From the rendered images presented, the findings also show that factors such as deep overhang resulted in better daylight performances in comparison with just simple shades. Thus, deep overhang planning was appropriate for daylighting design, especially for sunlight control. Although the glare problem is unavoidable, the traditional design elements and the forms of courtyard are suitable and capable for architects or owner occupants to re-design and adjust the problem to an acceptable level, especially through flexible and varied use of the space temporally.

In order to solve remaining problems, in particular where modern commercial use does not allow for such variation in function through time and space, it is argued here that there is no need to permanently cover the top of courtyards: instead, proper ecological design recommendation is needed for energy saving and visual comfort in traditional shophouse buildings.

7.3. Summary

This chapter has presented the lighting related studies of the shophouse typologies that utilizes a main courtyard and surrounding envelope to enhance high daylight also in their centre and visual cross-corner connection. The courtyard designs represent a traditional zero energy solar shophouse with respect to other high-performance houses. Results of daylight simulations have allowed discussing extensively parameters such as Daylight Factor, Daylight Autonomy, and Sky Component. Moreover, this chapter has investigated the problem of visual comfort inside the courtyards due to high solar exposure.

However, the role of daylight in the three categories of courtyards is often different. The most effective way to manage the amount of solar heat gain is to block it before it enters the building, something that is becoming ever important with the increasing use of glass within architecture. The traditional internal shading solutions often lead to further energy use as electrical lighting is required due to the low levels of natural daylight. The challenge therefore is to maximize the benefits gained from solar shading whilst optimizing natural daylight – often referred to as sky light white ultimately controlling the effects of direct solar radiation. External shading systems present a simple solution and have been utilised for many years but technological advancements have made them more versatile and appealing to architects, allowing them to be integrated into the building envelope as a dynamic façade.

The traditional ideas of the courtyard is still relevant to modern Southeast Asian dwellings. Transformed and/or retained, the courtyard idea still provides one of the prototypes of the modern shophouse dwelling. The various forms it has taken serve to promote the continuity and consistency of traditional shophouse architecture.

8. Flow Patterns in Courtyards: Computational Fluid Dynamics Simulation

Wind can be a friend to buildings because it can aid natural ventilation, providing a comfortable and healthy indoor environment, as well as saving energy. However, wind can also be an enemy when it causes discomfort to pedestrians, usually as a result of high wind speeds outside buildings (Chen 2004). Providing a central source of central air and light, courtyards play an important role in many traditional shophouses in Southeast Asia. When creating this building type, people in this region instinctively knew that the temperatures in their courtyards felt cooler and more comfortable than outside temperatures. It is well-known that a courtyard once existed, which is so constructed that it gives protection against the environmental temperature, and thereby assure itself as valuable today as they were in the past.

This study investigates internal airflow conditions in traditional shophouses in northern Taiwan, George Town, Penang, and Chinatown, Singapore, using the computational tool DesignBuilder CFD, to evaluate air flow in relation to architectural environmental design. It is important to understand traditional passive cooling techniques used in and around vernacular shophouse in Southeast Asia and apply them to the modernization of these urban houses. This analysis will consider the same three major types of vernacular shophouse found in the above areas analysed in the previous chapter. The three-storey (*Courtyard-S3*), the double-storey (*Courtyard-P2*), and the single-storey (*Courtyard-D1*) shophouses.

8.1. Introduction

Computational Fluid Dynamics (CFD) techniques are becoming an alternative and common method to investigate natural ventilation in buildings due to their informative results and low labour and equipment costs (Murakami *et al.* 1999). Over the last few years the improvement of the CFD has made it possible to get a better understanding of and to simulate the airflow which occurs in ventilated rooms and buildings. Only in recent years and as a result of increasing computational power have the three-dimensional geometrical models applicable at building scales become fine enough to enable sufficiently accurate modelling at these scales to minimize the adverse impact in the models resulting from the theory of turbulence (Almhafdy *et al.* 2014).

Starting from the climate consideration in architectural design, the CFD simulation is used to understand the wind environment in the Southeast Asian traditional courtyard shophouse based on the tropical climate conditions. Firstly, the wind environment in the original courtyard shophouse settlement is simulated. Secondly, and following the three major types of building, parametric studies on the formation of area-height ratio (A/H) on the thermal study in shophouse courtyards are conducted. Finally, several variants of courtyard shophouses were also tested in the final phase of this research, as presented in Chapter 9.

8.1.1. Literature review on previous studies

Courtyard buildings can be found not only in China or Southeast Asia but also in many other parts of the world (Edwards 2006). Worldwide, many studies on CFD simulation for vernacular buildings in different climate regions have been conducted. However, regarding the traditional shophouse in Southeast Asia, although there is a lot of research and practice on the associated architectural design issues, such as spatial design, cultural context inheritance and heritage conservation, there are only few studies on the wind flow and/or pressure based on CFD simulation.

Many researchers have studied and applied various CFD models, including Franke *et al.* (2004) for wind engineering on an urban scale, Sapian (2009) for high-rise buildings and Li and Nielsen (2011) for types of opening.

In the first study (Bauman et al. 1988), wind tunnel measurements have been made of the wind pressure distributions over an attached two-storey shop or housing unit contained in long building rows for a range of wind directions, building spacing, and building geometries. The results of this work were analyzed to assess the nature of wind pressure effects caused by surrounding building rows of the same size. The jack roof along with the choice of inlet and outlet locations have been discussed in an effort to identify promising naturally ventilated designs in closely spaced buildings typical of urban environments. The entire courtyard area was found to consistently fall within the wake flow region of the upwind building row. This was because the largest courtyard spacing tested was S_C=1 (length=height).

Later, Kato (1988) and Murakami *et al.* (1993) proposed a residential building model with voids (courtyards) which is appropriate for hot and humid regions of Asia with high population densities that also reduces the environment load of buildings. This study explained an outline of a porous-type residential building model in Hanoi and the design process for introducing voids in buildings in order to improve natural cross ventilation effectively. Furthermore, the effects of natural ventilation, solar shading, and other devices for reducing the air conditioning, cooling and, environmental load are estimated. Those ideas of 'voids' in the buildings bring advantages to the architectural, environmental, and structural aspects, which can be summarized as follows:

1. indoor environmental control with a low environmental load using the potential of the outdoor environment will be possible: where the voids facilitate natural ventilation and enable the IAQ to be controlled;
2. solar shading performance will be improved by introducing voids in the buildings.

In many cases, orientation of the courtyard depends on the building layout. Variables that can positively affect the microclimate condition within the courtyard are sun location, wind direction, shading performance and solar gain (Bagneid 2006). The orientation also has a direct effect on the ventilation or wind speed. For instance, Mier *et al.* (1995) concluded that the correct direction of courtyards can improve their thermal comfort; however, orienting them irrespective of solar angles and wind direction may create thermal discomfort. While past studies have not verified as to which courtyard orientation performs best, the general rule is that, in this climatic context, the courtyard orientation is to be elongated, facing north and south. It is interesting that in some cases where the courtyards walls are elongated towards the east and west, higher building blocks are introduced. This serves to moderate the heat transfer into the courtyard spaces.

Wall enclosure can play an important role in the microclimate condition of the courtyard through natural ventilation techniques. Wall enclosures can be manipulated by opening or closing of the apertures and by changing the window to wall ratio. Al-Hemiddi and Al-Saud (2001) investigated the effect of a ventilated interior courtyard on the thermal performance of a house in two situations. One with all exterior and interior windows (without ventilation) closed and the other with all apertures opened. The results show insignificant cooling when all windows are closed. However, there was a significant cooling effect through the courtyard via natural ventilation when all windows were opened. Therefore, in light of the above review, it is proposed that in this research a schedule for opening and closing of the doors and windows be undertaken to investigate natural ventilation.

A series of wind tunnel studies in Singapore (Wong and Chin 2002), considered the Wind Pressure Distribution (WPD) around a shophouse building to be an important parameter for multi-zone airflow simulation. The input is usually in the form of pressure coefficients (C_P). Using the C_P values obtained from the wind tunnel as the reference, the accuracy of the C_P values generated by the WPD model and the wall average values are analyzed and discussed. The effects of such accuracy on the computed airflow rates and age of air in the building, using a multi-zone network airflow model, were also considered for further discussion. With the advantage of computer technology and the confidence gained in the use of computational fluid dynamics (CFD) software for the study of ventilation in buildings, CFD has also been used for the study of airflow around buildings and thus is considered appropriate for use in the context of the shophouse courtyards.

The above have all reported that the accuracy of CFD models depends on the grid size, the boundary conditions, and the type of approximations used. More specific research applying CFD to research at the building scale has suggested the following:

Stack ventilation: Livermore and Woods (2006) studied the application of stack ventilation as secondary ventilation for multiple storey buildings (2-3 floors). The secondary ventilation within the lower floor is shown to increase with the ratio of the size of the openings on the lower to the upper floor and also the height of the stack. Results indicate that the lower openings need a large inlet area to preserve the high amount in the ventilation through the upper floor.

Buoyancy force inside a courtyard: Chiang and Anh (2012) have studied the effects of natural ventilation enhanced by buoyancy force inside a courtyard in high-rise residential building using Phoenics/Flair. A gradient of air temperature and airflow velocity in the courtyard is observed for all situations. The gradient is non-linear and is particularly high near the top of courtyard.

Natural Ventilation: Another investigation on the natural ventilation within a courtyard and another urban form was done by Taleghani *et al.* (2015). The courtyard form was analyzed for the hottest day so far in the temperate climate of the Netherlands (19th June 2000 with the maximum 33°C air temperature). The results establish that the duration of direct sun and mean radiant temperature (MRT) play a significant effect in thermal comfort. Taleghani's study has shown that the aspect ratio and cantilevered roof is significant role in promoting wind speed and enhancing the thermal comfort. In addition, increasing the shading area using cantilevered roofs has been shown to promote a remarkable improvement in occupant thermal comfort.

The courtyard offers the most comfortable microclimate compared to the other studied urban forms. As a matter of fact, the most efficient way of using courtyards in a temperate climate is to design urban courtyards. Designing small scale courtyards, such as those found in traditional shophouses, however, needs more attention in winter. Courtyards provide more indoor and outdoor comfort in comparison with linear and singular forms.

Multi-storey buildings were narrow and room depth was limited to about twice the floor to ceiling height. Deep plan spaces were lit from above. In cases where multi-storey buildings required deep plans they were pierced with lightwells. The enclosed courtyard is often used in deep plan, shophouse buildings to provide light and ventilation. In some sections, the roofs slope into the courtyard, allowing the penetration of air, rainwater, and light. Also, the larger the façade is, the larger the courtyards and greater potential for ventilation are (Gurstein 1984). In his article, Hyde (2013) highlights three main techniques (Figure 8.1) are used to maximize ventilation by the analysis of the window and glazing:

First, from the street, the elevation has approximately a 50% ratio of opening to wall with operable and permanent ventilation.

Second, at the first-floor level, the perimeter is enclosed by a similar fenestration pattern as the façade but with 75% operable windows.

Finally, in smaller courtyards (air well), the proportion of the courtyard changes so that the height is greater than the floor plan. This has the effect of reducing the sky openings and thus provides shading to the courtyard.

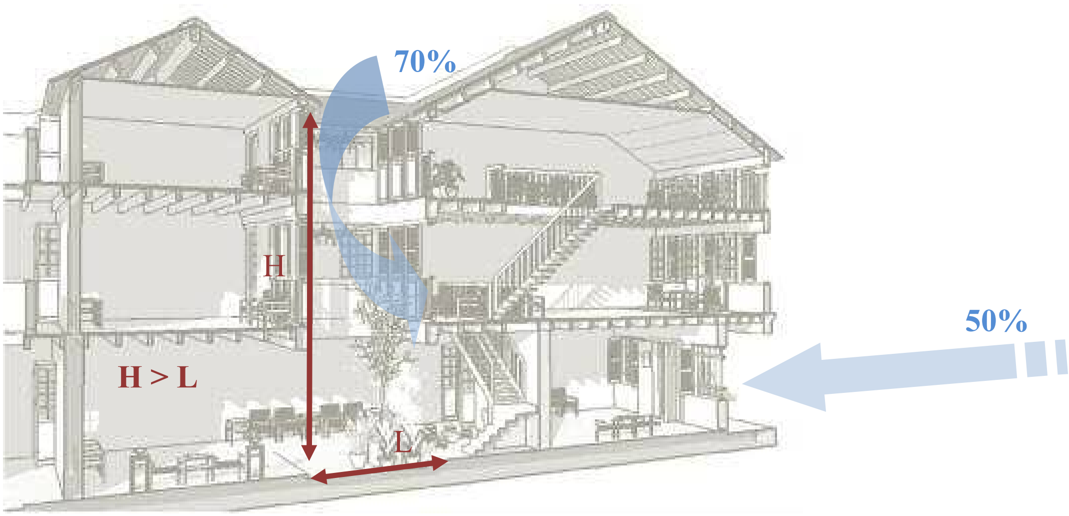


Figure 8.1: Section of a shophouse showing vertical openings for ventilation and horizontal shading effects. (Source: Hyde, 2013; Illustration by author, 2013)

A study which focused on the wind flow pattern in a small group of shophouse was conducted by the author (Li 2011), which is the initial part of this study. CFD software Virtualwind was employed to quickly predict, understand, and convey complex wind flow phenomena in the surrounding urban environments (Figure 8.2). Virtualwind is targeted toward CFD non-experts who need to understand 3D microclimate wind flows in complex environments (RWDI 2009). However, this is not intended for high-end CFD analysis of general flow physics processes, for which several costly commercial high-end CFD software packages are available. And it is also not intended to replace highly accurate physical wind tunnel modelling, such as the determination of pressures on buildings and outdoor structures. Virtualwind was not longer available after 2011.

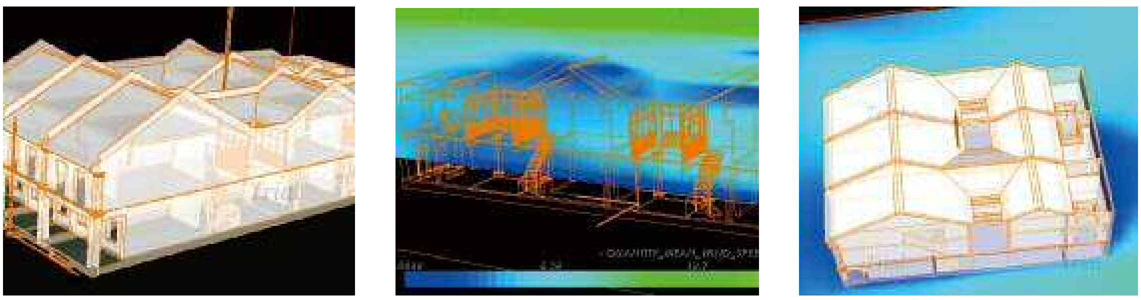


Figure 8.2: The small groups of double-storey and three-storey shophouse model and the animation shown in airflow movements in a previous study. (Source: Conducted by author, 2011)

Following Virtualwind, another airflow simulation output by WinAir4 was exported back to Ecotect Analysis. This CFD simulated and recorded each configuration cell temperature, cell pressure and flow vector. Celsius Centigrade represents the cell temperature. Cell pressure is represented by the Pascal unit (Pa). Wind is represented by flow vectors to indicate the wind speed and direction. WinAir4 calculates the pressure of wind surrounding the courtyard. The wind speed is represented by miles per second. However, the generated output of WinAir4 velocity vector was not considered in terms of figures, yet it was backed up with the generated prevailing wind frequency from the weather tool wind rose of the locations of case studies. Therefore, the wind speed is represented by Km/h. The values were extracted from a horizontal and vertical analysis grid. The horizontal slice position of the analysis grid is close to the ground surface at around 600mm. The initial wind speed input is 0.2m/s. The initial wind temperature input obtained from the temperature wind rose for June is 35°C and for December is 16°C. The obtained simulation result focuses on the courtyard only, to scrutinize the effect of the configuration on the courtyard performance.

The use of simulation tools is one of the research activities in this thesis, where research to explore, in a simple manner, the airflow pattern around the courtyards will be undertaken in order to investigate basic principles and reasons for occurrence of a particular event, process, or phenomenon. In order to evaluate the limitations and benefits of retention of traditional shophouse courtyards, the main aim of this research, an effective and easy-to-use simulation tool has been selected in order to assist in this fundamental research on the original functions of shophouse courtyards.

8.1.2. Wind climatic conditions in Peninsular Malaysia and Taiwan

Though the wind over the country is generally light and variable, there are some uniform periodic changes in the wind flow patterns. Based on these changes, four seasons can be distinguished, namely, the southwest monsoon, northeast monsoon and two shorter periods of inter-monsoon seasons (MMD 2014).

Penang has sunshine throughout most of the days, but with rainfalls in the evenings during periods of monsoon winds. The months from April till November come under the influence of the southwest monsoon. The southwest monsoon season technically lasts from May till September, but rainfall is high in the lead up to and the tailing off of the monsoon winds. On average, it rains more than half of the days in each month and later on in the season it is unusual to see a day without any rain. Storms are severe with unbelievably fast and heavy rain and sometimes strong winds. While some are over quickly, these storms can last for days and are often accompanied by thunder and lightning (MMD 2014).

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	163	66	149	27.8	22.2	2.5
February	159	72	125	28.2	22.7	2.2
March	173	83	125	28.2	23.8	2
April	160	80	109	28.3	24.6	1.8
May	153	74	108	28.5	24.6	1.7
June	141	82	85	28.2	24.3	1.8
July	148	81	94	27.9	24.1	1.9
August	144	86	79	27.8	24	1.8
September	138	74	88	27.5	24	1.8
October	135	79	80	27.2	24	1.7
November	135	77	83	27.4	24	1.8
December	145	70	115	27.6	23.1	2.4
Year	1797	924	1240	27.9	23.8	1.9

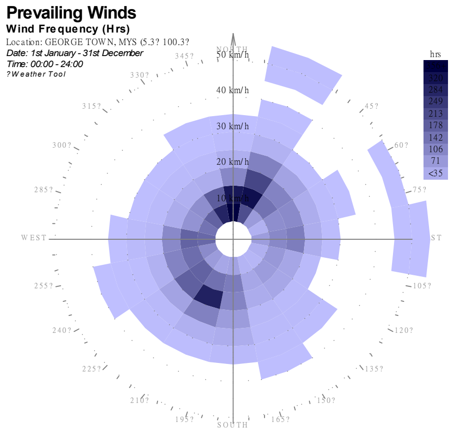


Figure 8.3: Data table and wind wheel of Georgetown in Penang, Malaysia. (Source: Meteonorm 7, Climate Consultant 2014, and Ecotect Weather Tool)

With almost no seasonal differences Singapore experiences a tropical rainforest climate, which always remains hot, humid. Generally the city is subject to two different monsoon seasons with middle pre-monsoon periods of slightly reduced rainfall. From March until May, Singapore sees the pre-southwest monsoon season, throughout which it experiences heavy early evening showers. As the season progresses, the level of rainfall and humidity reduces dramatically and winds appear less strong. Also, from June until September is the period of southwest monsoon season. The winds often become very strong in the mornings and mist is most likely at this time of year. October and November are considered as pre-northeast monsoon season and during this season, cool sea breezes help to reduce the afternoon heat. Although storms often occur in the evening, winds generally remain reduced. The Northeast monsoon season starts in December and lasts until March, when the northeast strong winds bring the heaviest rain of the year. During January and February violent winds often appear (NEA 2014; World Weather Online 2015).

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	141	74	99	27.1	23.4	3
February	144	76	96	27.7	23.5	3.2
March	153	90	87	28.1	24.2	2.2
April	138	83	80	28.6	24.7	1.4
May	134	70	96	29.1	24.8	1.8
June	130	71	86	28.8	24.5	2.1
July	137	79	87	28.3	24.4	2.4
August	140	81	85	28.4	24.3	2.5
September	135	79	80	28.3	24.2	2.2
October	137	84	73	28.3	24.2	1.8
November	118	74	64	27.8	24.3	1.6
December	123	69	80	27.4	24.1	2.3
Year	1632	929	1013	28.2	24.2	2.2

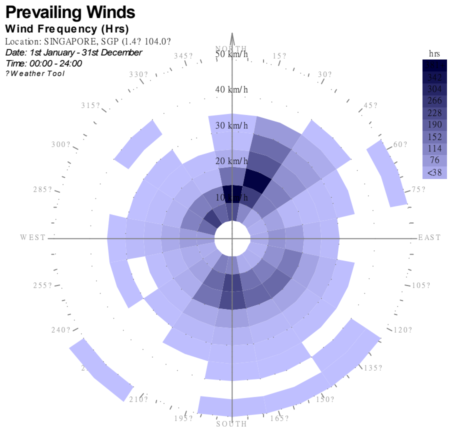


Figure 8.4: Data table and wind wheel of Chinatown in Singapore. (Source: Meteonorm 7, Climate Consultant 2014, and Ecotect Weather Tool)

Taoyuan, located to the north of Taiwan has a humid subtropical climate with four distinct seasons. Summers are hot and humid during the day, and warm and muggy at night. During the autumn months, the weather is at its best with temperatures typically in the 20°C and the largest percentage of comfortable and sunny days, providing the ideal time for outdoor activities. Winters tend to be cool and rainy, while, spring brings lots of rainfall, as this is during the rainy season. Taiwan also has a typhoon season, with most storms falling between July and September. Taoyuan is sometimes affected by strong winds and rains from these storms (CWB 2014).

As to the wind, what can be seen from Table 8.1 is that the average wind speed in Peninsular Malaysia is approximately between 2.4m/s to 3.2m/s.

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	65	46	38	13.9	10.4	4
February	65	49	28	14.9	11.7	3.8
March	86	62	36	16.9	12.7	3.5
April	107	76	45	20.8	16.4	3.2
May	127	86	59	24.1	19	3.1
June	143	87	77	26.5	21.8	2.7
July	183	85	134	28.1	22.6	3
August	160	77	115	27.6	22.8	2.9
September	136	74	91	25.6	21.1	3.8
October	97	68	49	22.7	18	4.3
November	78	46	60	19.6	15.4	4.3
December	66	42	49	15.9	12	4.2
Year	1310	797	780	21.4	17	3.6

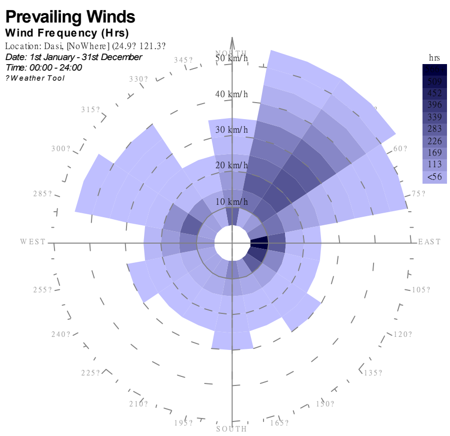


Figure 8.5: Data table and wind wheel of Daxi Township, Taoyuan County in Taiwan. (Source: Meteonorm 7, Climate Consultant 2014, and Ecotect Weather Tool)

Comparing Peninsular Malaysia and Northern Taiwan, this wind speed demonstrates the lowest and/or average speed during the whole year of Daxi area, in which the wind speed can reach 4.3m/s or even more due to the typhoon season (CWB, 2014). The highest frequency wind direction in Daxi is from the north-east (30°-50°, N=0°). In Peninsular Malaysia, frequencies of winds from different directions are relatively uniform (Figures 8.3 and 8.4).

	Georgetown, Penang, Malaysia		**Chinatown, Singapore**		**Daxi, Taoyuan County, Taiwan**	
	Wind Direction (degrees)	Wind Speed (m/s)	Wind Direction (degrees)	Wind Speed (m/s)	Wind Direction (degrees)	Wind Speed (m/s)
JAN	0	2.5 (avg.)	30	3	30	4
FEB	0	2.2	30	3.2 (avg.)	40	3.8
MAR	0	2	30	2.2	30	3.5
APR	0	1.8	40	1.4 (low)	110	3.2
MAY	0	1.7 (low)	0	1.8	80	3.1
JNU	0	1.8	120	2.1	50	2.7 (avg.)
JUL	0	1.9	190	2.4 (avg.)	90	3
AUG	0	1.8	200	2.5 (avg.)	90	2.9
SEP	0	1.8	150	2.2	100	3.8
OCT	0	1.7 (low)	0	1.8	40	4.3 (high)
NOV	0	1.8	0	1.6	50	4.3 (high)
DEC	20	2.4 (avg.)	20	2.3	30	4.2
YEAR		1.9		2.2		3.6

Table 8.1: Comparison chart of wind conditions between Peninsular Malaysia and Northern Taiwan. (Source: Meteonorm 7; Climate Consultant 2014; CWB, 2008)

In CFD simulations, a large number of choices needs to be made by the user. It is well-known that these choices can have a very large impact on the results. In a typical CFD simulation, the user has to choose the level of detail in the geometrical representation of the buildings, the size of the computational domain, the boundary conditions, the computational grid, the discretisation schemes, the initialisation data, the time step size and the iterative convergence criteria. Thus, the background of wind climate conditions provide this study a minimum requirements for the level of details.

8.1.3. Comparative thermal performance

This part of the study focuses on the comparative thermal performance of a combination of case studies from three distinct generic types of vernacular shophouses, and their different locations and climates. Thermal comfort for naturally ventilated buildings, especially in the courtyards of early shophouses, mainly depends on the size and orientation of the void openings. The objective of this study has been to evaluate the core urban courtyard in these case study shophouses in order to ascertain which type(s) has responded to the prevailing climate better than others and what factor(s) or strategies may be contributing to their improved performance.

In order to identify similarities and differences, this study used a comparison matrix to determine the basic characteristics of a courtyard in relation to the three local climates: Singapore, Penang, Malaysia and Taiwan. Using the aggregation method, a comparison matrix outlines the most typical features of the courtyard form without drawing a conclusion directly, but by simplifying the process of analysis. Table 8.2 lists the paired comparisons matrix of all of the three courtyard forms and weather data.

COURTYARD FORM	LOCAL WEATHER DATA		
	SGP	MYS	TWN
Courtyard-S3	S3-SGP	S3-MYS	S3-TWN
Courtyard-P2	P2-SGP	P2-MYS	P2-TWN
Courtyard-D1	D1-SGP	D1-MYS	D1-TWN

Table 8.2: Paired comparisons of courtyard form and local weather data matrix.

Thermal comfort is an imperative factor that determines the health and productivity of the occupants living in traditional shophouse buildings. Moreover, learning from the Southeast Asia vernacular has also established their effective thermal performances with respect to existing environments especially the warm-humid climates. It is interesting to note that all these courtyard forms are distinct and varied from each other and yet seem to be thermally comfortable in the varying composite climate conditions of the region.

Concurrently Ecotect models were developed for all nine paired cases with simulation for critical discomfort periods and tested for varying monthly degree days. The tested models were taking *void* as the deep structure of traditional shophouse courtyard types, by regulating its *windward surfaces*, a three-dimensional void-regulated system of airflow pattern would be developed. When the courtyard is surrounded by built mass and maintaining direct contacts with the outdoor environment through openings, the space above the courtyard can act as an opening that discharges airs into the sky while openings in the envelope act as inlets. Considering the flow of incoming air within the courtyard, the top area, where ventilation inlets to the ground area, and to the eave height (maximum courtyard void height) ratio (A/H) was selected as the variable in this parametric study. Three different A/H ratios are re-checked and defined for comparison range from 1:1:4m (*Courtyard-D1*), 1:4:8m (*Courtyard-P2*) to 1:6:10m (*Courtyard-S3*). Figure 8.6 show the diagrams of current courtyard void cases with A/H ratios.

The thermal analysis undertaken below using Ecotect Thermal Analysis included several calculations, including:

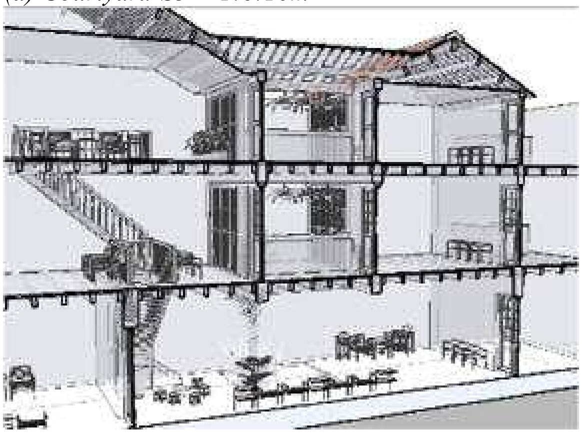
heating degree days (HDD),
cooling degree days (CDD), and
total heat gains and losses.

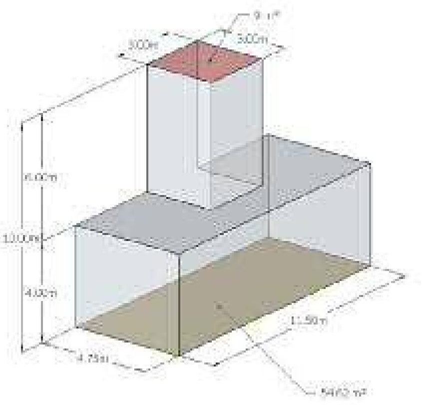
Where degree days are a specialist type of weather data, calculated from readings of outside air temperature, these are measures of how cold or warm a courtyard is, where each measure indicates the period of time multiplied by the number of °C by which the temperature differs from comfort, therefore indicating a measure of heating or cooling required. This section studied degree day patterns to assess the climate and the heating and cooling needs for the three different regions of the country during the seasons of the year.

Each calculation is analyzed separately, and then the relation between all analysis and courtyards are expressed. The relevant extracted data is summarized using Excel and then tabulated below. In order to comprehend the behaviour of the different courtyard configurations, it is important to verify the factors that affect the simulations.

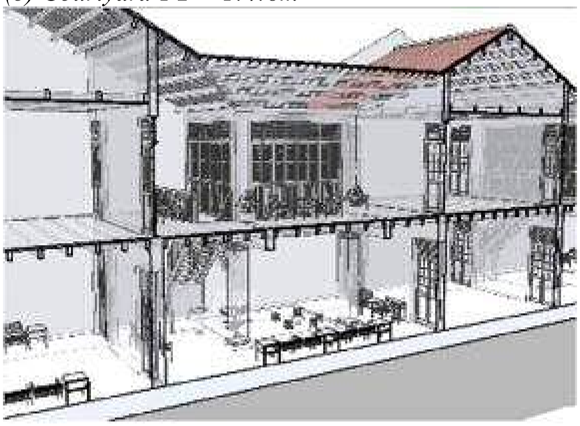
As discussed earlier, the independent factors, or the varying parameters are the courtyard form and configuration, and the opening orientation. These influence the performance of the dependent factors; which are natural daylight and thermal comfort within the inter-zonal adjacencies, airflow, solar exposure, and shading within the courtyard.

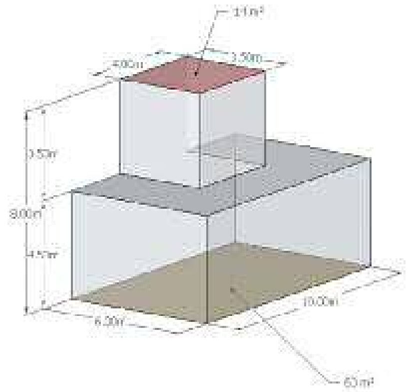
(a) Courtyard-S3 = 1:6:10m



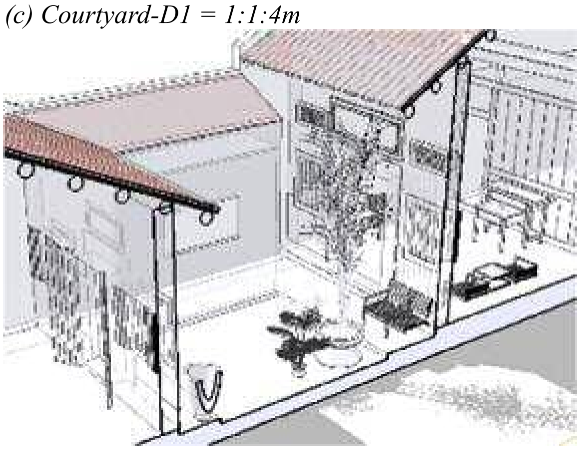


(b) Courtyard-P2 = 1:4:8m





(c) Courtyard-D1 = 1:1:4m



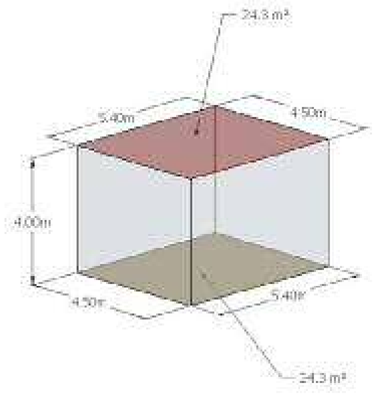


Figure 8.6: Courtyard void configurations of current case studies with different A/H ratio: (a) Chinatown in Singapore (SGP); (b) George Town in Penang, Malaysia (MYS); and (c) Daxi in Taiwan (TWN).

‘Degree days’ is a quantitative index demonstrated to reflect demand for energy to heat or cool houses and businesses. They are commonly used in monitoring and targeting to model the relationship between energy consumption and outside air temperature. The following A3-format page (Table 8.3) shows a summary of monthly degree days of the 3 courtyard forms against the 3 different locations of weather data. Each of the sub-table is showing the monthly raw data of the paired courtyard in:

1. heating degree days (HDD),
2. cooling degree days (CDD),
3. total heat losses, and
4. total heat gains.

In terms of monthly degree days, both Singapore and Malaysia with 6 paired courtyard forms (S3-SGP, S3-MYS, P2-SGP, P2-MYS, D1-SGP, and D1-MYS) are accounted as zero heating degree day throughout a year, while in Northern Taiwan, it has the peak 31.5 heating degree days in winter, January, as the season change in Taiwan affects solar heat gain values. Where summer, lasting from May to October, are also accounted as zero heating degree days, while in spring, April, it has the minimum 0.1 and the average is 7.3 heating degree days.

While in terms of cooling degree days, all three locations are accounted at least over 210 cooling degree days. Where, Taiwan tops the list in summer, July, with 264.5 cooling degree days followed by Singapore and Malaysia with 223.8 and 215.1 cooling degree days respectively. It has the minimum 3.6 and the average is 104 cooling degree days throughout a year, while in Southeast Asia, both Singapore and Malaysia have the minimum at least 165 cooling degree days. The difference of the average between two regions are over 90 cooling degree days.

This is justified, as Northern Taiwan has obvious seasonal changes comparing it to the Southeast Asian locations of Singapore and Penang, which admits a lower rate of average solar heat gains throughout a year. Please refer the comparison matrix in Table 8.3.

MONTHLY DEGREE DAYS: S3-SGP				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	0	176.4	0	40284
Feb	0	174.5	0	39982
Mar	0	204.9	0	44544
Apr	0	213.6	0	46541
May	0	223.2	0	46636
Jun	0	223.8	0	45655
Jul	0	209.9	0	45279
Aug	0	209.3	0	43905
Sep	0	186.5	0	41031
Oct	0	201	0	42359
Nov	0	170.9	0	36815
Dec	0	165.4	0	36944
Average	0	196.62	0	42497.92

MONTHLY DEGREE DAYS: S3-MYS				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	0	194.3	0	44873
Feb	0	183.5	0	44290
Mar	0	215.1	0	51048
Apr	0	207.1	0	46920
May	0	209.6	0	46573
Jun	0	203.5	0	44084
Jul	0	192.2	0	42574
Aug	0	184.2	0	40345
Sep	0	169.7	0	39237
Oct	0	172.5	0	38580
Nov	0	173	0	38911
Dec	0	187.2	0	40133
Average	0	190.99	0	43130.67

MONTHLY DEGREE DAYS: S3-TWN				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	31.5	4.1	5373	15204
Feb	23.8	3.6	4426	14334
Mar	15.2	27	2880	22805
Apr	0.1	55.8	85	29731
May	0	124.5	11	33487
Jun	0	184.5	67	38641
Jul	0	264.5	42	52525
Aug	0	246.1	52	51650
Sep	0	180.1	87	35950
Oct	0	88.5	2	27070
Nov	3.4	56	694	20264
Dec	13.7	13.5	2514	18029
Average	7.31	104.02	1352.75	29974.17

MONTHLY DEGREE DAYS: P2-SGP				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	0	176.4	0	45344
Feb	0	174.5	0	45004
Mar	0	204.9	0	49856
Apr	0	213.6	0	51573
May	0	223.2	0	51192
Jun	0	223.8	0	49767
Jul	0	209.9	0	49837
Aug	0	209.3	0	48460
Sep	0	186.5	0	45834
Oct	0	201	0	47224
Nov	0	170.9	0	41175
Dec	0	165.4	0	41415
Average	0	196.62	0	47223.42

MONTHLY DEGREE DAYS: P2-MYS				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	0	194.3	0	50601
Feb	0	183.5	0	49989
Mar	0	215.1	0	57215
Apr	0	207.1	0	52115
May	0	209.6	0	51466
Jun	0	203.5	0	48657
Jul	0	192.2	0	47134
Aug	0	184.2	0	44868
Sep	0	169.7	0	44113
Oct	0	172.5	0	43176
Nov	0	173	0	43710
Dec	0	187.2	0	44811
Average	0	190.99	0	48154.58

MONTHLY DEGREE DAYS: P2-TWN				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	31.5	4.1	5096	18186
Feb	23.8	3.6	4220	16975
Mar	15.2	27	2657	26942
Apr	0.1	55.8	83	34107
May	0	124.5	4	38153
Jun	0	184.5	25	43550
Jul	0	264.5	25	58444
Aug	0	246.1	24	58158
Sep	0	180.1	45	41332
Oct	0	88.5	0	31547
Nov	3.4	56	667	23316
Dec	13.7	13.5	2421	20993
Average	7.31	104.02	1272.25	34308.58

MONTHLY DEGREE DAYS: D1-SGP				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	0	176.4	0	95719
Feb	0	174.5	0	94792
Mar	0	204.9	0	102835
Apr	0	213.6	0	104592
May	0	223.2	0	102482
Jun	0	223.8	0	97538
Jul	0	209.9	0	100799
Aug	0	209.3	0	98281
Sep	0	186.5	0	94651
Oct	0	201	0	96794
Nov	0	170.9	0	86594
Dec	0	165.4	0	87262
Average	0	196.62	0	96861.58

MONTHLY DEGREE DAYS: D1-MYS				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	0	194.3	0	105263
Feb	0	183.5	0	104382
Mar	0	215.1	0	118291
Apr	0	207.1	0	107071
May	0	209.6	0	104766
Jun	0	203.5	0	99276
Jul	0	192.2	0	97214
Aug	0	184.2	0	93975
Sep	0	169.7	0	94397
Oct	0	172.5	0	91374
Nov	0	173	0	92242
Dec	0	187.2	0	93093
Average	0	190.99	0	100112

MONTHLY DEGREE DAYS: D1-TWN				
MONTH	HEATDD (dd)	COOLDD (dd)	LOSSES (Wh)	GAINS (Wh)
Jan	31.5	4.1	4160	44392
Feb	23.8	3.6	3324	41143
Mar	15.2	27	2003	64346
Apr	0.1	55.8	20	76728
May	0	124.5	0	84347
Jun	0	184.5	0	94741
Jul	0	264.5	2	119500
Aug	0	246.1	0	122018
Sep	0	180.1	0	92860
Oct	0	88.5	0	74416
Nov	3.4	56	533	52978
Dec	13.7	13.5	1877	48440
Average	7.31	104.02	993.25	76325.75

Peak

Minimum

Table 8.3: Comparison matrix for monthly degree days of the 9 paired courtyard forms.

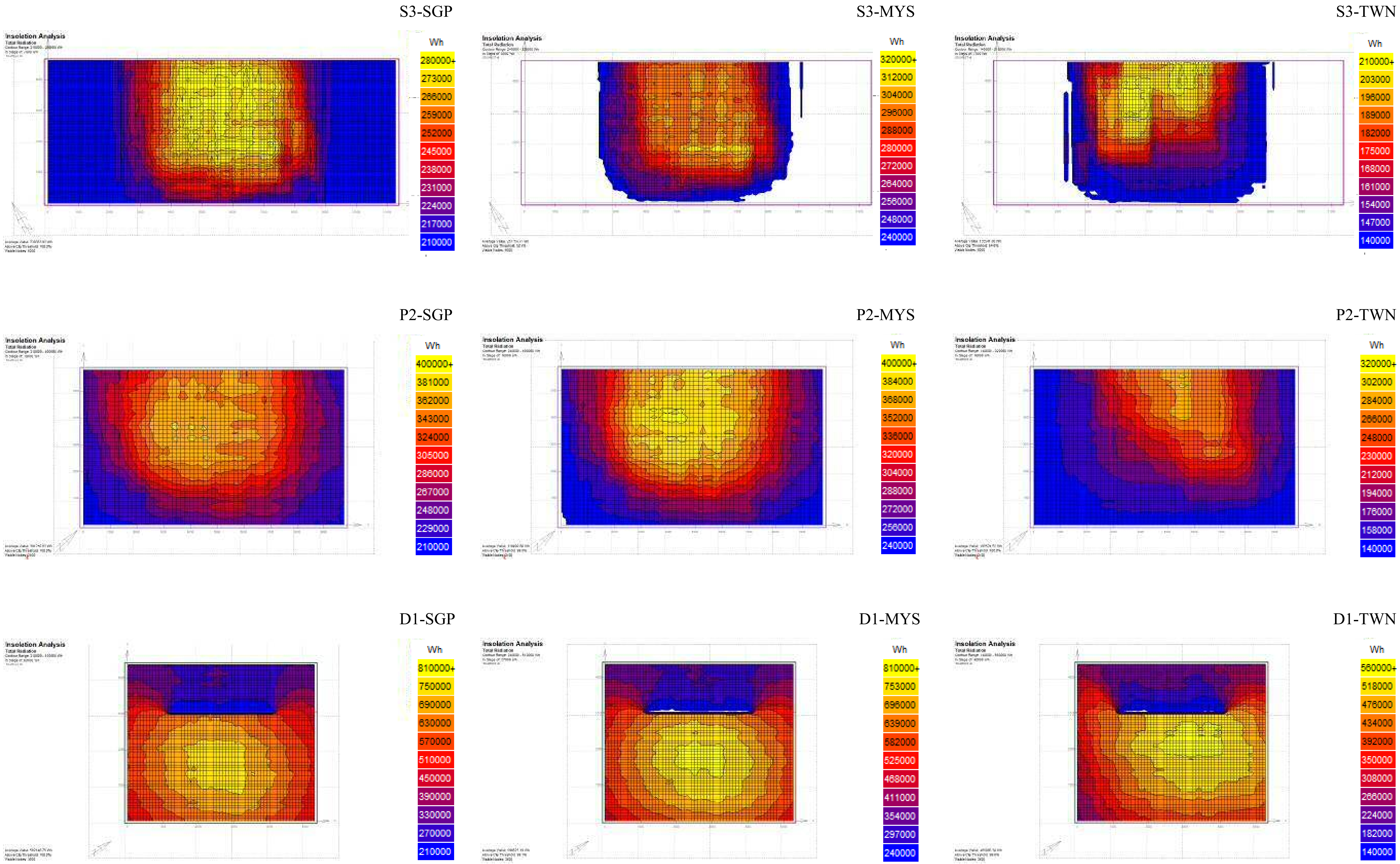


Figure 8.7: Comparison matrix for total solar radiation received in the 9 paired courtyard forms.
(Please be noted that the Wh scales are different between these plots in Ecotect software.)

Next, in the aspect of courtyard forms, comparing the D1-TWN to the others, it presents the highest figures of solar heat gains in summer, August and then July. This is as a result of relatively low temperatures due to the large opening exposed to solar radiation. Within the *Courtyard-S3*, it has the lowest heat gains in the month of July receiving 52,525Wh. This can be seen to be influenced, as S3-SGP has a smaller courtyard opening and higher wall height comparing it to P2-SGP and D1-SGP, which admits a lower rate of solar exposure and more shading.

However, comparing all courtyard forms in Northern Taiwan, the S3-TWN has the highest heat losses in the month of January losing 5,373Wh followed by P2-TWN and D1-TWN with 5,096Wh and 4,160Wh respectively. In fact, these three types of values are very close between 4kWh to 5kWh, that there are four coldest months in Northern Taiwan, starting from December to March, is also cold enough (refer to the days of heating degree day in Taiwan only).

Beside the difference of case study courtyard forms, in the month of July in Taiwan, S3-SGP received the least solar heat gains due to the least solar radiation access, as an effect of its more enclosed configuration (highest courtyard wall height compared to others).

Muhaisen (2006) analyzes the impact of different design configuration of courtyards based on shading simulations. This study found that shading conditions of courtyards are highly influenced by formal proportions, location latitude and climate conditions. Furthermore, the study suggest that in the hot and humid climate in the Southeast Asia, courtyards with three storey levels and a long axis oriented towards north-east/south-west result in an optimized performance.

8.2. Airflow simulations

The airflow pattern around an isolated shophouse building is briefly discussed to support the explanations in the following sections. Figure 8.8 provides a schematic illustration of the wind-flow pattern. As the wind approaches the building, it gradually diverges. At the windward facade (not shown in figure), a stagnation point with maximum pressure is situated at approximately 60-70% of the building height. From this point, the flow is deviated to the lower pressure zones of the facade: upwards, sidewards and downwards. The upward and sideward flow separate at the upwind facade edges, and create a separation bubble or recirculation zone characterised by low velocity and high turbulence intensity (Blocken *et al.* 2009).

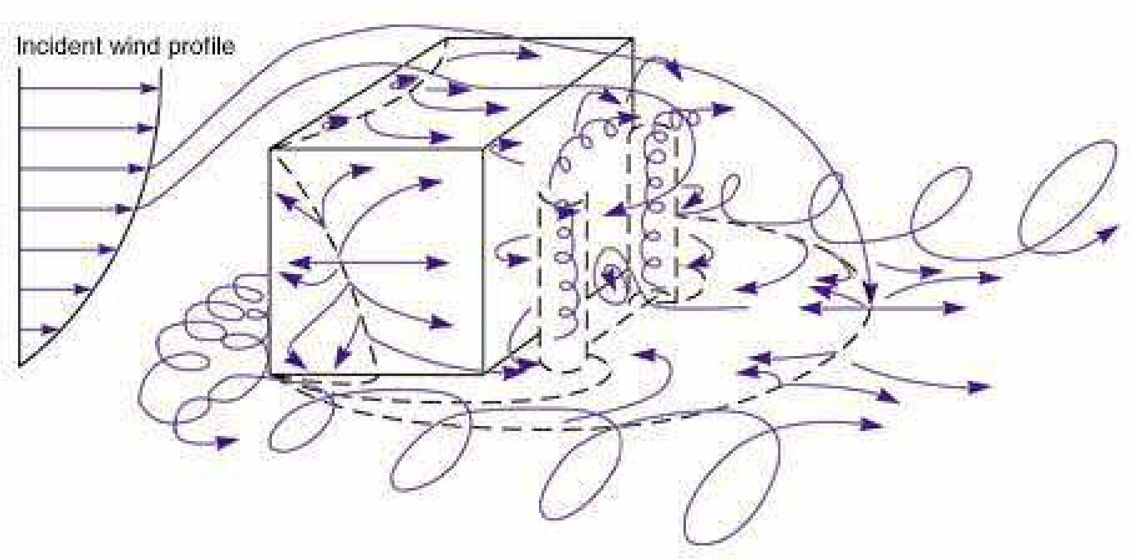


Figure 8.8: The aerodynamics of buildings. Depending on the building dimensions and the turbulence of the oncoming flow, the separated flow can reattach to the side facades and roof. (Source: McCabism 2011)

It is important to note that Figure 8.8 only shows the mean wind-flow pattern, and that the actual flow pattern exhibits pronounced transient features, such as the build-up and collapse of the separation/recirculation bubbles and periodic vortex shedding in the wake. This figure also only shows the mean wind-flow pattern for a single building. In multi-building configurations, the flow patterns can interact, yielding a higher complexity.

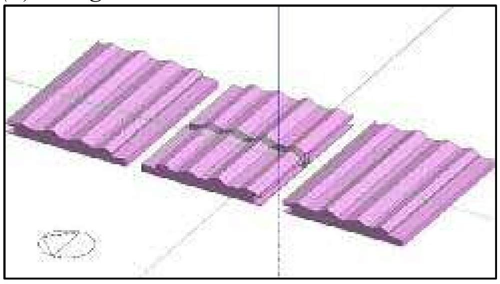
Reynold-averaged Navier-Stokes (RANS) equations with standard K-ε turbulent flow are used to simulate the wind environment of the traditional shophouse. This numerical method, used by DesignBuilder CFD, is known as a primitive variable method, and involves the solution of a set of equations that describe the conservation of heat, mass, and momentum. It can be used for both external and internal analyses. External analyses provide the distribution of air velocity and pressure around building structures due to wind effect and this information can be used to assess pedestrian comfort, and to calculate more accurate pressure coefficients for EnergyPlus calculated natural ventilation simulations (DesignBuilder 2011).

The three courtyard configurations, *Courtyard-D1*, *Courtyard-P2* and *Courtyard-S3*, are the subject investigated. The wind velocity field inside and around the front courtyard in each configuration is studied to understand the climate adaptive design strategies. For these traditional shophouses in hot and humid regions of Southeast Asia, the thermal mass of buildings is considerable. Therefore, the air movement due to the temperature difference is relatively insignificant compare with the air movement due to courtyard geometry.

8.2.1. Physical models and simulation setting

As mentioned, the simulation and parametric study are based on a shophouse model (Figures 8.9, 8.10 and 8.11). Simulation was conducted under open and closed door and window conditions separately. The distance between shophouses (street width) is set based on the current urban texture of major towns in Southeast Asia (Rumney 2010). Following the climate analysis in Sections 7.1.1 and 8.1.2, for summer time simulation setting, the initial temperature is 35°C, the wind condition is 6.5m/s with north-east and southeast directions based on the prevailing wind condition in Peninsular Malaysia; and for winter time setting, the initial temperature is 15°C, the wind condition is 8.0m/s with north-east direction based on the most negative condition for thermal comfort in Taiwan. Initial wind environment is generated based on the logarithmic wind profile with a reference height of 10m. The air movement was simulated with wind at 0^o, 45^o, 90^o and 180^o ($N = 0^o$) to the courtyard voids. At first, the wind environment in the original shophouse building settlement is simulated.

(A) DesignBuilder CFD model



(B) shop front street width 10m (approx.)

(C) single-storey shophouses model

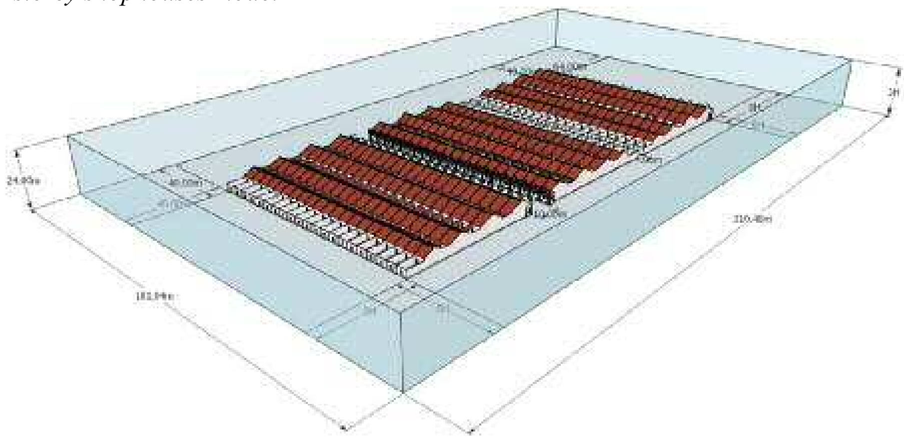
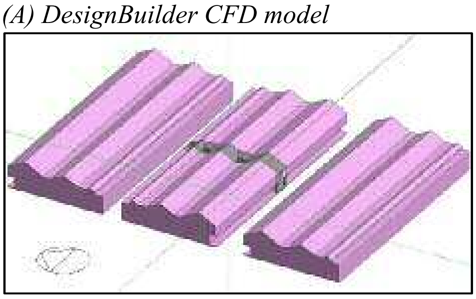
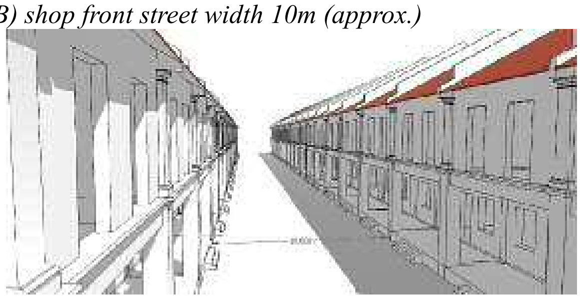


Figure 8.9: The single-storey shophouses (*Courtyard-D1*) model and the simulation domain used in CFD analysis. (DesugnBuilder and SketchUp)

(A) DesignBuilder CFD model



(B) shop front street width 10m (approx.)



(C) double-storey shophouss model

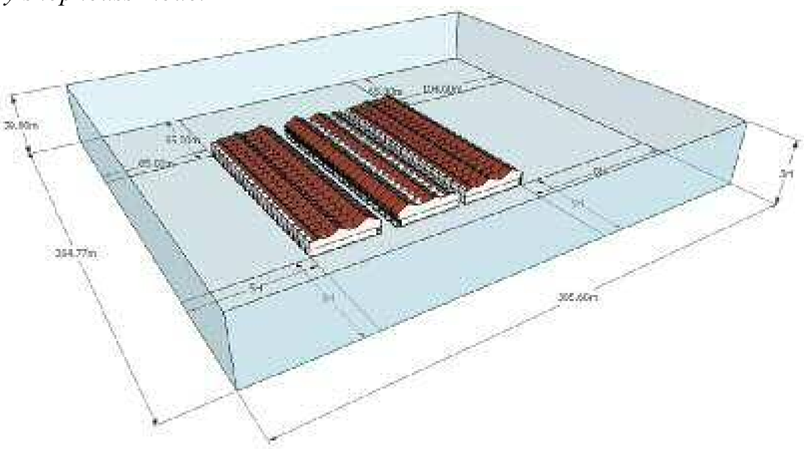
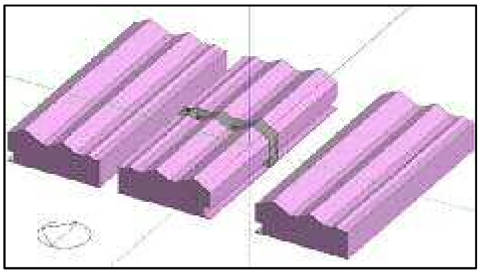
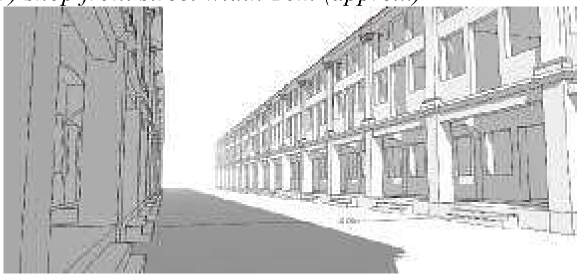


Figure 8.10: The double-storey shophouses (*Courtyard-P2*) model and the simulation domain used in CFD analysis. (DesugnBuilder and SketchUp)

(A) DesignBuilder CFD model



(B) shop front street width 10m (approx.)



(C) double-storey shophouses model

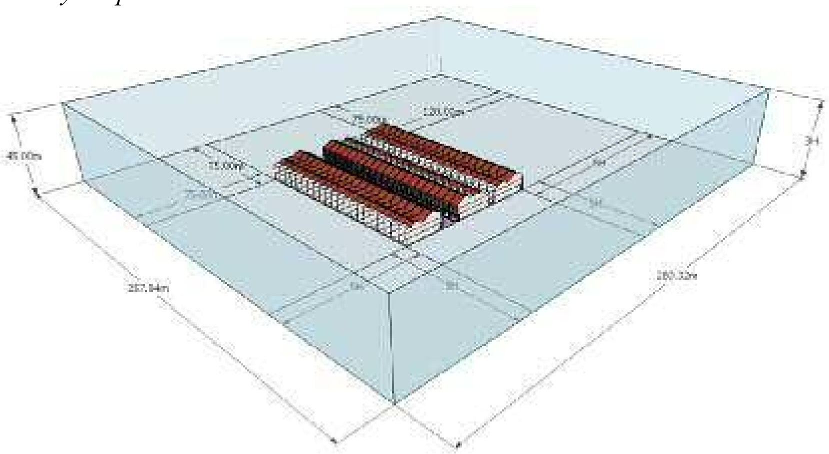


Figure 8.11: The three-storey shophouses (*Courtyard-S3*) model and the simulation domain used in CFD analysis. (DesugnBuilder and SketchUp)

8.2.2. Airflow pattern at courtyards

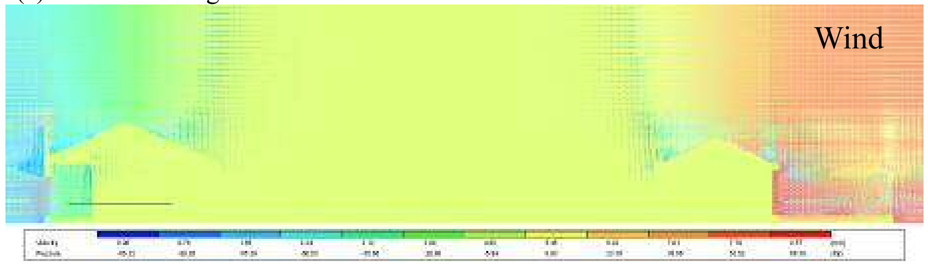
Courtyard and building geometry are crucial aspects to achieve efficient natural ventilation in a compact traditional shophouses district. A comparison between different geometries of courtyards in terms of wind flow characteristics and indoor speed is performed based on the computational fluid dynamics simulation. The courtyard dimensions, the position of the room, and the orientation are important aspects influencing the indoor air speed and thermal comfort.

The results of CFD simulation for each shophouse buildings case is shown in the following sections in order to inform an emerging intuitive understanding of how the overall airflow pattern affects the performance of traditional courtyard shophouses. The doors and windows opening and closing schedule has a critical impact on the effectiveness of natural ventilation. In the DesignBuilder CFD model, the results are three-dimensional diagrams, which show the amount of fresh airflow in and flow out to and from the doors and windows *closed* and *open* at both ends of the shophouse.

Building case at Daxi (Taiwan): Courtyard-D1

Figures 8.12, 8.13, 8.14 and 8.15 show that the airflow patterns with the wind direction from the back lane of the building (wind at 0º and 180º) for the doors and windows *closed* and *open* at both ends of building are very similar. The airflow inside the rooms and courtyards are not affected in the vertical direction.

(a) Raw CFD image



(b) Front part of *Courtyard-D1*

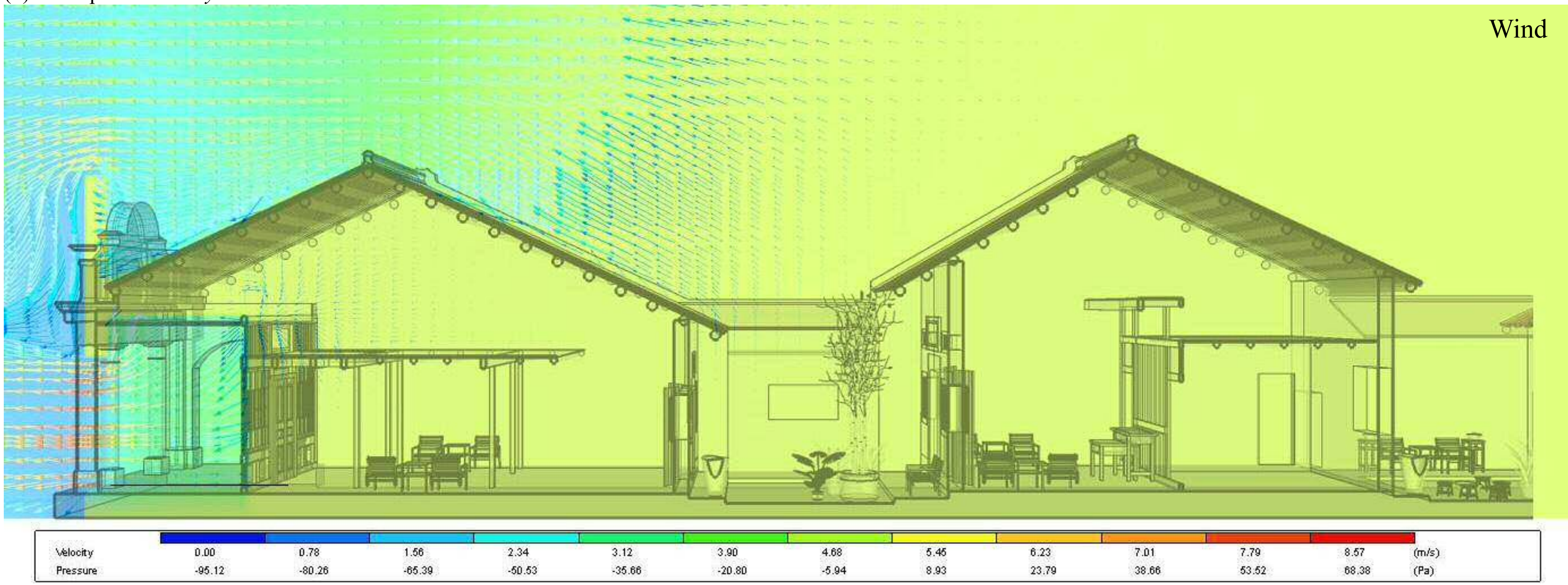
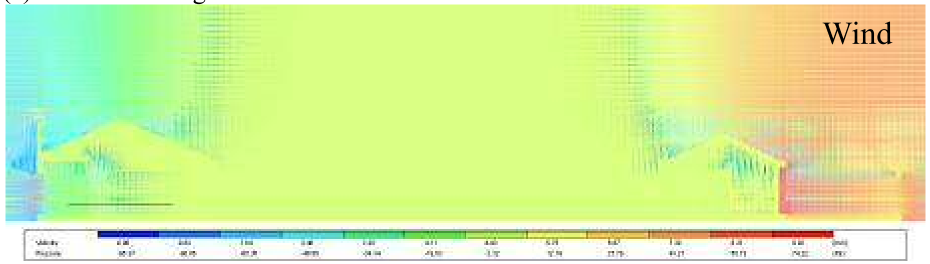


Figure 8.12: Airflow pattern at *Courtyard-D1* in CLOSED type with wind at 0º.

Figures 8.12 and 8.13 illustrate the air movement inside the front courtyard for the two cases is not affected. The free air streams are too weak to the ground plane of the first courtyard after over buildings.

(a) Raw CFD image



(b) Front part of *Courtyard-D1*

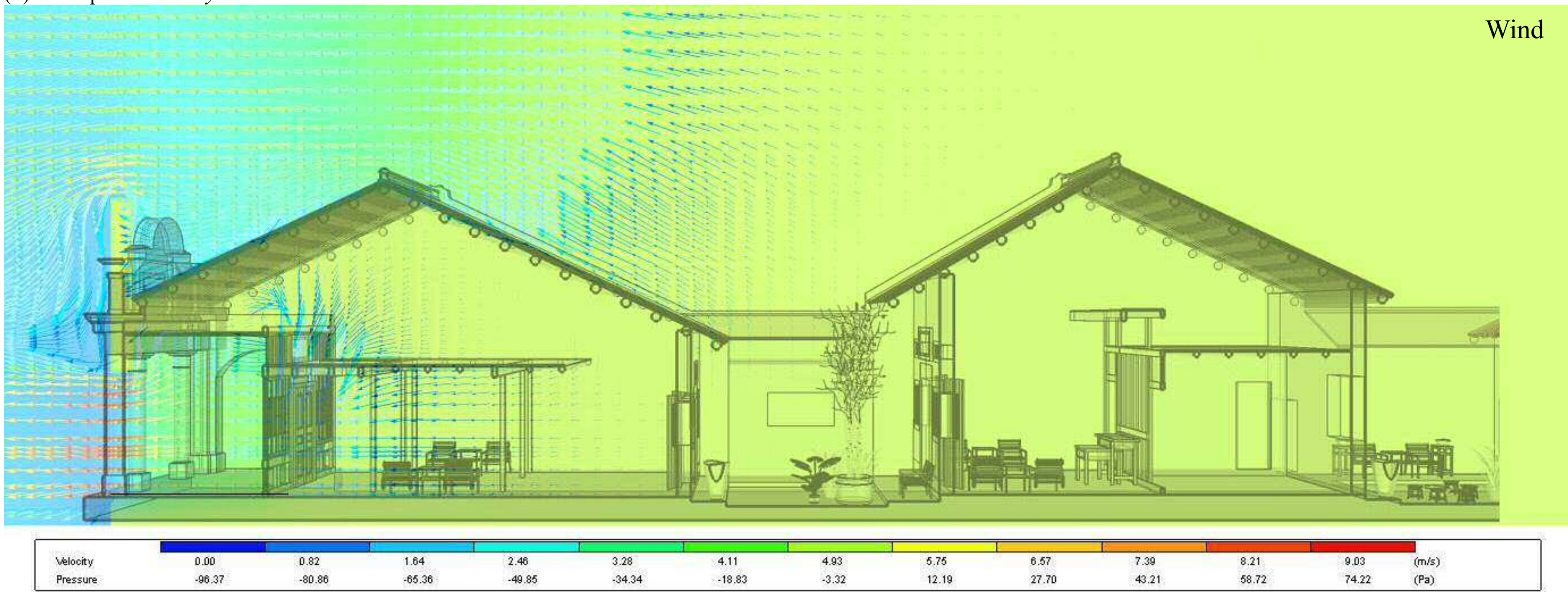


Figure 8.13: Airflow pattern at *Courtyard-D1* in OPEN type with wind at 0º.

It is observed in Figures 8.14 and 8.15 that the air movement with the wind direction from the front for both doors and windows *closed/open* schedules are slightly more effective in promoting internal airflow than the wind from the back. Both Figure 8.14b and 8.15b illustrate the first building can draw air from the free-running zone to the ground plane of the first courtyard. In this way, wind shadow occur where wind is forced over buildings.

(a) Raw CFD image

(b) Front part of *Courtyard-D1*

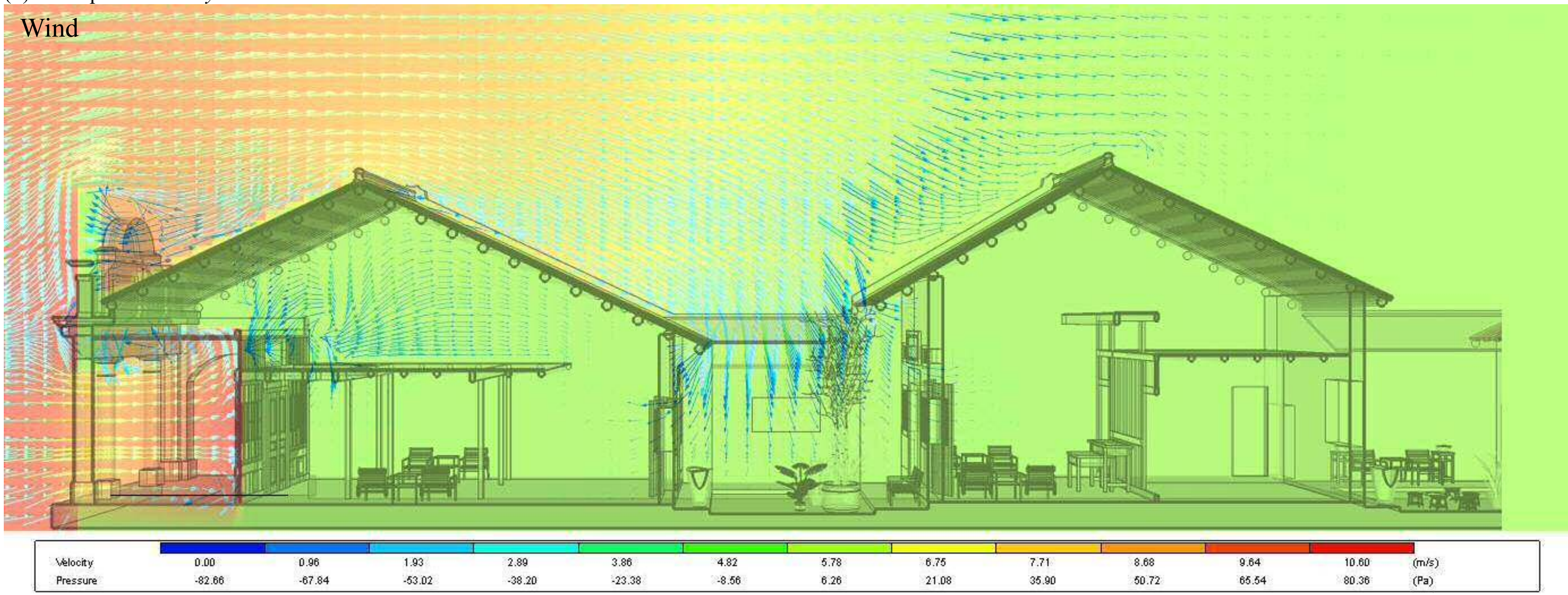
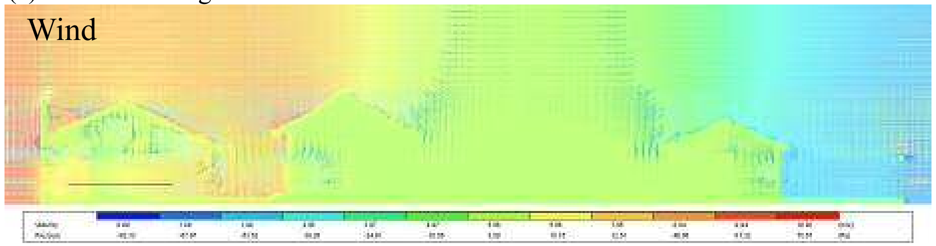


Figure 8.14: Airflow pattern at *Courtyard-D1* in CLOSED type with wind at 180°.

However, only the stack ventilation works quite effectively at the first two building blocks by the *open* schedule (Figure 8.15), except the third building, which must need assistance by mechanical air extraction. The overall cross ventilation is not affected in the horizontal direction. The effects of stack ventilation reduce and cross ventilation becomes dominant.

(a) Raw CFD image



(b) Front part of *Courtyard-D1*

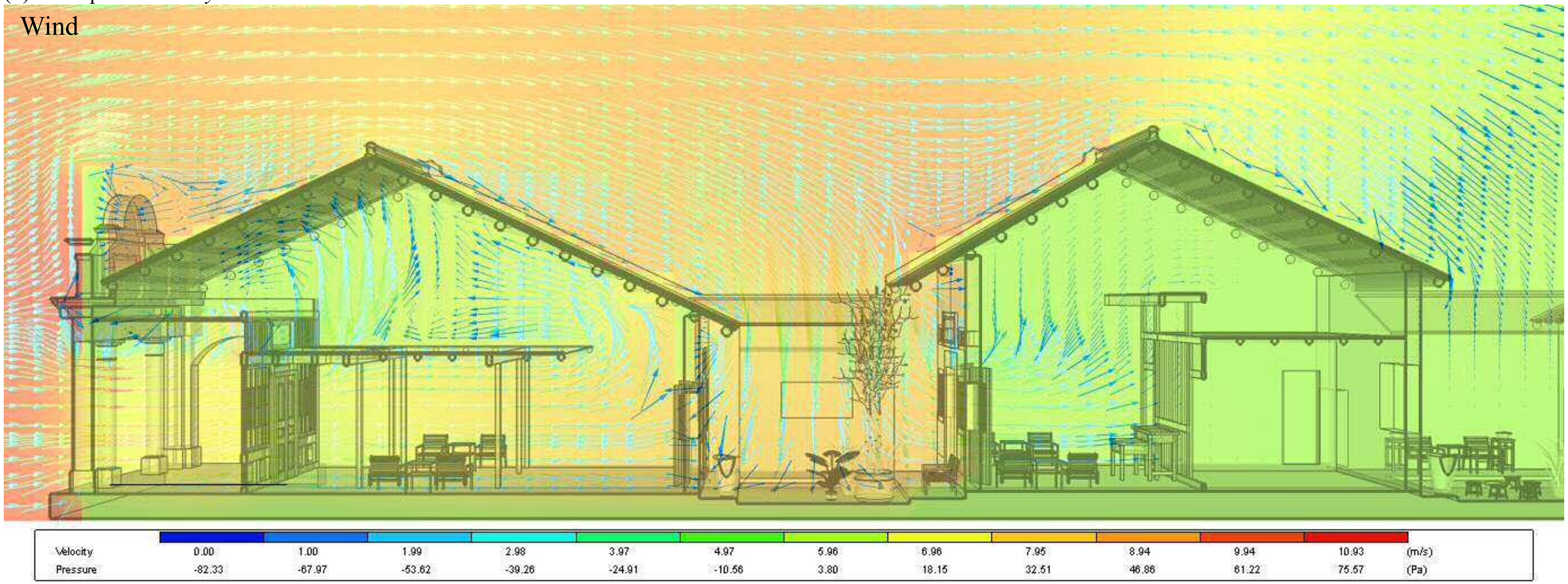


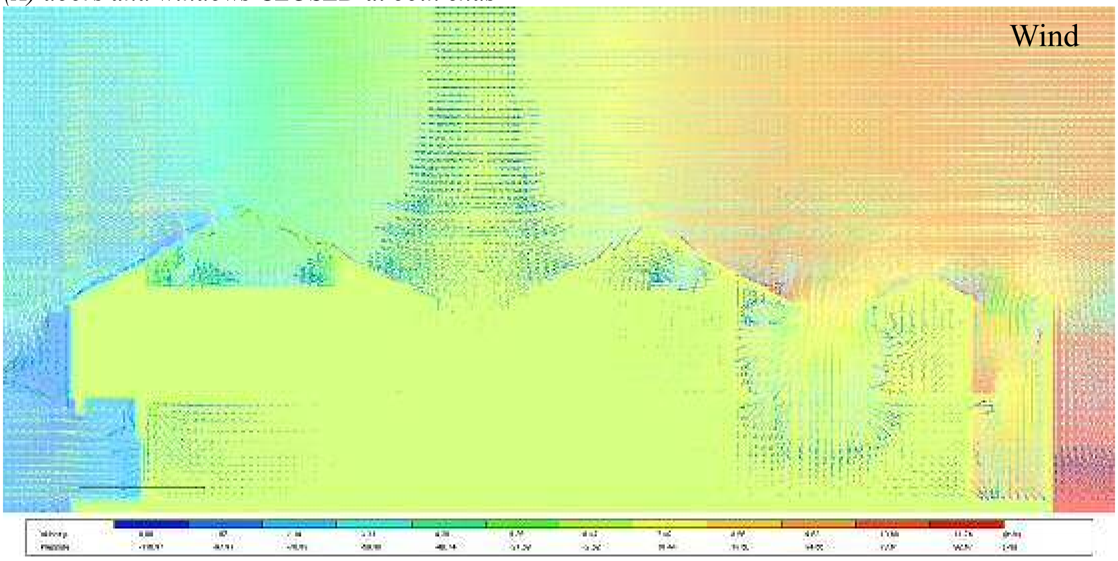
Figure 8.15: Airflow pattern at *Courtyard-D1* in OPEN type with wind at 180^{o}.

Building case at George Town (Penang): Courtyard-P2

Figure 8.16 and 8.17 show that the raw CFD images of airflow patterns with the wind direction from the back lane and the front of building are quite different between the different floors, between the rooms at both sides of the courtyard and between both cases of the doors and windows *closed* and *open* at both ends of the building.

It is observed that there is almost no air movement between the rooms at both sides of the courtyard under the doors and windows *closed* schedule. Only the airflows inside the courtyard which facing towards the wind direction are affected.

(A) doors and windows CLOSED at both ends



(B) doors and windows OPENED at both ends

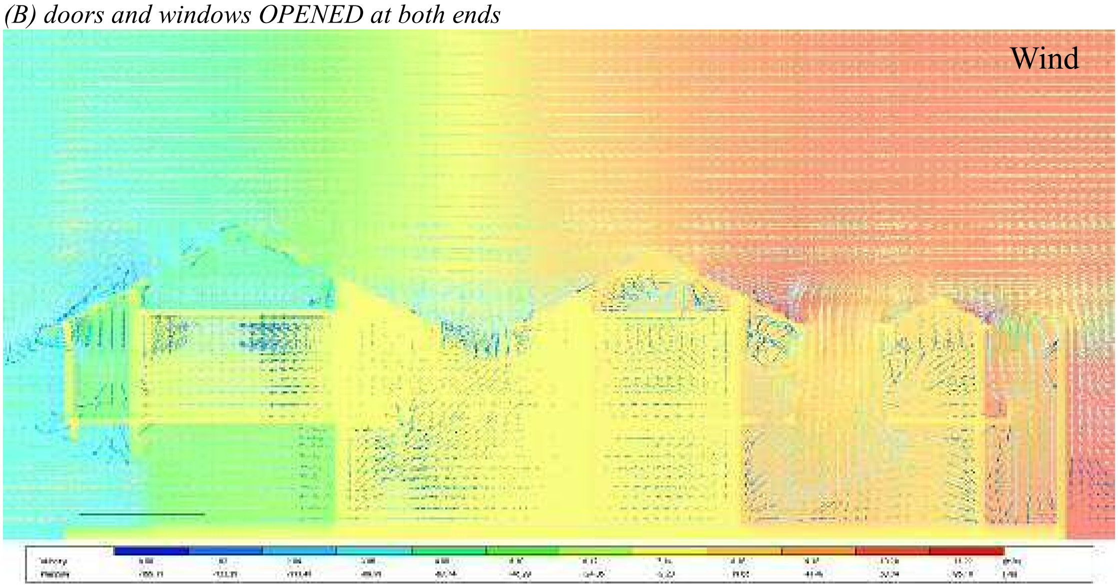
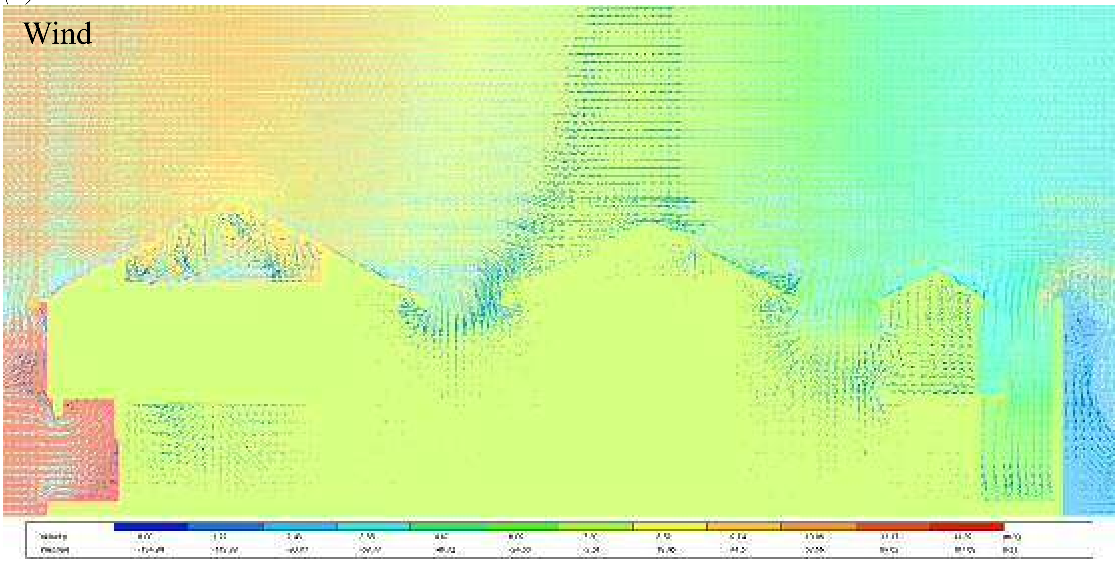


Figure 8.16: Vertical airflow pattern of *Courtyard-P2* with wind at 0° (wind direction from the back lane); by CFD images in invisible of component blocks.

(A) doors and windows CLOSED at both ends



(B) doors and windows OPENED at both ends

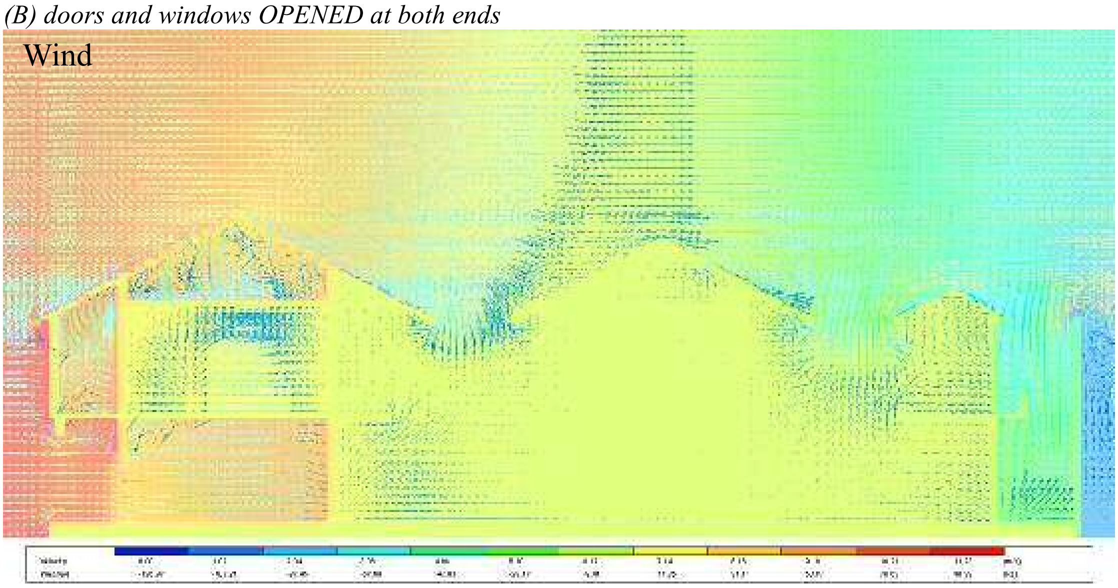


Figure 8.17: Vertical airflow pattern of *Courtyard-P2* with wind at 180º (wind direction from the front); by CFD images in invisible of component blocks.

It can been seen from Figures 8.16 and 8.17 that as before, the incoming airflows in both front courtyard and rear courtyard play an important role in the promotion of stack effects in the rear part of this two-storey shophouse building. The airflows in both directions of cross ventilation and stack ventilation remain around the same level at 3.06m/s. The airflow of the second building block remains normal. On the other hand, the height of the two buildings increase the air velocity, with the incoming airflow being divided by the gable roofs (Figures 8.18 and 8.19), causing the air stream to strike the side wall and divert to the courtyard. It also results in the reduction of incoming airflows and buoyant force in rear courtyard. However, the effect of cross ventilation for overall spaces reduces.

(a) doors and windows CLOSED at both ends

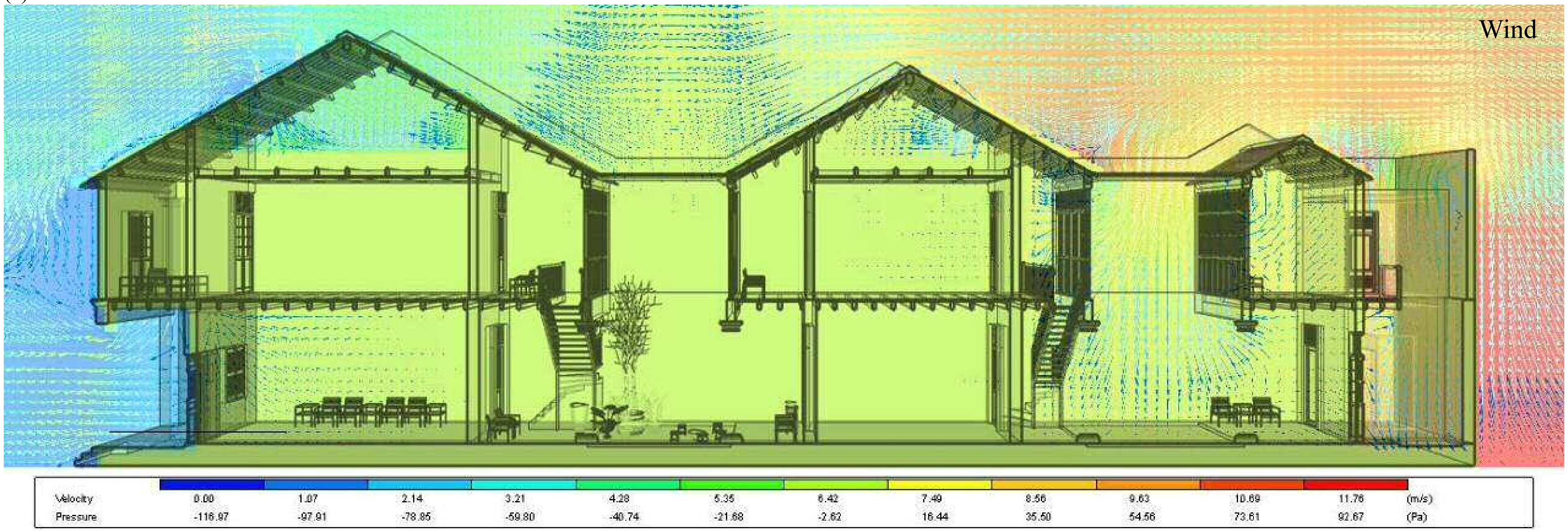


Figure 8.18a: Vertical airflow pattern of *Courtyard-P2* with wind at 0º (wind direction from the back); with Model-CFD blend images

(b) doors and windows OPEN at both ends

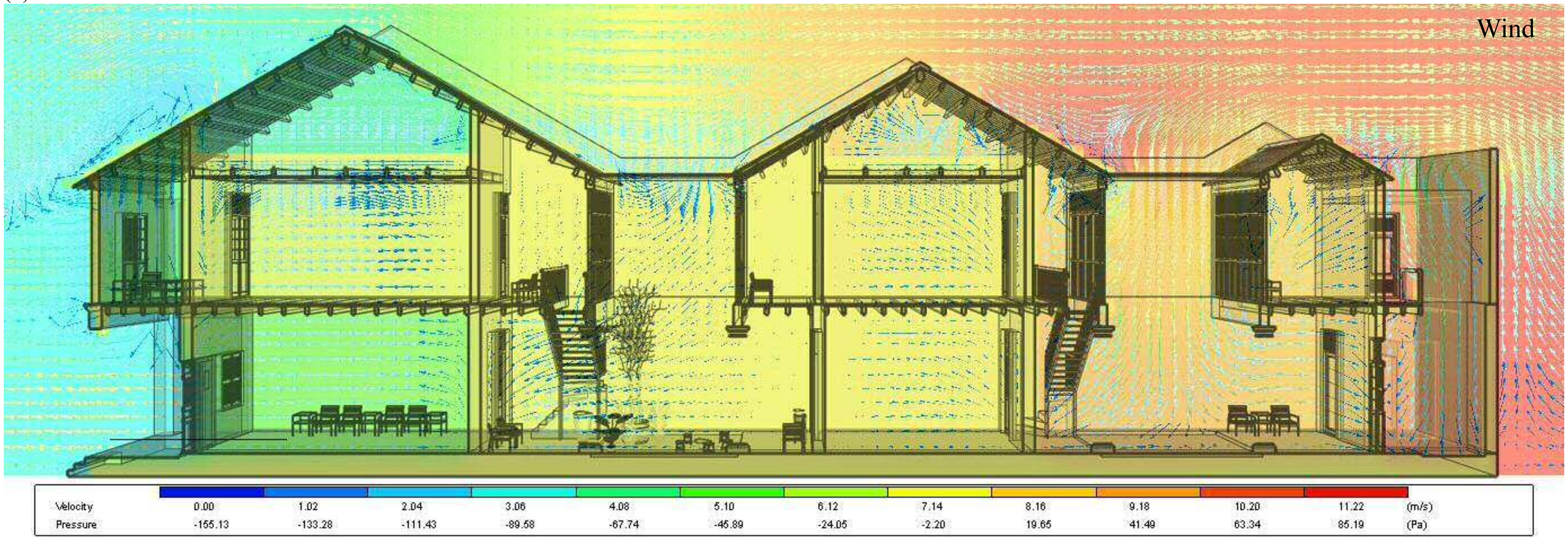


Figure 8.18b: Vertical airflow pattern of *Courtyard-P2* with wind at 0º (wind direction from the back); with Model-CFD blend images.

(a) doors and windows CLOSED at both ends

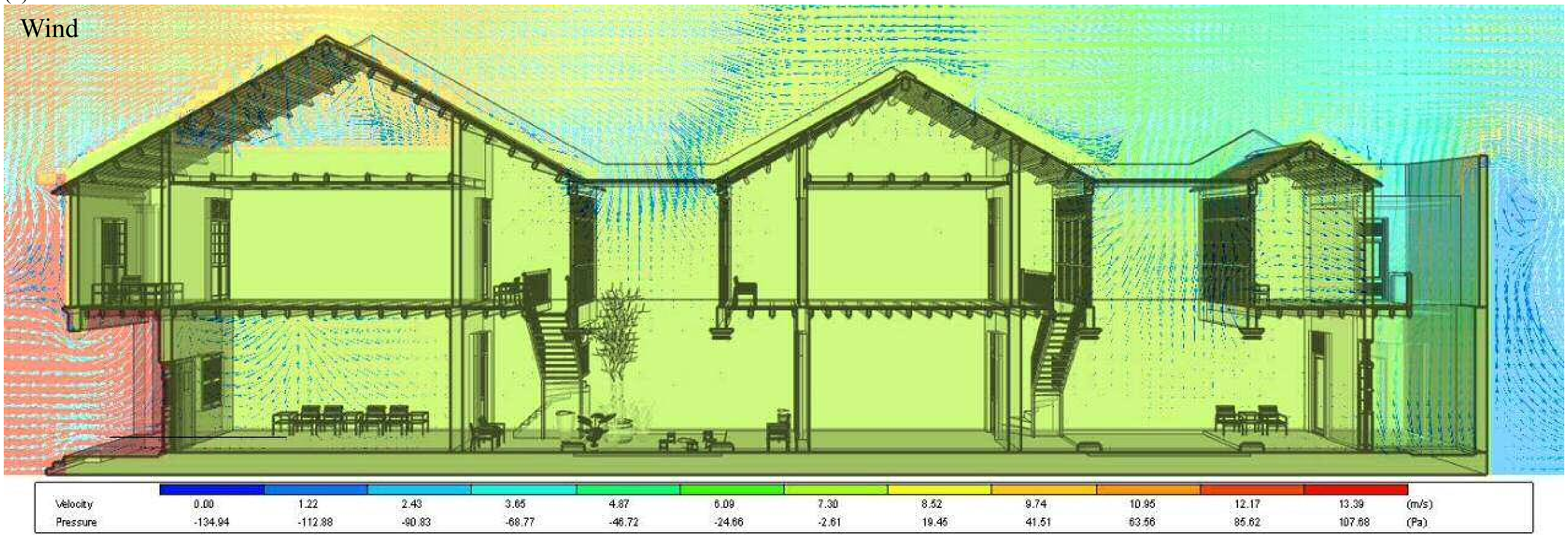


Figure 8.19a: Vertical airflow pattern of *Courtyard-P2* with wind at 180^{o} (wind direction from the front); with Model-CFD blend images.

(b) doors and windows OPENED at both ends

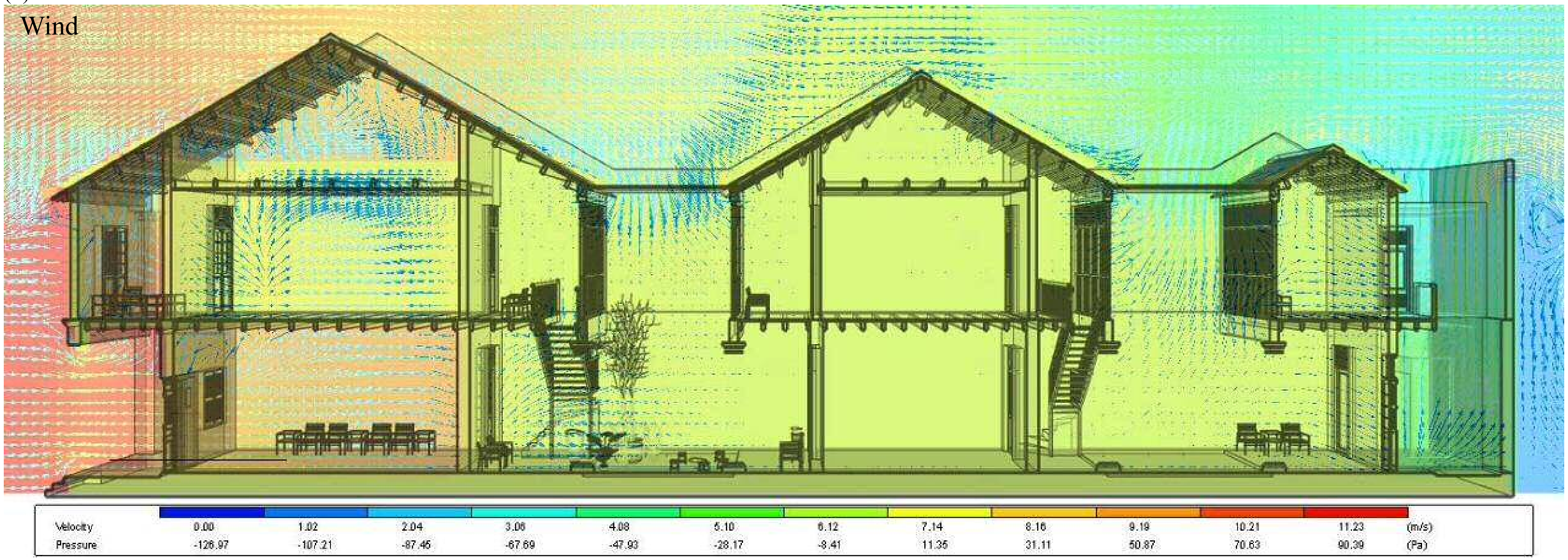
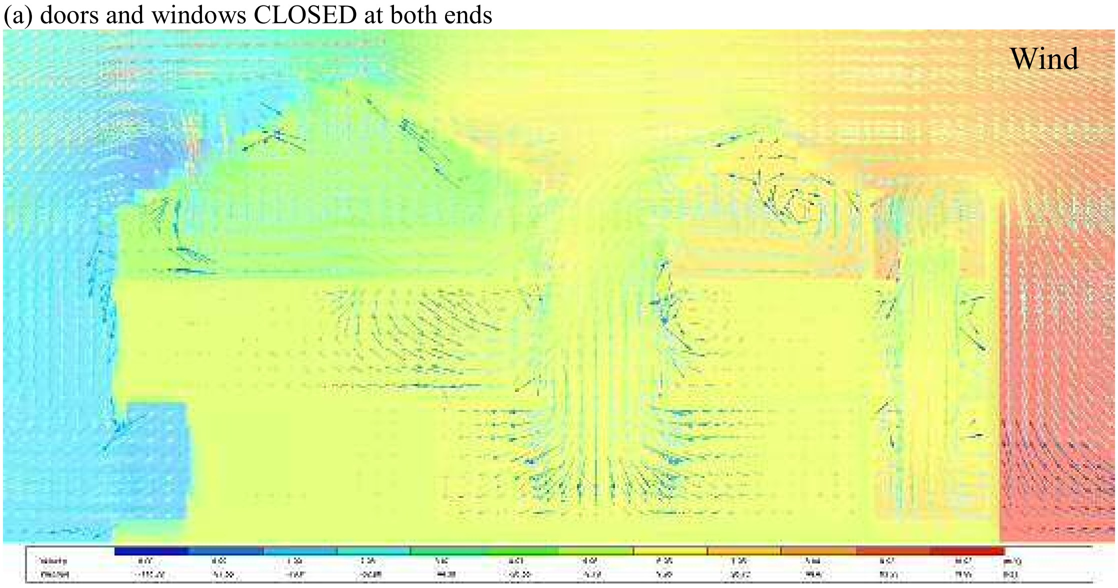


Figure 8.19b: Vertical airflow pattern of *Courtyard-P2* with wind at 180° (wind direction from the front); with Model-CFD blend images.

Building case at Chinatown (Singapore): Courtyard-S3

Figures 8.20 and 8.21 show the flow regime inside the spaces for the cases of the doors and windows *closed* and *open* at both ends of the building and their CFD predictions. Qualitatively, the stack ventilation works effectively in this traditional design. The airflow is adequate for most rooms, except the case of the doors and windows *closed* at both ends of the building with the wind direction from the front, where only the top-floor rooms of the building have increased air speeds and movement than the first floor and the ground floor (Figure 8.21a).

(a) doors and windows CLOSED at both ends



(b) doors and windows OPEN at both ends

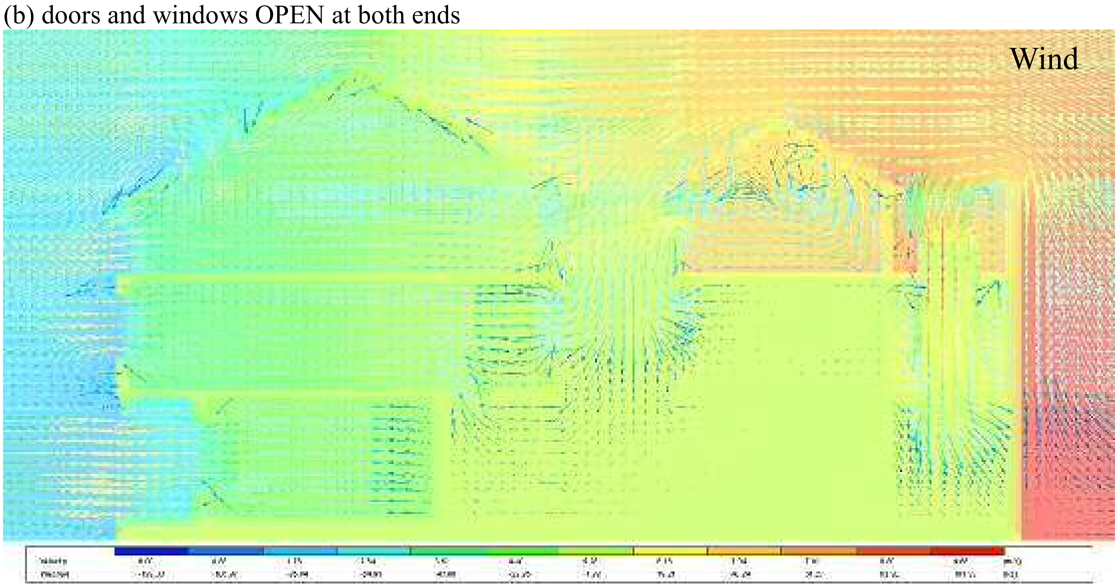
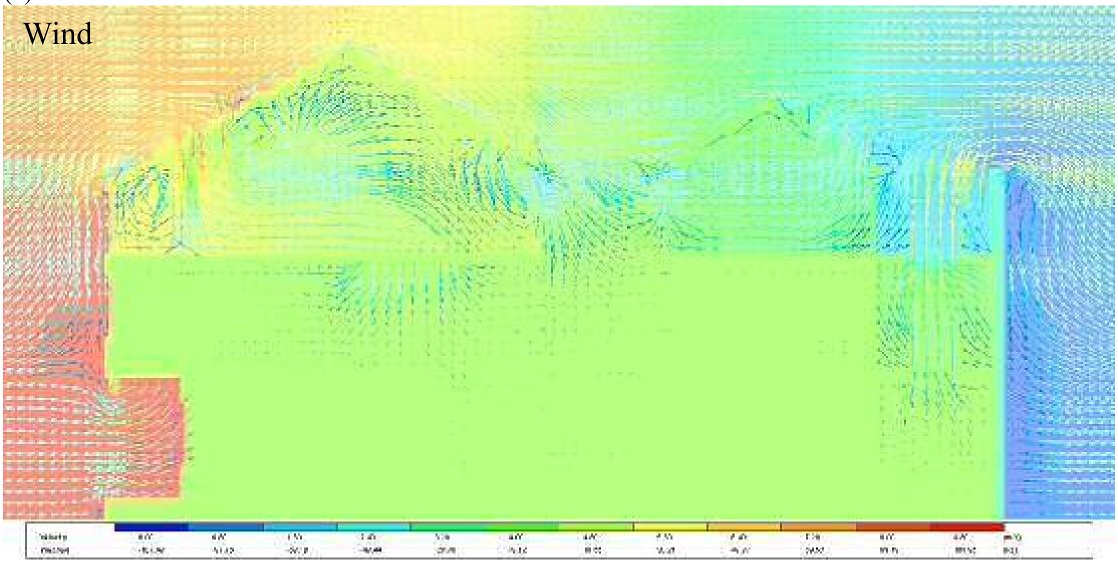


Figure 8.20: Vertical airflow pattern of *Courtyard-S3* with wind at 0^{o} (wind direction from the back); by CFD images in invisible of component blocks.

(a) doors and windows CLOSED at both ends



(b) doors and windows OPEN at both ends

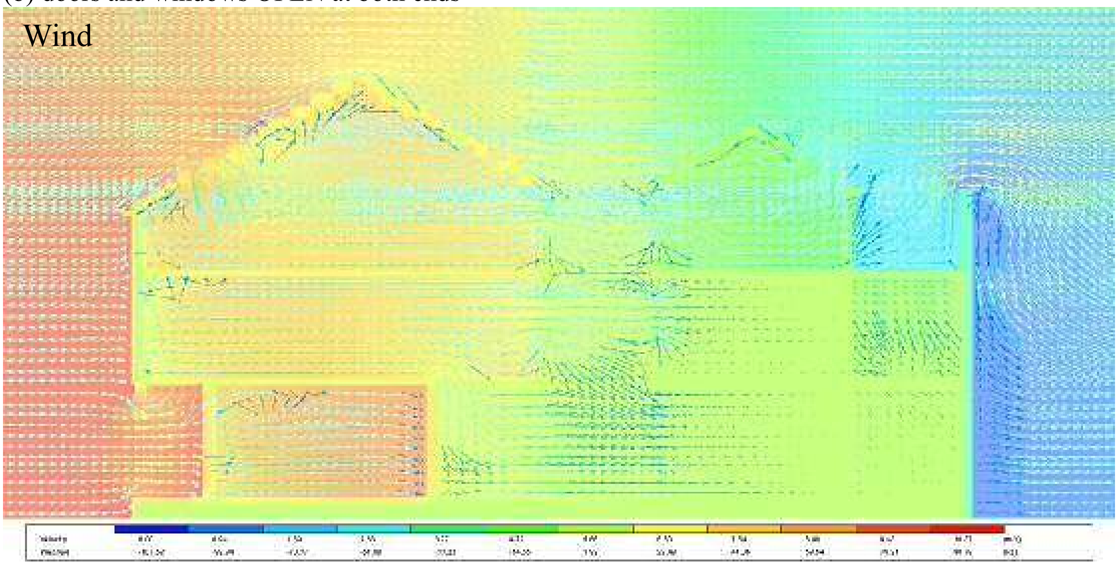


Figure 8.21: Vertical airflow pattern of *Courtyard-S3* with wind at 180^{o} (wind direction from the front); by CFD images in invisible of component blocks.

(a) doors and windows CLOSED at both ends

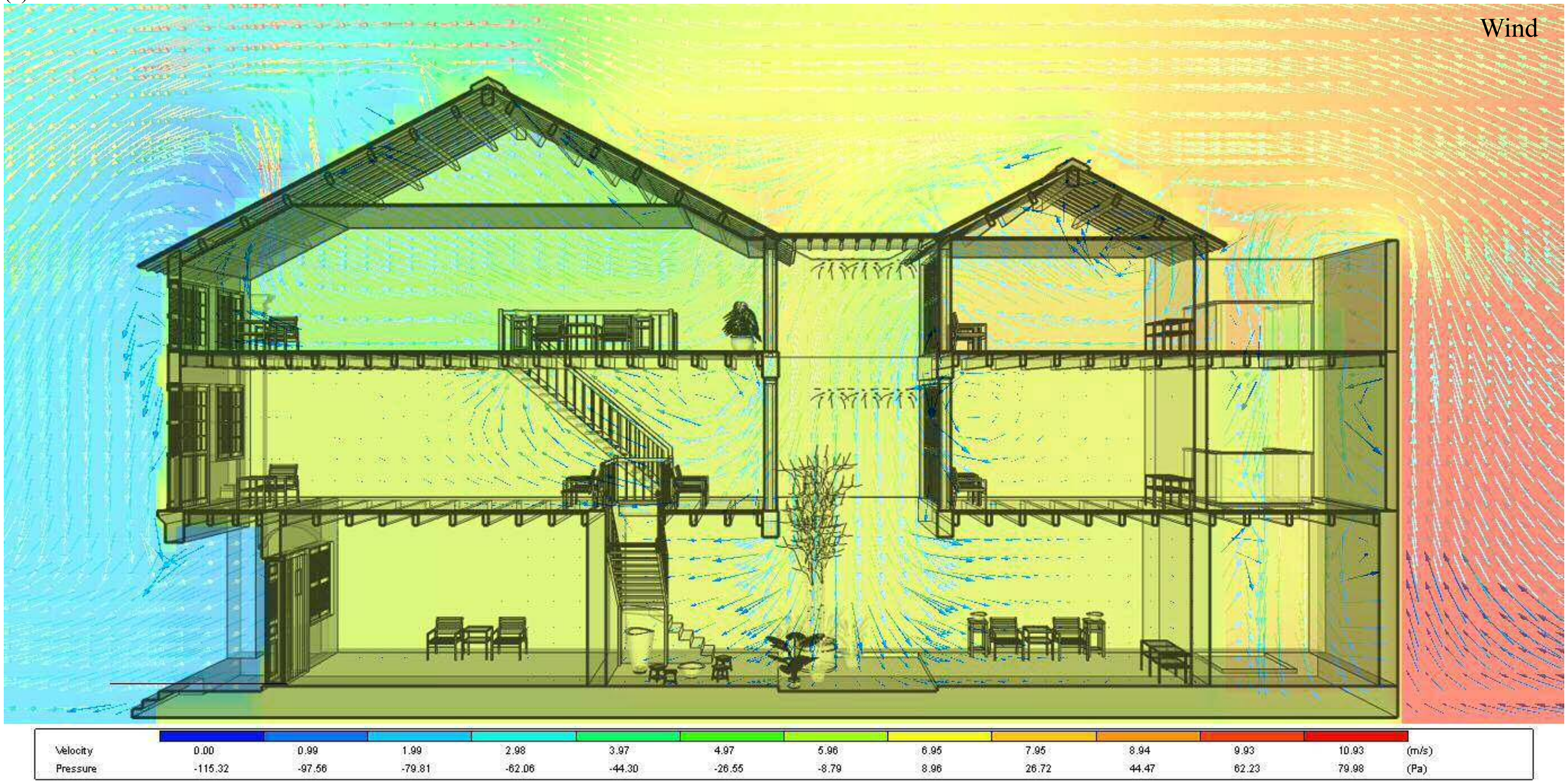


Figure 8.22a: Vertical airflow pattern of *Courtyard-S3* with wind at 180^{o} (wind direction from the back); with Model-CFD blend images.

(b) doors and windows OPEN at both ends

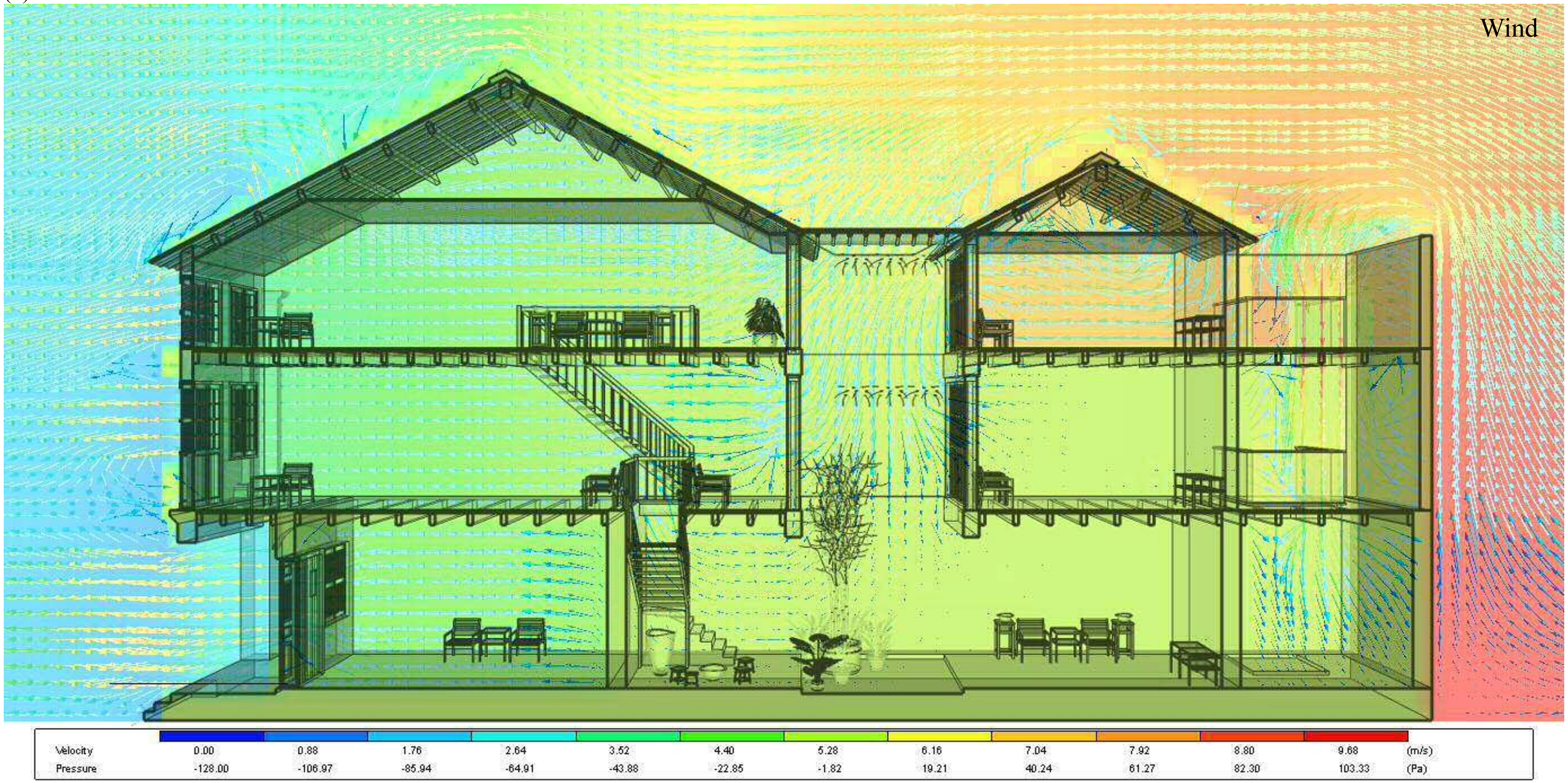


Figure 8.22b: Vertical airflow pattern of *Courtyard-S3* with wind at 180º (wind direction from the back); with Model-CFD blend images.

(a) doors and windows CLOSED at both ends

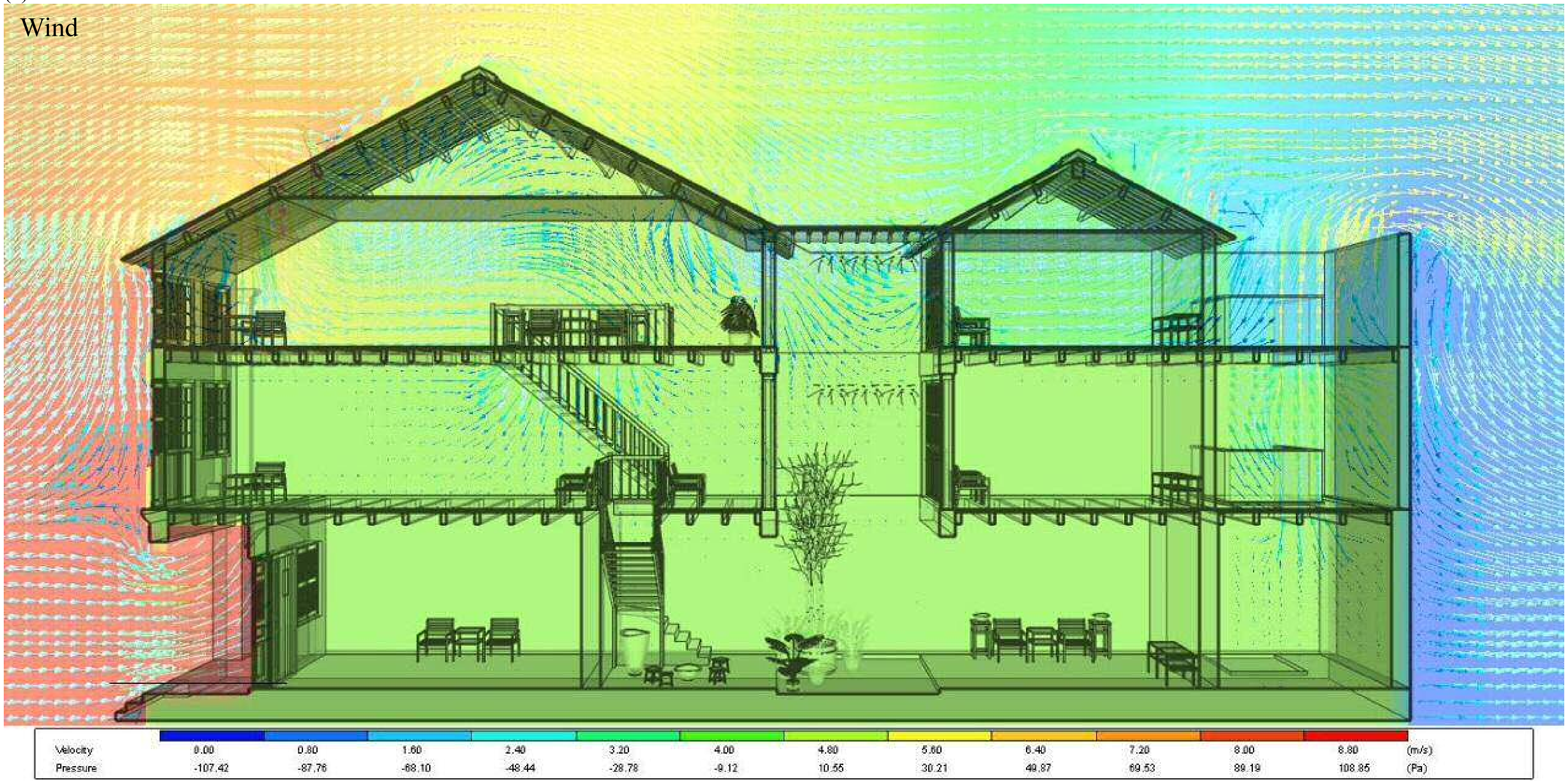


Figure 8.23a: Vertical airflow pattern of *Courtyard-S3* with wind at 180º (wind direction from the front); with Model-CFD blend images.

(b) doors and windows OPEN at both ends

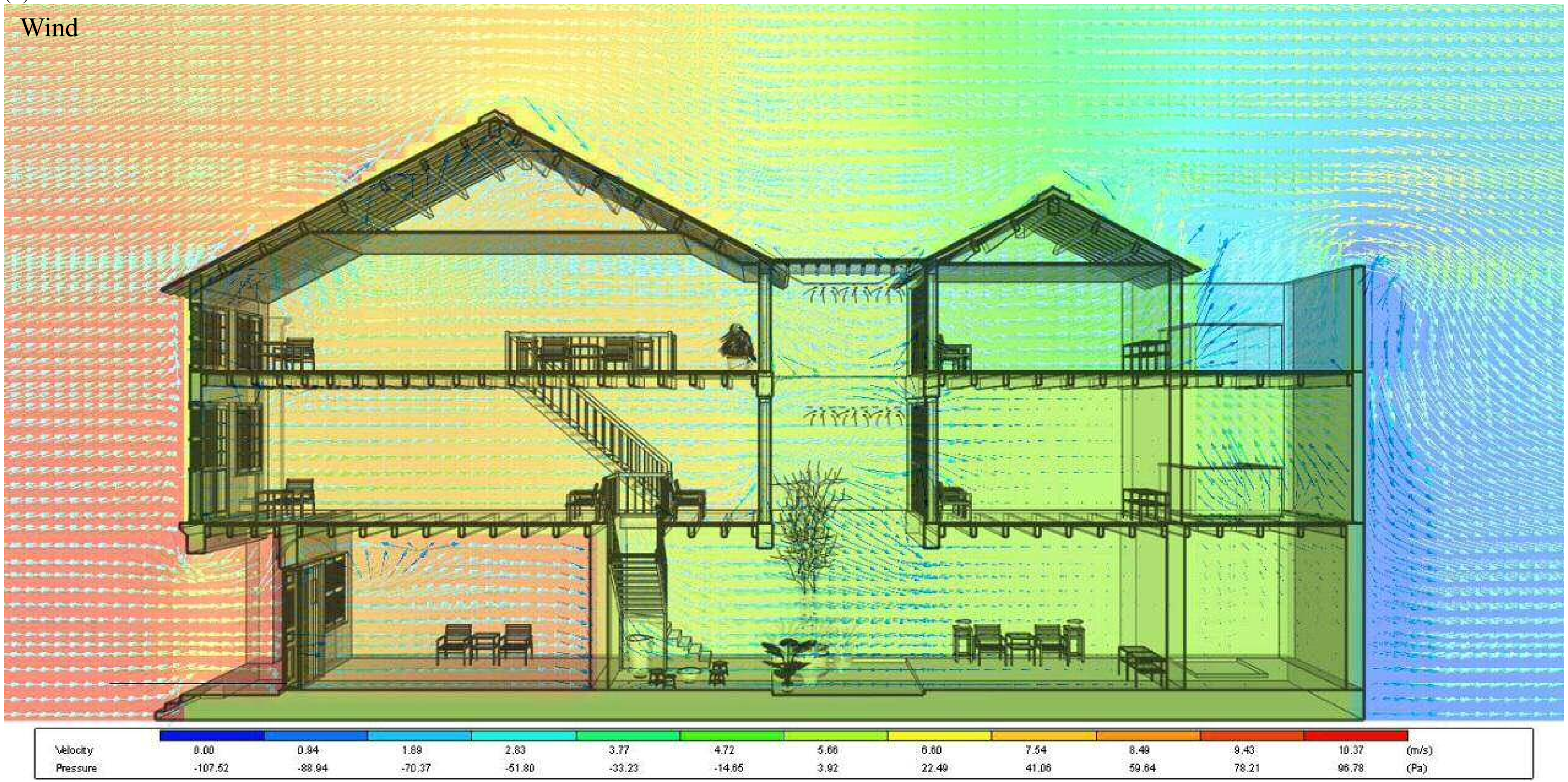


Figure 8.23b: Vertical airflow pattern of *Courtyard-S3* with wind at 180° (wind direction from the front); with Model-CFD blend images.

Considering the Figure 8.21a, the building may benefit from ventilation assistance by mechanical air extraction during the scenario of both doors and windows *closed* at both ends of the building with wind direction from the front as an active vortex is developed at the top of the front courtyard. The vortex occupies almost the whole top-floor level due to the inversed flow created through and around the eaves.

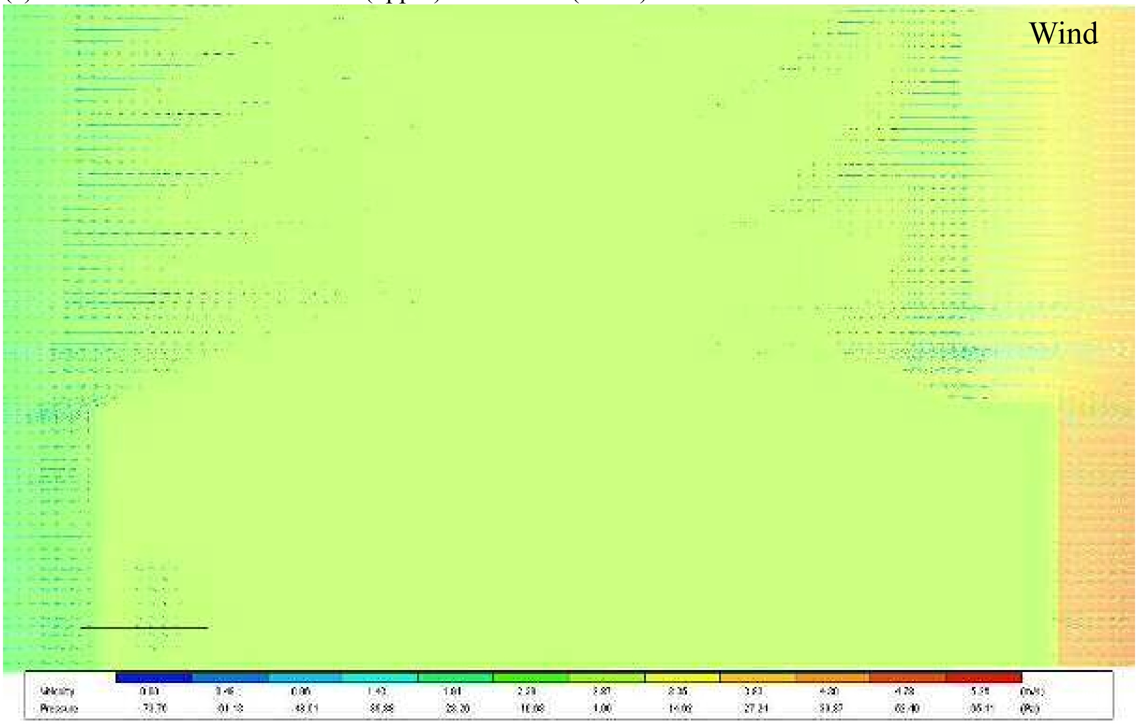
Under the same *closed* schedule, it is observed in Figures 8.20a and 8.22a that the stack effect works effectively in both the front courtyard and the rear courtyard with the wind direction from the back of the building. The wall of the first building divides and deflects the incoming airflow, it causes the free air stream to strike the internal openings and divert into the rooms and the ground plane of the front courtyard. As for the internal open staircase layout, it allows airflow to enter the upper floors space smoothly. But the first rear room does not have much influence on the ventilation strategy, the circulation became slowest in each cases. However, the overall ventilation strategy is a combination of cross ventilation and stack ventilation.

The final series of wind simulations illustrated in Figures 8.24, 8.25, and 8.26 concern each shophouse building cases and represent the combination of two directions of wind at 45^{o} and 90^{o} from normal ($N = 0^{o}$) to the courtyard voids. One of the objectives was to see the influence of the windward side of the model on the airflow and inside air speed in the courtyards with single-side ventilation. Bauman *et al.* (1988) performed wind tunnel experiments to predict the performance of a naturally ventilated building, where estimates of the wind-induced surface pressure distribution are needed. As he mentioned that at 90^{o} wind angle, the pressure coefficients for both sides of the model are very nearly equal and approach zero. This is an expected result as the wind is channelled between building rows on both sides of the model (Bauman *et al.* 1998).

Concerning the wind angle at 45^{o} to the front courtyard for all shophouse building cases. In all cases the airflow patterns around and/or passing through the top of the front courtyard remain around the same level as well as direction of wind from normal (Figures 8.24a, 8.25a, 8.25b, 8.26a and 8.26b).

Building case at Chinatown (Singapore): Courtyard-S3

(a) doors and windows CLOSED (upper) and OPEN (lower) at both ends…………wind direction = 45°



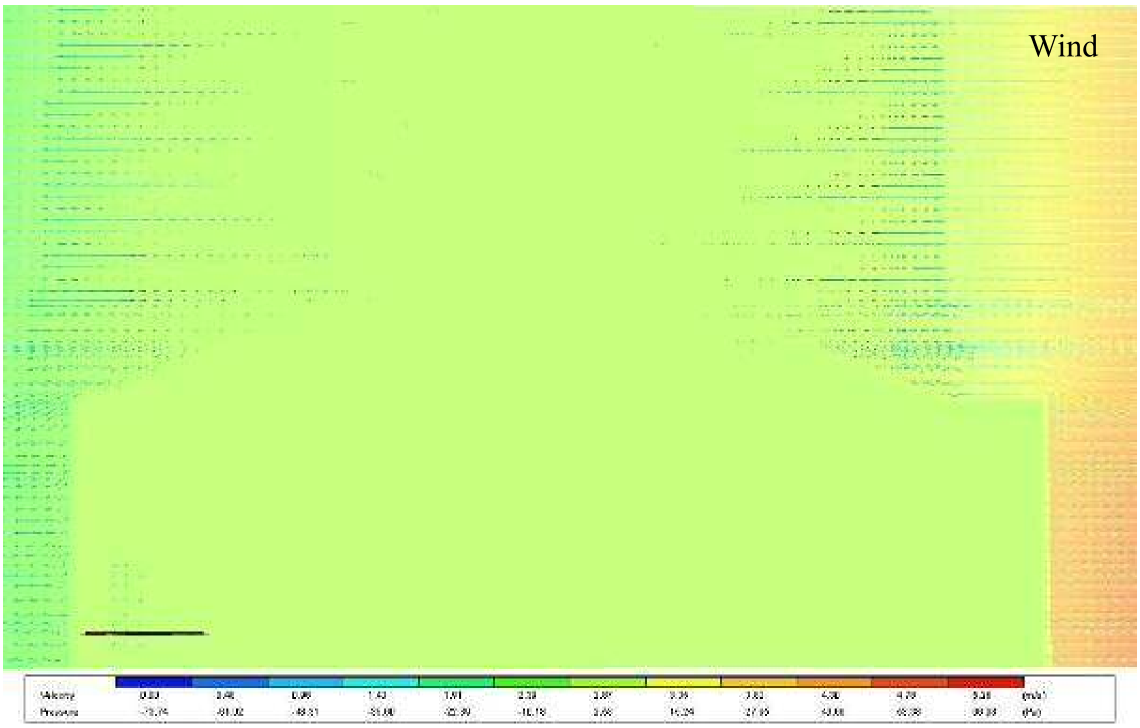
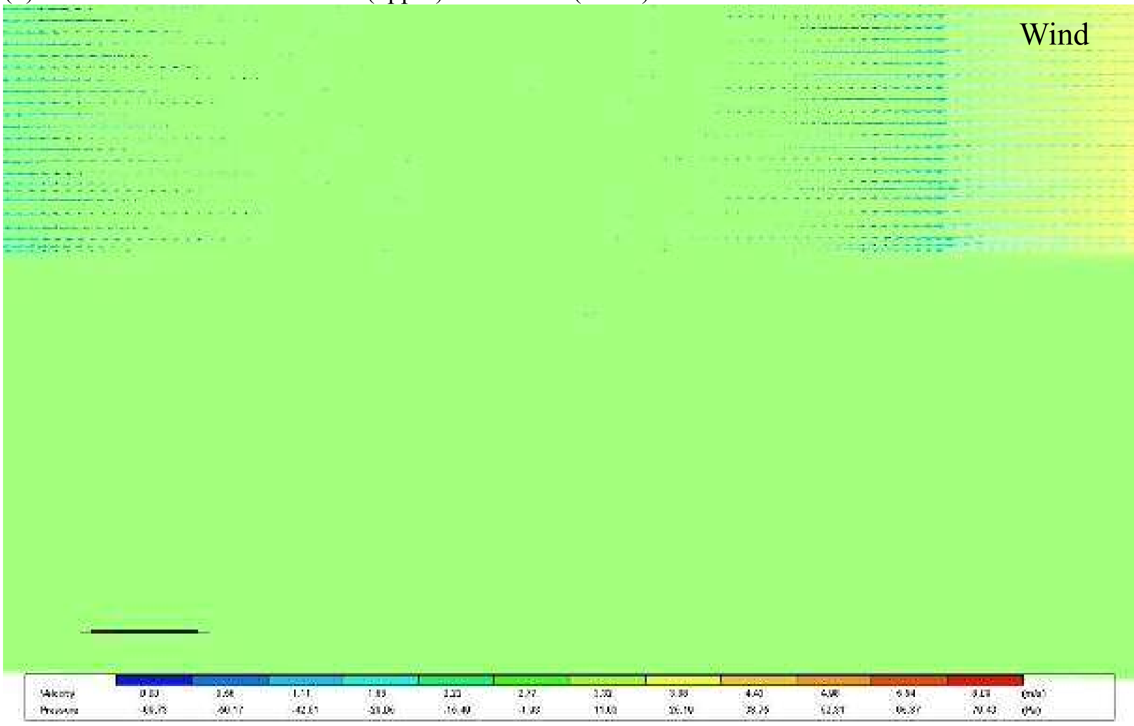


Figure 8.24a: Airflow inside inner first courtyards of Courtyard-S3 with wind at 45° (North-East, wind direction from the back at 45° from normal) and 90° (East, wind direction from the side); by CFD images in invisible of component blocks.

(b) doors and windows CLOSED (upper) and OPEN (lower) at both ends………..wind direction = 90º



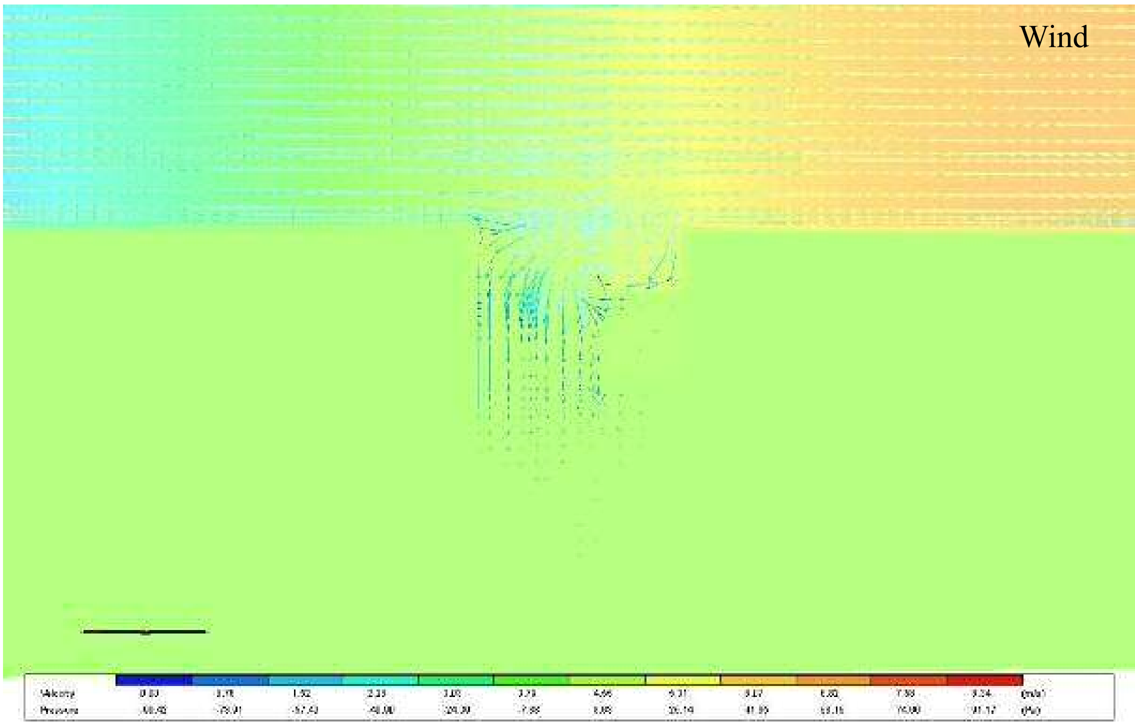


Figure 8.24b: Airflow inside inner first courtyards of *Courtyard-S3* with wind at 45º (North-East, wind direction from the back at 45º from normal) and 90º (East, wind direction from the side); by CFD images in invisible of component blocks.

Building case at George Town (Penang): Courtyard-P2

(a) doors and windows CLOSED at both ends……………………………………wind direction = 45º

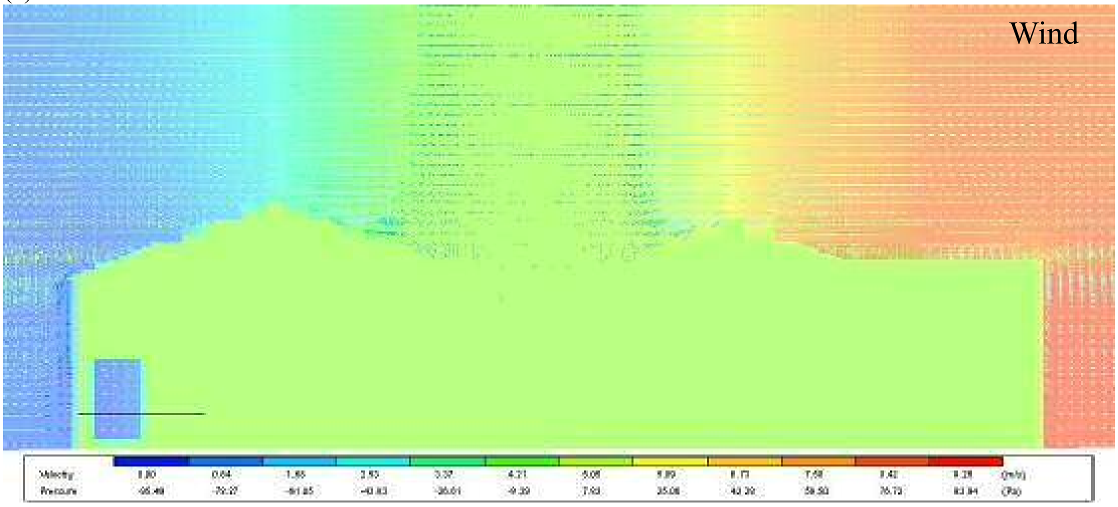


Figure 8.25a: Airflow inside inner first courtyards of *Courtyard-P2* with wind at 45º (North-East, wind direction from the back at 45º from normal) and 90º (East, wind direction from the side); by CFD images in invisible of component blocks.

(b) doors and windows OPEN at both ends…………………………………………wind direction = 45º

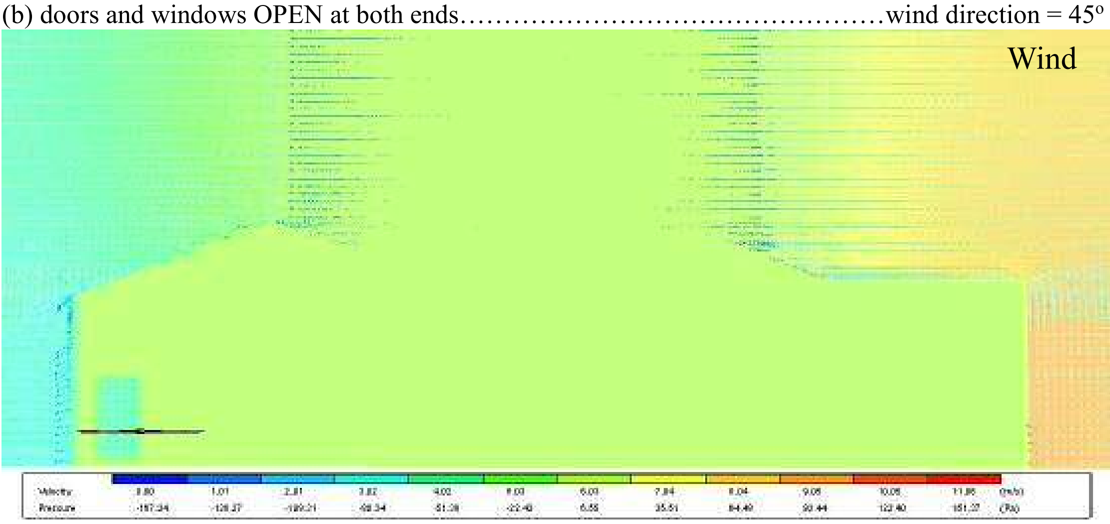
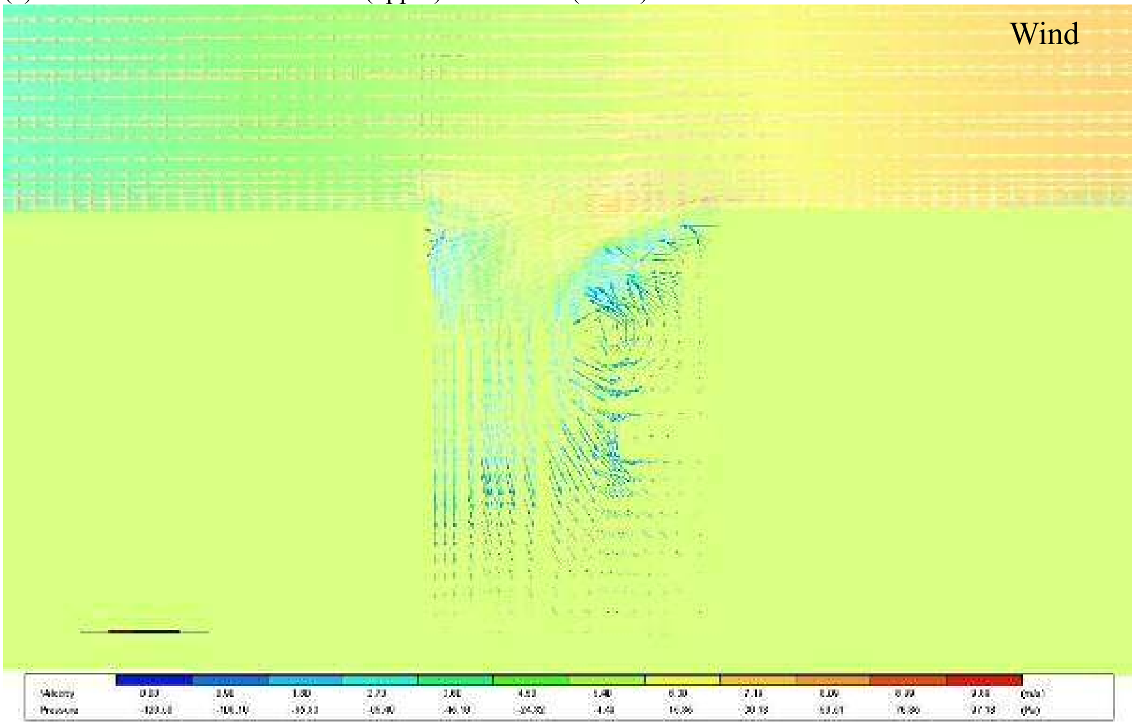


Figure 8.25b: Airflow inside inner first courtyards of *Courtyard-P2* with wind at 45º (North-East, wind direction from the back at 45º from normal) and 90º (East, wind direction from the side); by CFD images in invisible of component blocks.

(c) doors and windows CLOSED (upper) and OPEN (lower) at both ends…………wind direction = 90º



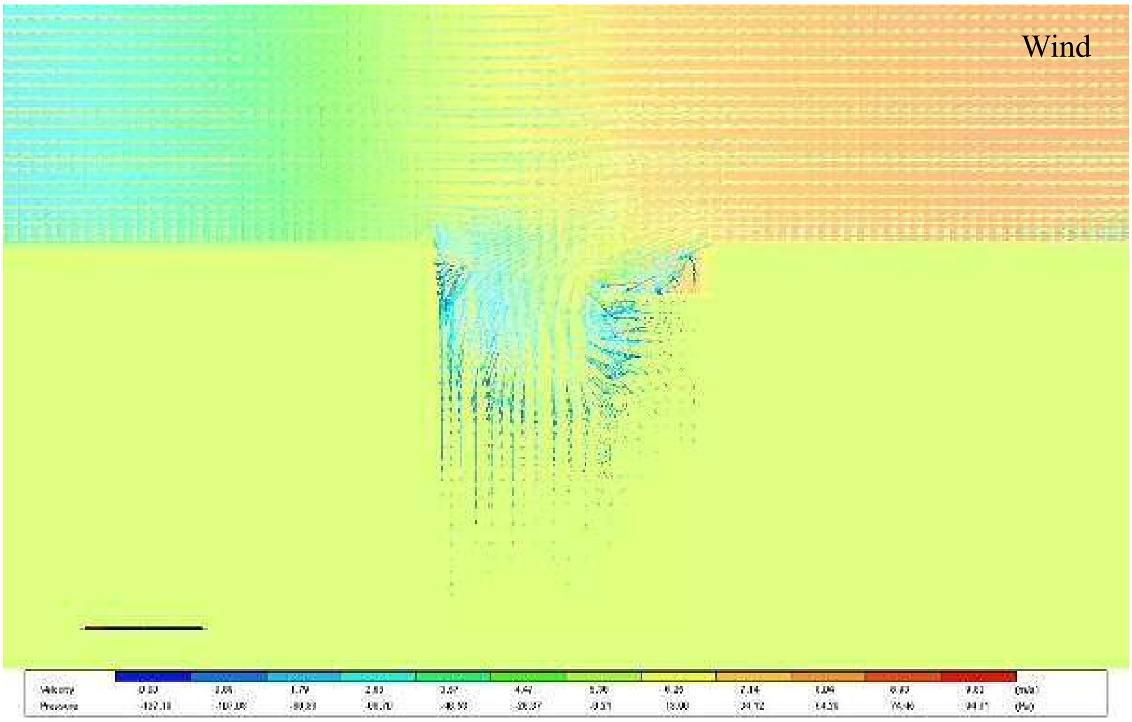
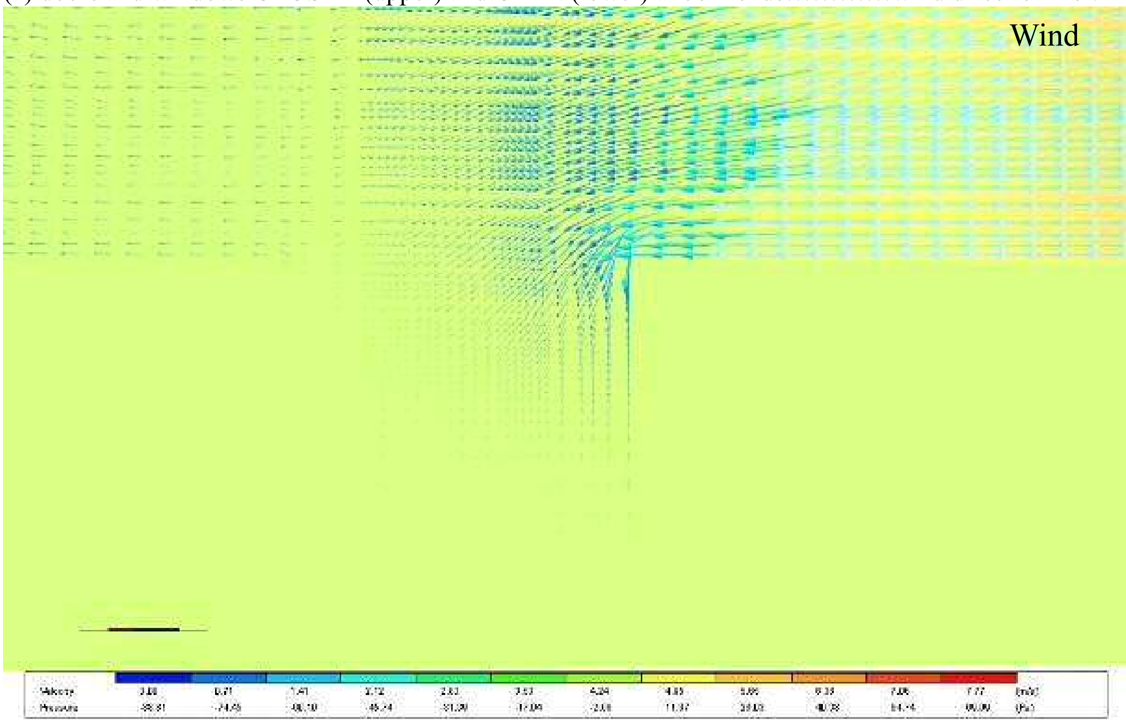


Figure 8.25c: Airflow inside inner first courtyards of *Courtyard-P2* with wind at 45º (North-East, wind direction from the back at 45º from normal) and 90º (East, wind direction from the side); by CFD images in invisible of component blocks.

Building case at Daxi (Taiwan): Courtyard-D1

(a) doors and windows CLOSED (upper) and OPEN (lower) at both ends...........wind direction = 90°



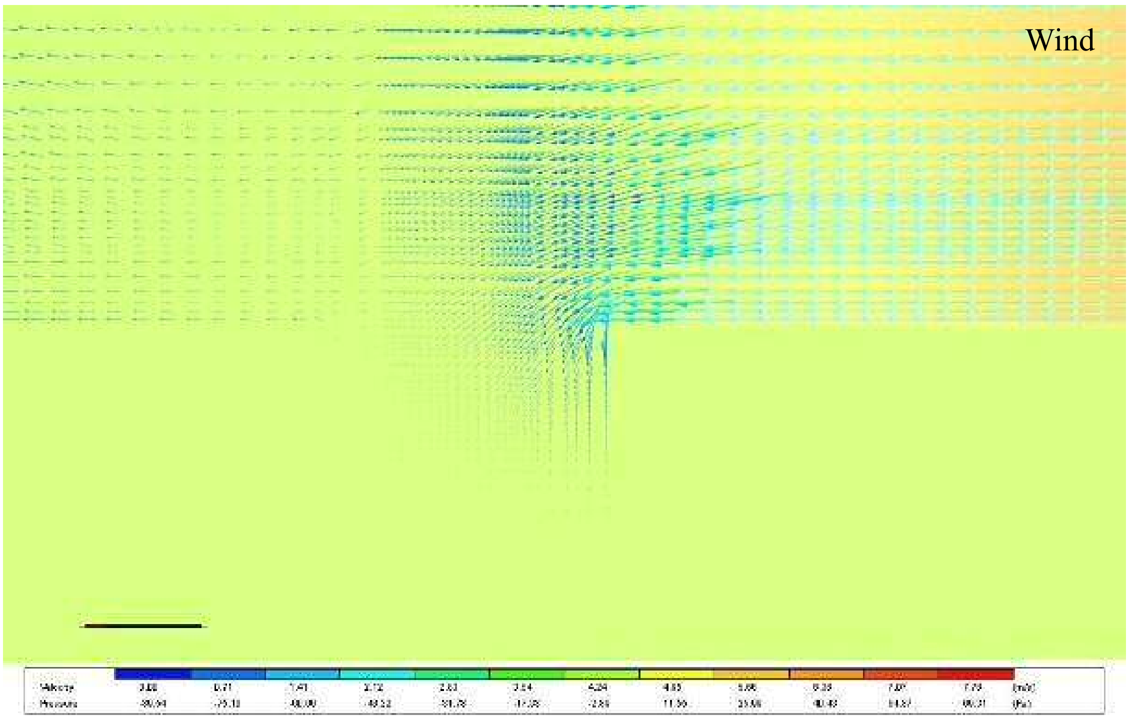
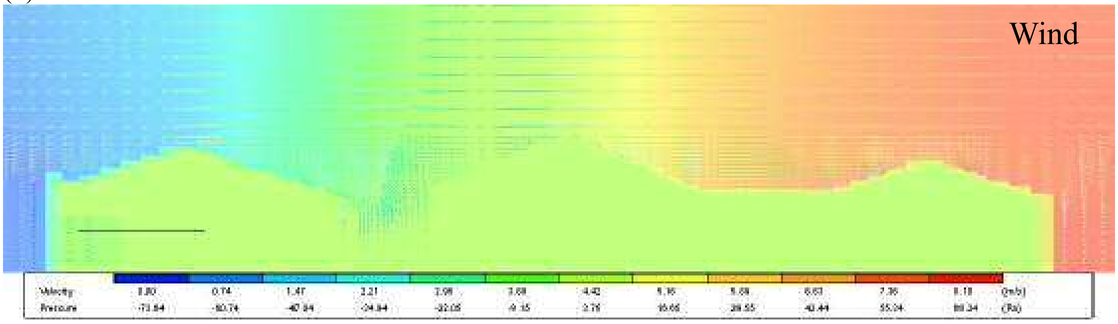


Figure 8.26a: Airflow inside inner first courtyards of *Courtyard-D1* with wind at 45° (North-East, wind direction from the back at 45° from normal) and 90° (East, wind direction from the side); by CFD images in invisible of component blocks.

(b) doors and windows CLOSED at both ends……………………………….wind direction = 45°



(c) doors and windows OPEN at both ends……………………………………….wind direction = 45°

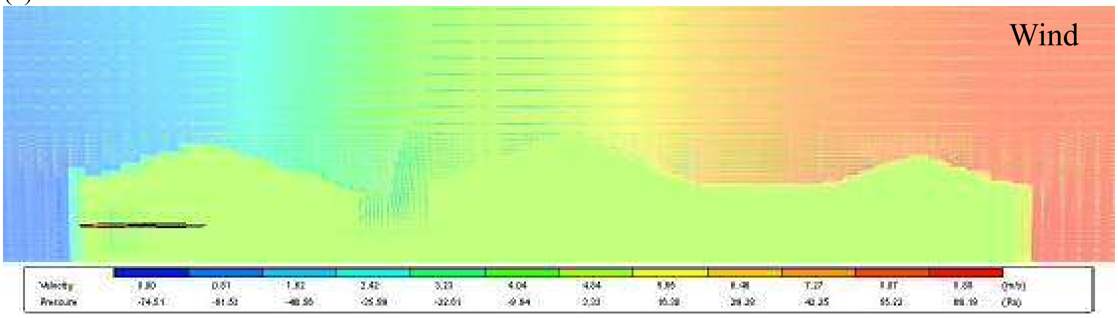


Figure 8.26: Airflow inside inner first courtyards of Courtyard-D1 with wind at 45° (North-East, wind direction from the back at 45° from normal) and 90° (East, wind direction from the side); by CFD images in invisible of component blocks.

Figures 8.24b, 8.25c and 8.26a illustrate the flow regime towards the front courtyard voids for all three buildings at 90° wind angle (wind direction from the side). Very similar results were obtained at all cases, except with the schedule of the doors and windows *closed* at both ends of the three-storey shophouse building (*Courtyard-S3*, refer to left image of Figure 8.24b). The *Courtyard-S3* is narrower and this is the highest courtyard among all building cases being studies. In contrast, in the wider and lower courtyard, the influence of the open windows on the airflow in the courtyard is less pronounced. As a consequence the main vortex inside the courtyard is not affected (Tablada *et al.* 2005).

8.3. Summary

This chapter has presented the natural ventilation related studies for the traditional shophouse typologies. Computational simulation was selected as a tool to test the effectiveness of the natural ventilation design. The relationships between the angles of wind direction, the natural ventilation openings and whether these openings were *closed* and/or *open* and how these factors interact with one another are the most important aspects of the natural ventilation design. When all the factors are organized in a right arrangement, air was found to flow through in an expected route with a desired volume according, what might be assumed to be the intended design.

Reviews present new insights to ameliorate the ventilation comfort conditions of the traditional shophouses in Southeast Asia by designing efficient courtyards. A comparison between the models and their overall ventilation comfort situations helps clarify guidelines for further optimization of the natural ventilation performance characteristics of courtyards. Natural ventilation design is a pattern arising as the consequence of relating different natural ventilation factors. Computer modelling provides a good tool to define and understand the relationship.

In the past, the central courtyard was the only way to solve the needs of lighting and ventilation, and today it was not just a void only. If one really wants to live in this traditional shophouse, one must change some of the equipment to meet the specific needs. Colonization in the past and globalization at present has enabled the transfer of ideas to the developing world. The built environment of the developing nations faces the challenge to adapt to the modern world and is losing its 'sense of place' (Chang *et al.* 1996; Chapman 1997). It should be able to preserve its identity since response to shelter is closely affiliated with cultural, social, climatic and economic factors.

The process towards ecological design of traditional shophouses starts with profound analyses of the past (natural lighting and ventilation) and present culture (the surveys from occupant and visitor) of the old commercial districts.

9. Toward an Ecological and Respectful Philosophy

The results presented in three earlier chapters (4, 7 & 8) demonstrate that in current traditional and old shophouse buildings design projects, the planning of the house form mainly took place in an intuitive manner based on the ability to use minimum resources for maximum comfort. This is to be expected under conditions of weak technology and limited environmental control systems, where man cannot dominate nature but must adapt to it (Rapoport 1969). Also, it was concluded that climate was an important aspect of the form-generating forces in order to be considered a well-founded design in the 18th, 19th and early 20th centuries.

This chapter deals with the development of a selection procedure for adaptive reuse of traditional shophouses. The main goal is to develop an approach for well-founded decision making. In doing so, it addresses the study issues of how the current traditional shophouse architecture can be improved. The approach that is developed in this chapter is intended to be applicable during the early design of renovation phases, and must enable optimised use of architectural science. In order to reach the goal, two study issues need to be answered:

- which opportunities exist to arrive at a well-founded choice of types of business to reuse traditional shophouses?
- how can an approach for the well-founded selection of ecological design in lighting and ventilation be developed?

In order to answer these study issues, the following research steps have been taken:

- analysis of existing opportunities to make a well-founded choice, and
- development of an approach for a well-founded selection of ecological thinking for improving the current traditional and old shophouse buildings.

The analysis of existing opportunities to make a well-founded choice of alternative new businesses to reuse traditional shophouses, as described in Section 9.3, consists of:

- analysis of the requirements and constraints that can be identified for making a well-founded choice, that must be met by any approach that tries to rethink usage for the future of traditional shophouses;

- overview and assessment of existing practices for making design decisions and specifically for selection of business usage, resulting in identification of gaps and missing aspects in existing practices.

The development of an approach for a well-founded selection of ecological thinking is described in Section 9.4., and consists of:

- development of an approach for ecologically-based design decision-making on the selection of business types, using applicable elements from existing practice to define the essential steps that should be taken and where needed structuring the sequence and interrelations for these steps;
- Analysis of the viability of the resulting approach by means of application of the approach to a schematic design, allowing evaluation of whether or not the resulting approach meets the requirements and constraints as identified in the first step, and fills the gaps in existing practices.

Before that, a critical literature review establishes and elaborates on the need for this study. It does this by critically reviewing previous research and theory related to the topic, and identifying existing knowledge gaps. An argument emerges that the aims of this research are novel and that research such as this has not been done before. This review aims to:

(i) learn and compare the influence of values on public and users' attitudes to traditional shophouses, and

(ii) try to construct a typology that illustrates how users' management behaviour differs according to the values that they hold.

These aims are being pursued by focusing on building renovation but the overall aim of the study is to develop an understanding of users' values and attitudes that are more widely applicable than just to shophouse building.

9.1. Trends and developments

This section on future trends for the development, preservation, and management of historic districts emanates from practical work this research have carried out. Over the years, it became evident to this study that physical-built heritage and human development were two sides of the same coin, and unless taken as a whole, there would be no point in undertaking any preservation programme as such in isolation.

In relation to socio-cultural trends, it is important to establish the value of the shophouse in Taiwan post-war town centres since 1945 as well as to establish the extent to which they are considered to incorporate culturally significant elements. Finally, the relationship between the value of these elements and their function in achieving strategies to enhance ecological concepts.

In terms of the economic trends regarding urban heritage, the current development towards citizen science could become a significant opportunity for shophouses to involve more people in the interpretation of urban heritage. Besides this, cultural resources in Taiwan seems to be receding. Although this is not a welcome development, traditional shophouses could play an increasing role in supporting urban heritage stakeholders who find themselves under pressure to seek better ways to advocate the value of heritage shophouses.

From the literature, it can be found that typically, the owners of traditional shophouses were mostly the rich businessmen in early times (Cheng and Lin 2011). Some of them still live there now, maintaining their traditional living styles; although most of them have moved out to other places with their own sufficient financial support. Therefore, these owner occupants were not active enough on the reconstruction of shophouses, even though the prices of the land were more than those of the buildings. Shophouses were used temporarily. Some of them await the proposal of new combined construction with their neighbourhood. Besides age and damage, shophouses also revealed the risk of structures. The maintenance work was expected for the sake of safety. However, they were uncertain about the time of the maintenance.

Since some owners ‘did not have the money nor the intention of good maintenance’ or ‘thought that the visitors or money might not increase after the maintenance works’, they were forced to continue to use the old shophouses (Fieldwork 2010). However, the business of such historic streets was not vigorous and the owners might not successfully rent out the houses after the increase of rental fees. Therefore, the reconstruction has been risky and the owners were mostly conservative.

On the side of renovation of traditional shophouses, availability of funding is one of the most critical issues and indeed it is the main factor influencing reconstruction and is significantly related to the quality of work undertaken. Shophouse owners and occupants have different positions (Fieldwork 2010). At the same time, access to labour can also be a significant barrier, where skilled workers are unwilling to work on such small construction projects. The quality of construction, selection of materials and the states of shophouses will be influenced by all of these factors and as a result of these challenges, the lowest level of investment is typically made on renovation or reconstruction works.

From the perspective of urban regeneration, a government initiative in community building, influenced by the Machizukuri Movement in Japan, has led to a growing movement in community planning and participation (Evans 2002; Sorensen and Funck 2009). However, this movement focuses on shop front renovation only. The streets within the old town centres, once dominated by rows of old shophouses, have also lost their strength. A lot of the rows are already broken by either new buildings or old buildings with modified facades that are sympathetic to the old buildings in the area. Apart from the height control, there is no proper guideline regarding the design of the façade, within the conservation area.

There have been a number of developments in Taiwan, based on the concepts of the Machizukyri movement. One completed in 2011, is a redevelopment in one of Taiwan's historic districts, namely, the Dihua Xintiandi, is located at the north end of the Dihua Street, Taipei City, Taiwan (Figures 9.1 and 9.2), by running at shop fronts renovation, this is a case of part preservation but largely reconstruction.

In Dihua Xintiandi, for example, street renovation was not necessarily to remove the whole of existing shophouse buildings. It was just leaving the existing features of the building, and with a modest creative packaging and the rectification of the street layout, the injection of new elements in an old street can enhance the brightness of an urban block. Thus, it is conducive to the development of sightseeing. Today, the Dihua Street should be regarded as the most preserved in Taipei City, and it has its own style. In addition to the old imitation of Baroque Style, even the new projects also follow the local preservation of the architectural styles.

Figure 9.1: Satellite images showing the housing project, Dihua Xintiandi, (upper) the original row of shophouses with dense planting at the courtyards; and (lower) for the purpose of the historic cultural attraction, the built housing block keeps a minimal range of preservation for shophouses and leaving a gap with the row of partly first hall. (Source: Google Map, 2012; iOS Maps, 2014)

Figure 9.2: New housing development case: (left) the visual effects of 'volume control' for renewal; (middle) a brand new building blocks behind the shop fronts; (right) view from the former courtyard area.
(Source: Photographs taken by author, 2012)

Providing a central source of central air and light, courtyards play an important role in many traditional shophouses in Southeast Asia, and also in Taiwan. At the same time, people in this region instinctively knew that the temperatures in their courtyards felt cooler, more comfortable than outside temperatures. Unfortunately, such customary rules of ecological minds or building science concepts are just terminated here only. It seems no further action is needed by ongoing changing lifestyles with the power of modern mechanical facilities. The spatial advantages of courtyards have become an impedance to current users, and it is likely that the case of Dihua Xintiandi, will be a common phenomenon in Taiwan.

9.2. On-street visitor survey

The visitor experience of historic districts is influenced by a number of factors, including ease of access and movement, visual impressions, the range and quality of things to do and see, and human interaction (Chang *et al.* 1996). In order to learn more about what visitors like and dislike about Taiwan's and Southeast Asia's historic streets and/or towns, especially in relation to shophouse courtyards, this study undertook a face-to-face survey of on-street visitors in Northern Taiwan as well as some major towns or cities in the Malay Peninsula.

Approximately ten to twenty overseas or local visitors were interviewed in each of the districts and/or towns, giving a total sample size of 151 (Table 9.1). The aim of the survey was to assess their level of satisfaction on street fronts and internal courtyards with their visit to these streets or towns.

Survey Location and Period		Number	Percentage
Taiwan (2010)	Hukou	17	11.25
	Daxi	26	17.21
	Sanxia	31	20.52
	Dihua Street	9	5.96
Malay Peninsula (2011)	Georgetown of Penang	37	24.50
	Ipoh	6	3.97
	Melacca	13	8.61
	Chinatown of Sngapore	12	7.94
Total		151	100.00

Table 9.1: Distribution of survey respondents by survey location. (Source: Fieldwork, 2011)

9.2.1. Approach

The study was conducted during periods of summer holidays from 11th July to 22nd August 2010, and 29th July to 6th August 2011; and covered eight historic districts across three countries as detailed in Table 8.1. Surveyors from the Department of Architecture and Urban Planning, Chung Hua University, were hired to carry out the major part in Taiwan, while the overseas surveys were carried out by the author. All respondents to this survey were anonymous and selected at random from those who were in the study area at the time of the survey and were willing to participate. The time allocated for each respondent to complete the survey was between 10 to 15 minutes. A blank copy of questionnaire used in On-Street Visitor Survey is included in Appendix C.

The study focus is on people who visit the target areas, and not those passing through, so the surveyors avoided the peak morning and afternoon commute hours in an attempt to exclude most of the pedestrians passing through the area to work or school. In this study, SPSS statistics software was used for data analysis. This section provides selected analysis of the data obtained from the On-Street Visitor Survey. The findings are presented in Cross Tabs, and relating to the general statements that were used for categorization, description and discussion purposes.

When exploring the on-street visitor surveys, one central idea focuses upon whether or not the public believed a small space, courtyard, would help not only spur economic development, but also the rise of heritage preservation. Three groups of survey questions gathered the necessary data, so they were initially considered:

1. perception data,
2. environmental attitudes, and
3. personal data.

The key question Q5 asked: *Do you think that visitors should have access to the inner courtyards?* While another question nominally elicited a response to this statement: if there were more courtyards open to public, I would visit more often. As noted, some of these survey questions were initially considered to help determine a sound discovery process, but the first was chosen.

The research question, and our primary variable, is as follows: Do the occupants or users of traditional shophouses believe an existing and opened courtyard will encourage economic development?

9.2.2. Statistical analysis

In order to examine the research question thoroughly, this section presents the descriptive statistics of the relevant variables collated from this survey that correspond to this particular research question. The survey question, *'Do you think that visitors should have access to the inner courtyards?'* responses have one of three values. The respondents could answer *happy to see*, *unnecessary* or *not sure*. The preferred measured of central tendency for this value is the mode.

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Happy to see	84	55.6	55.6	55.6
Unnecessary	46	30.5	30.5	86.1
Not sure / missing	21	13.9	13.9	100.0
Total	151	100.0	100.0	

Table 9.2: Respondent view on access to the inner courtyard (both Southeast Asia and Taiwan).

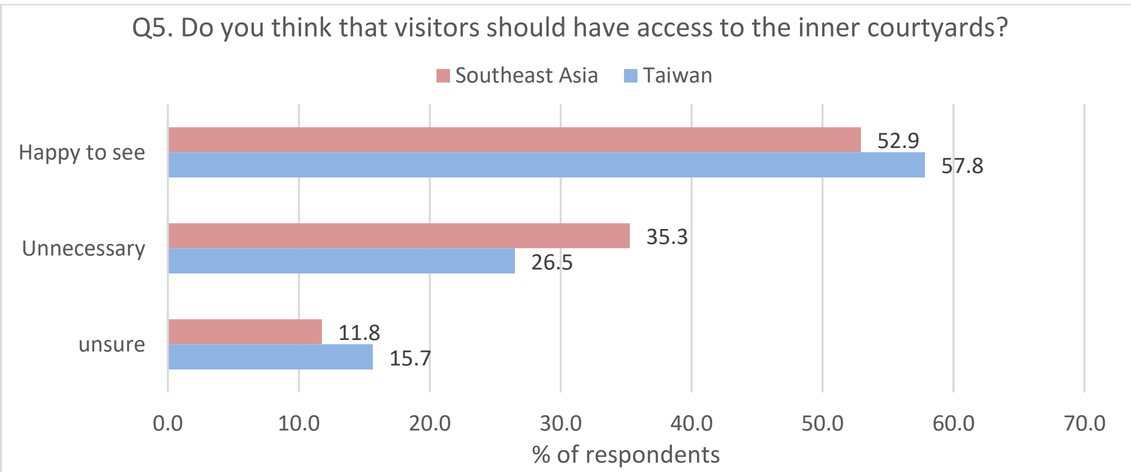


Figure 9.3: Respondent view on access to the inner courtyard.

From Table 9.2, it is easily noted that 84 respondents chose *happy to see* while 46 chose *unnecessary*; furthermore, 21 respondents were *unsure*. The valid percentage show that 55.6 percent of the respondents answered *happy to see* while 30.5 percent answered *unnecessary*. Figure 9.3 includes the entire sample in percentage calculations, and illustrates that 57.8 percent of the overall sample in Taiwan set responded *happy to see* to the question. Given these descriptive statistics, it is clear that many respondents (both Southeast Asia and Taiwan) appear to wish to have access to the shophouse courtyards.

However, from Figure 9.3 again, the difference between Southeast Asia and Taiwan in their own answers has slightly reversed in order. A higher proportion of respondents in Taiwan answer *'happy to see'* the courtyards, it is likely to be because domestic visitors are typically unaware of the presence of the inner courtyards. This is likely to be because the number of shophouses that remain in Taiwan, is relatively low and therefore many people are unaware of their typical form, including the courtyards, while a lot of earlier shophouses still remain in many coastal cities of Southeast Asia, they are therefore a very familiar form. Since most traditional shophouses in Taiwan are private owned, and the courtyards are inside the building: these typically private zones have been subject to the phenomenon of illegal construction would be quite common in most historic streets.

In this context a number of independent variables were selected. These variables are considered to help the understanding of the other dependent variables in relation to the level of satisfaction of traditional shophouse buildings in relation to the overall environmental resources in Taiwan's old and historic districts. And it is important to note the use of some independent variables is intended to enable exploration of possible hypothetical relationships between the variables. For example, by assuming that the rating of the *walkway into the surroundings* differ from the view of visitor on having access to the inner courtyard, the impact of the independent variable on the dependent one becomes obvious. In other words, the investigation of such a relationship should provide an answer to the question in relation to the level of satisfaction of historical streetscape and whether the vernacular shophouses face any difficulties in modern development which are not apparent in other urban areas.

Figure 9.4 shows the opinions of on-street visitors in Taiwan with respect to the rating of *the integration of the walkway into the surroundings* according to their view on access to inner courtyards. In the rating 63.4% of very satisfied respondents refer to *happy to see*, while 26.8% do not refer to any access as compared to 9.8% who refer to *unsure*.

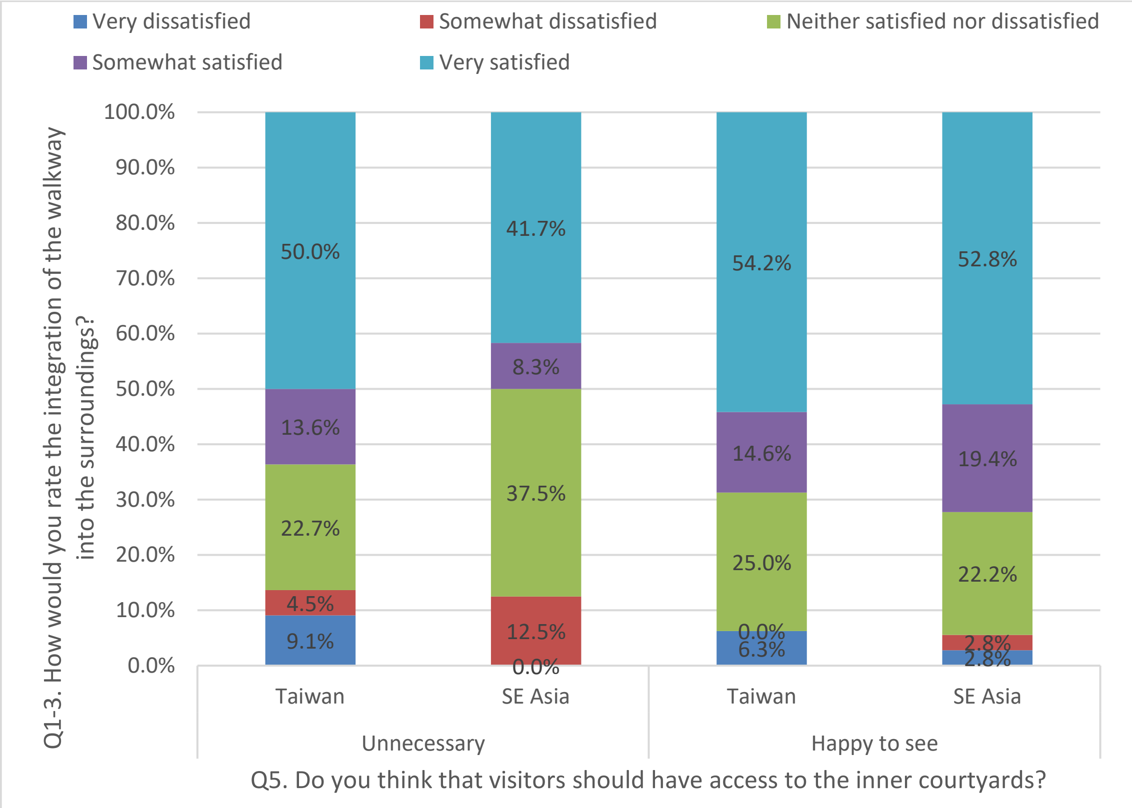


Figure 9.4: Cross-tabulation of visitor view on the public walkway.

It can be seen that the majority of the respondents in Taiwan express their satisfaction with the *integration of the walkway into the surroundings*. This satisfaction is slightly higher in those who think that it is *unnecessary* to see the inner courtyards in particular for those respondents in Southeast Asia.

Figure 9.5 indicates the level of satisfaction of the *quality of open courtyards* in relation the key question again. In the rating 63.4% of *neither satisfied nor dissatisfied* respondents refer to *happy to see*, while 26.8% refer to *unnecessary* as compared to 9.8% who refer to *unsure*.

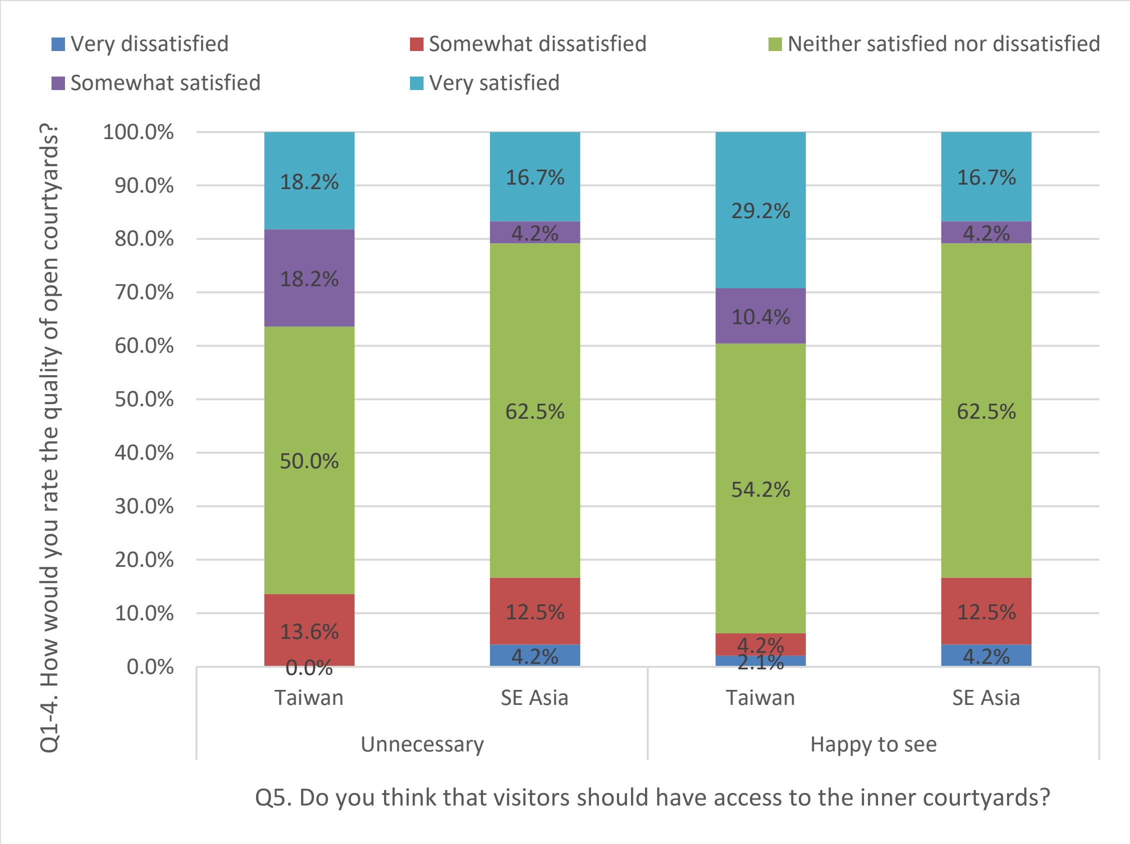
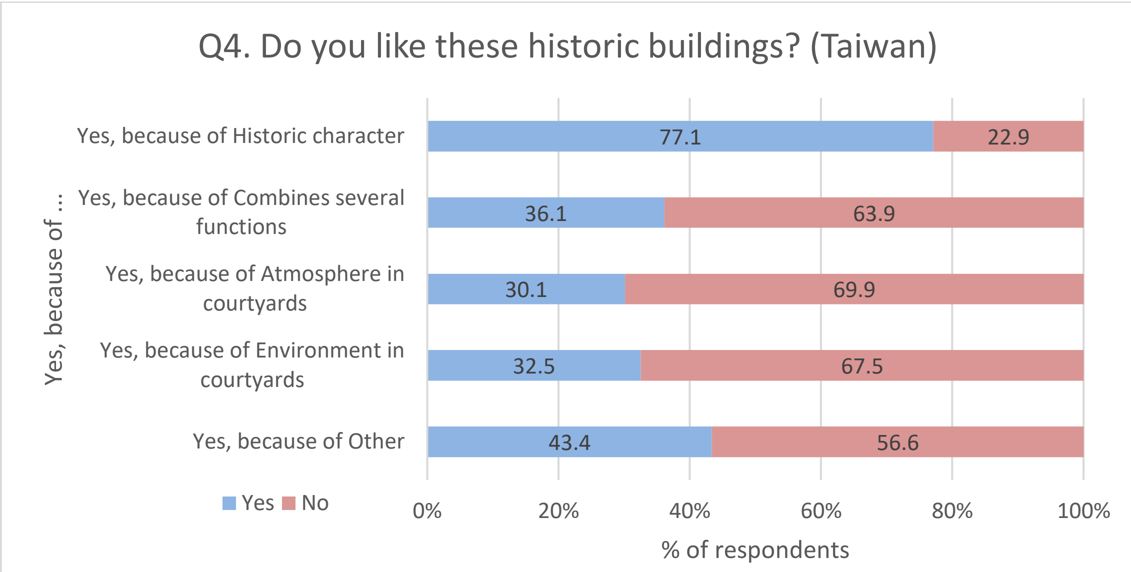


Figure 9.5: Cross-tabulation of visitor view on the quality of open courtyards.

As the findings depicted in Figure 9.5 show, a higher proportion of the respondents in Taiwan express their satisfaction with the level of the overall quality of inner courtyard, than those respondents in Southeast Asia, although the level of satisfaction is relatively similar for those who are *happy to see* and those that consider seeing the courtyards to be *unnecessary*.

Figures 9.6 focus on the relationship between the reason of the respondents to be happy in historic buildings in the aspects of atmosphere and environment which related to their view on access to the inner courtyards. In contrast to the opinion in terms of *happy to see*, the respondents expressing their view within historic buildings as compared with *environment* and *atmosphere* in courtyards with 47.9% and 39.6% respectively. It is apparent that while the *atmosphere*, *environment* and *historic character* of the courtyards are the most frequent reason to like these buildings in Southeast Asia, it is the *historic character* that is the most frequent preference in Taiwan.



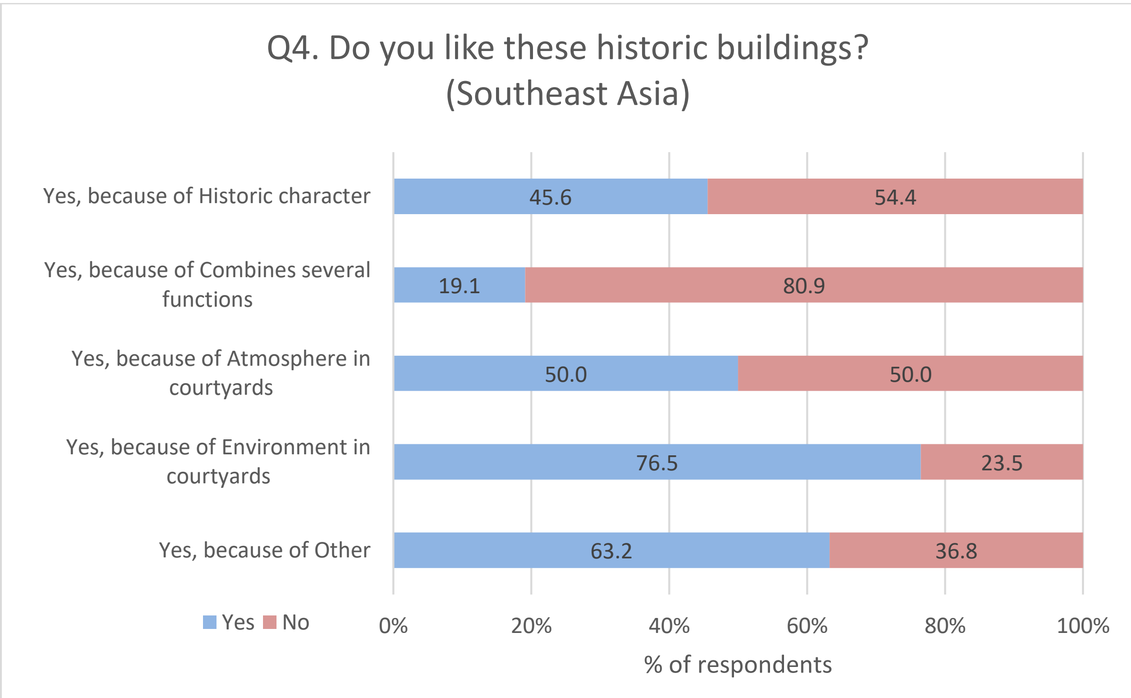


Figure 9.6: The reason to like shophouses in Taiwan (Upper) and Southeast Asia (Lower).

The results in Figures 9.7 provide open-ended data on the management intentions and actions for seeking change, add or improve in the future, plotted against perspective on access to the interior courtyards of these buildings. It can be seen that the categories are different for Southeast Asia and Taiwan that emerged were different (Table 9.3):

Taiwan	Southeast Asia
Change usage for tourism	Change usage for tourism
Must not be compromised for modern things	Must not be compromised for modern things
Need renovation	Need renovation
Hope to change inappropriate commercial spaces	Hope to change inappropriate commercial spaces
Increase local activities to attract crowds	Increase local activities to attract crowds
No response	No response
	Avoid sightseeing pollution
	Retain the cultural characteristics of this area
	Public facilities and traffic management

Table 9.3: The questionnaire response of Visitor Survey question number 11.

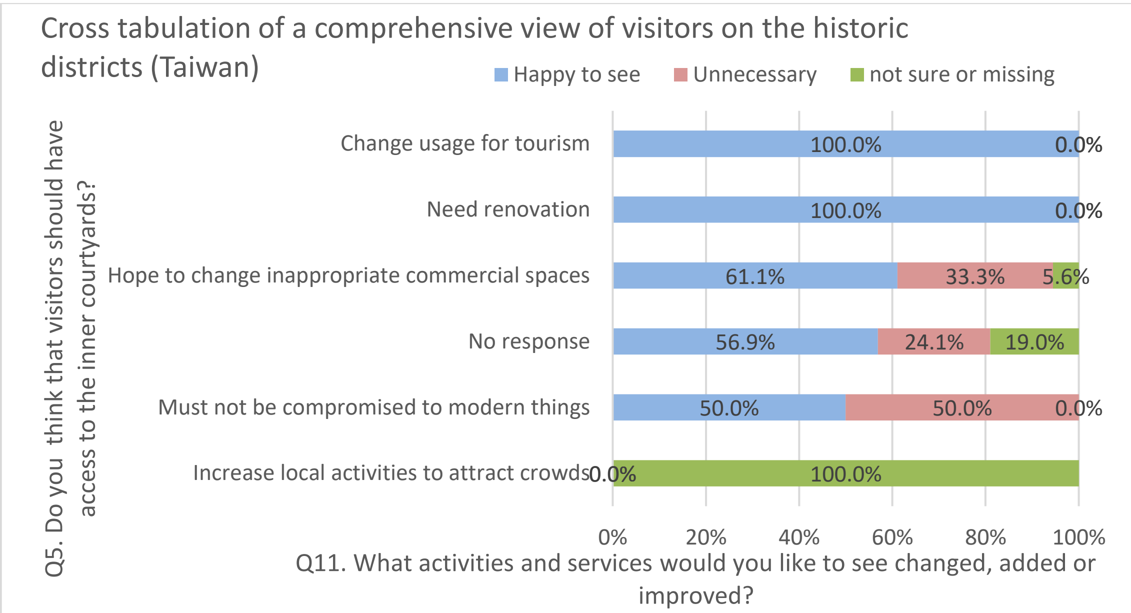


Figure 9.7a: Cross-tabulation of a comprehensive view of visitors in Taiwan.

Having categorized these responses it can be seen that for Taiwan (Figure 9.7a), all of these who expressed a preference for the shophouses to be changed use for tourism and needed renovation were also *happy to see* inside the shophouses. While all of those respondents who suggested that activities outside should be increased in these areas were *unsure* as to whether they wished to see the interior courtyards. Respondents who sought changes to remove inappropriate commercial spaces, considered that uses should not compromise the historic buildings and had no response to wishing to see the courtyards.

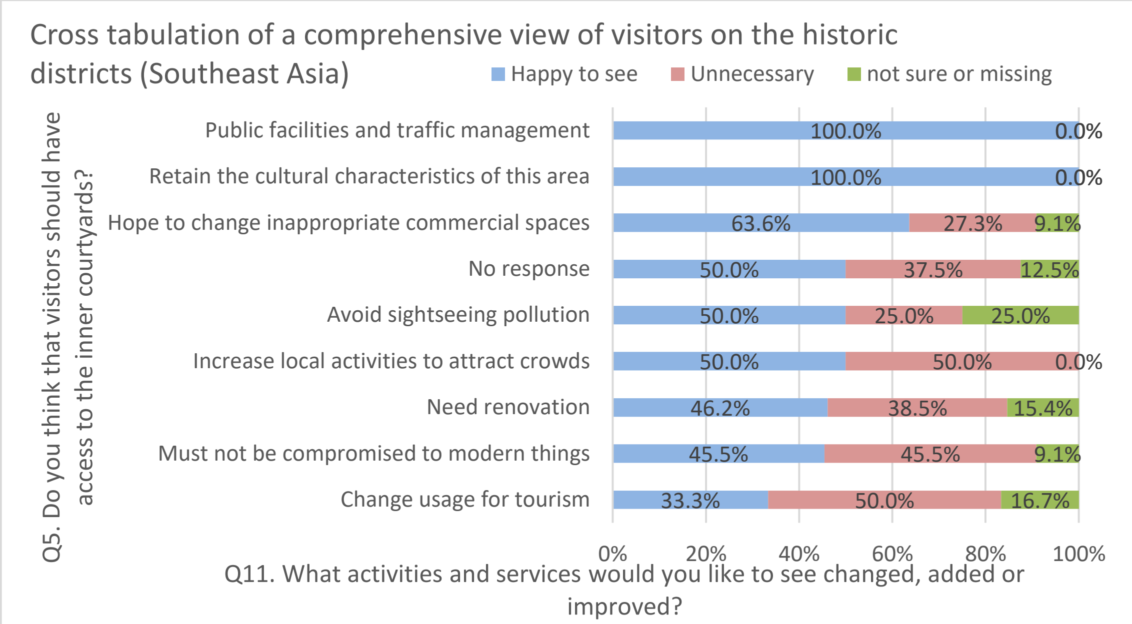


Figure 9.7b: Cross-tabulation of a comprehensive view of visitors in Southeast Asia.

While responses for Southeast Asia (Figure 9.7b), all of those who expressed a preference for the *Retain the cultural characteristics of this area*, *Public facilities and traffic management*, responses unique to Southeast Asia, were also *happy to see* inside the shophouses. While responses to the categories: *Hope to change inappropriate commercial spaces* and *Must not be compromised to modern things* were similarly distributed, in terms of access to courtyard preferences, as that found in Taiwan. While change of use for tourism and needing renovation was associated much less with those respondents *happy to see* the courtyard, perhaps in relation to the high level of investment in these buildings in these locations.

9.2.3. Summary of key findings

As the preceding discussion evidences, a number of difficulties exist regarding the physical characteristics given to on-street visitors. The majority of respondents expressed their dissatisfaction with the unexpected commercial activities taking place in these aged or historical buildings. Of course, visitors may not understand how the old street has developed in history, yet they are likely to be captivated by the story of the building and its layers of history which may be read through the fabric of the street. However, it appears shophouse buildings which are fully owned by the occupants, particularly those on the old or historic district, were the most affected by a successful business. In general where people go, business follows. Also negatively the secondary matter of respondents expressed dissatisfaction with the lack of maintenance of existing shophouse buildings and this increases with increasing business activities. Most visitors seem unhappy about modernisation issues within the historic districts. Positively, the majority of the respondents were happy to visit historic districts. Furthermore, the level of satisfaction rises in relation to good experiences of inner courtyard in traditional shophouses.

From the findings discussed, it can be concluded that the majority of old street visitors were in favour of the integration of the surroundings, thereby making it more attractive to business inflows. As stated in the above, cultural heritage tourism is a very significant generator of earnings for a district economy. The economic attraction of tourism for a historic street is that it leverages an existing set of local 'assets' to generate economic activity in that street. While the above images are impressive, there is in fact some room for improvement in terms of the impact that tourism could have on the economy of the street. Most of visitors (refer to Figure 9.7) have mentioned that they would like to see changes and/or improvement on the space usage for tourism. However, this implies that they couldn't get adequate or suitable facilities on the street for their whole day visiting, especially in lack of travel information, visitor centre, and also the sanitation facilities at such tourist spots.

The more one city comes to look and feel just like every other city, the less reason there is to visit. On the other hand, the more a city does to enhance its uniqueness, whether that is cultural, natural or architectural, the more people will want to visit. The primary assets of an historic street will often be its stock of historic buildings and its 'sense of place'. Identifying a district's sense of place can be a difficult and amorphous exercise, but is important to try if the district is to clearly identify its 'unique selling proposition', which will allow it to better position itself in the tourist market. Identifying this sense of place can begin by identifying what makes the district different from other streets of towns – what is its essential character and distinctiveness (Clifford and King 1993; Ashworth *et al.* 1999). A sense of place is a unique collection of qualities and characteristics – visual, cultural, social, and environmental – that provide meaning to a location (Martin 2007). Traditional shophouses, it is argued can be one factor that helps in making one town, in this region, different from another, and its courtyard is also what makes our physical surroundings worth caring about.

The gap in knowledge that this thesis addresses is how the dimensions of occupants, visitors, land developers, community, and lifestyle combine to influence the use of a shophouse building from the past to the future. The argument of this issue is that: if there is a future, traditional shophouses, we still want it?

9.3. Analysis of opportunities

From the findings of the research presented in Chapter 5 it is concluded that the current types of business in Taiwan is based on the original shophouse occupants' family home business, and/or has been changed to meet the requirements of tourism. This section analyzes the opportunities to re-think the procedure for the selection of business types by analyzing the requirements that must be met when making a well-founded design decision regarding the selection of such usage, and by analyzing existing practices that might be used to support a well-founded choice.

9.3.1. Requirements for a well-founded selection

The following criteria are proposed for application in the selection of appropriate business types to support a well-founded and ecological informed design decision:

1. the selection must be based on a choice between a set of alternatives (respecting spatial integrity of shophouse buildings), ensuring that different options have been considered;
2. when deciding between the different alternatives, the retention of courtyards must be taken into account;
3. for each design alternative information about the required performance for each of the relevant aspects must be available, allowing a comparison of advantages and disadvantages.

These criteria are intended to ensure that the search for business types includes more than one alternative, enabling the decision to select the best option from a range of alternatives. They aim to ensure that not only lighting and ventilation are assessed, but also other relevant building performance aspects (especially thermal comfort). Finally, they call for design decisions to be made on the basis of ecological information, which allows designers to rationalize these decisions.

It must be noted that an approach for the selection or consideration of a new business type must be applicable in the context of an ongoing shophouse redevelopment processes. This means that the procedure must:

- be applicable during the early phases of the redevelopment process (feasibility study, conceptual design, cost analysis), since it is in these phases that most decisions related to reuse are made;

- only target the selection of functions that enable the retention of inner courtyards. It is important to note that selection of these business type is only one of many activities that take place during the redevelopment process of shophouses. Other, unrelated activities must not (or only minimally) be constrained or impacted by the approach.

9.3.2. Spatial change and identity

It is increasingly recognized that there is a strong connection between adaptive reuse of historic buildings and sustainable urban development (Bullen and Love 2010). Adaptive reuse projects provide economic and social benefits. They generate tourism and create job opportunities (Tweed and Sutherland 2007). However, balancing economic viability and cultural significance for heritage buildings is a major challenge (Murtagh 2006; Wang and Zeng 2010).

Over the past decade, lacking in maintenance and recognition as built heritage, a very large number of older shophouse buildings have been destroyed or modified beyond recognition (Doling 2014). For example, Singapore once had many shophouses, the majority of which were destroyed in the 1970s as the country embarked on a relentless development and modernization drive. Not until the publication of the Wong Report of 1984 – which claimed that the disappearance of the country's built heritage was one of the principle causes of a decline in tourist numbers – did the Singapore government begin to reassess the value of its urban heritage (Lim 1990; Kong and Yeoh 1994; Riegl 1996). By that time, destruction of familiar urban landscape, coupled with stress of everyday life, had left many Singaporeans feeling that they had lost their roots. The government subsequently acknowledged the important role of history, memory and heritage in the making of the city, and launched a major programme to protect and preserve what remained of Singapore's historic architecture. Today, heritage tourism plays a key role in reinforcing Singapore's image as a vibrant global city (Chang and Teo 2009).

Among Singapore's many types of built heritage, its shophouses have provided the most flexible and adaptable foundation for repurposing as cultural, recreational and commercial facilities (Larson 1984). Restored and renovated according to the principle of adaptive reuse to meet the needs of modern life, they now house a wide range of organizations, including theatres, galleries, offices, hotels, café and shops. In recent years, Malaysia has also sought to develop understanding of built heritage as an expression of history and identity (Henderson 2004), and today it, too, encourages heritage tourism as a key component of an economic strategy which extends across the whole service sector. Refurbished shophouses once again play a central role in the lifestyles of local people and in tourism promotion – those in Malacca and George Town have been recognized by UNESCO as World Heritage.

Chapter 5 outlined the selecting and collecting of data through the occupant survey from 182 occupants living in traditional shophouses in Northern Taiwan's historic towns. This section tries to provide an in-depth look at traditional shophouses with home-based business through a change from owner occupants.

In the type, *live-nearby*, home and workplace are in separate buildings a small distance apart. Taiwanese examples, probably more common in the historic districts than in rural areas, including the Liu family in Daxi Township (*Courtyard-D1*), comprising a grandparent, a married couple, and their two children. Having converted a bedroom to woodcarving workshop of the third building in his shophouse (Figure 9.9, A3 format), his family has since now lived in a nearby apartment for many years. However, this apartment is just a place to sleep, they are still living (eating, working, social) in their original and traditional shophouse.

Using Table 9.4, some associations can be seen in Daxi Township. Of those who rate their shophouse as a place to live, the largest population of respondents rated *much worse* than the other types of home in the nation with 40.0%. However, two considerable percentages in 23.3% and 36.7% expressed that shophouses are *much better* and *fair* respectively (Figure 9.8). This implies that about 60% of respondents were quite satisfied with their traditional shophouses.

			Location of Shophouse						
			TW-Beimen	TW-Hukou	TW-Daxi	TW-Sanxia	TW-Xinzhang	TW-Dihua	Total
C2 How would you rate the shophouse as a place to live, compared to other types of home in the nation?	Much better	Count	3	3	7	6	7	7	33
		% within Location of Shophouse	14.3%	9.1%	23.3%	16.7%	26.9%	28.0%	19.3%
	Fair	Count	15	19	11	20	14	11	90
		% within Location of Shophouse	71.4%	57.6%	36.7%	55.6%	53.8%	44.0%	52.6%
	Much worse	Count	3	9	12	7	3	6	40
		% within Location of Shophouse	14.3%	27.3%	40.0%	19.4%	11.5%	24.0%	23.4%
	Not applicable	Count	0	2	0	3	2	1	8
		% within Location of Shophouse	0.0%	6.1%	0.0%	8.3%	7.7%	4.0%	4.7%
Total		Count	21	33	30	36	26	25	171
		% within Location of Shophouse	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9.4: Cross-tabulation of rating the shophouse as a place to live in different locations.

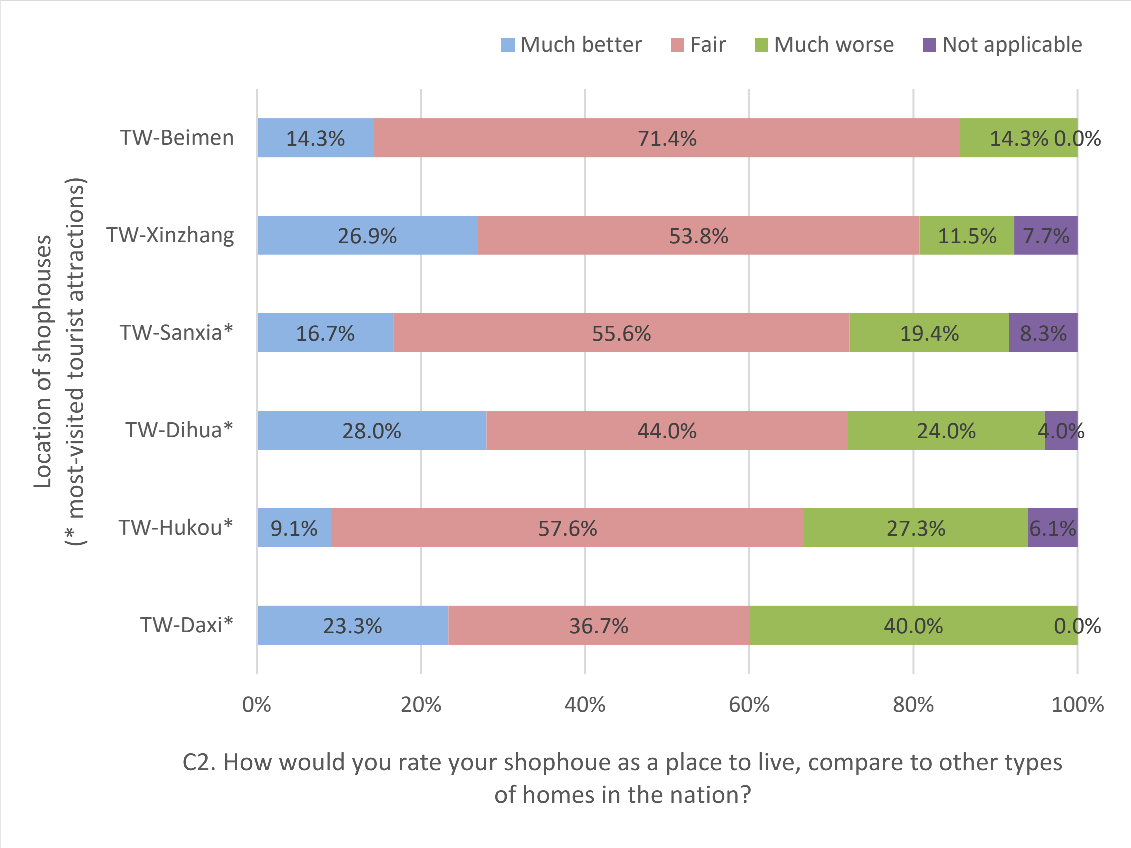


Figure 9.8: Cross-tabulation of rating shophouse as a place to live in different locations in Taiwan.

The owner occupant in Daxi Township underscored this view when he said:

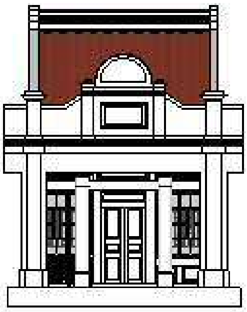
I think it [shophouse re-development] has been great. Daxi and other such areas were becoming rather dilapidated though they retain much history and character. Personally, leisure has been the perfect way to rejuvenate the area while leveraging this history and character. The main advantage of this arrangement is that my work is woven around family life again and my parents, my wife and children are much happier. On hand to support my wife, my parents collects our children every day from school and has more hours' family time in our home [shophouse]. During the day we work and play here, and at night we sleep in our modern apartment (personal interview with the owner, a woodcarving craftsman, 3rd July 2008).

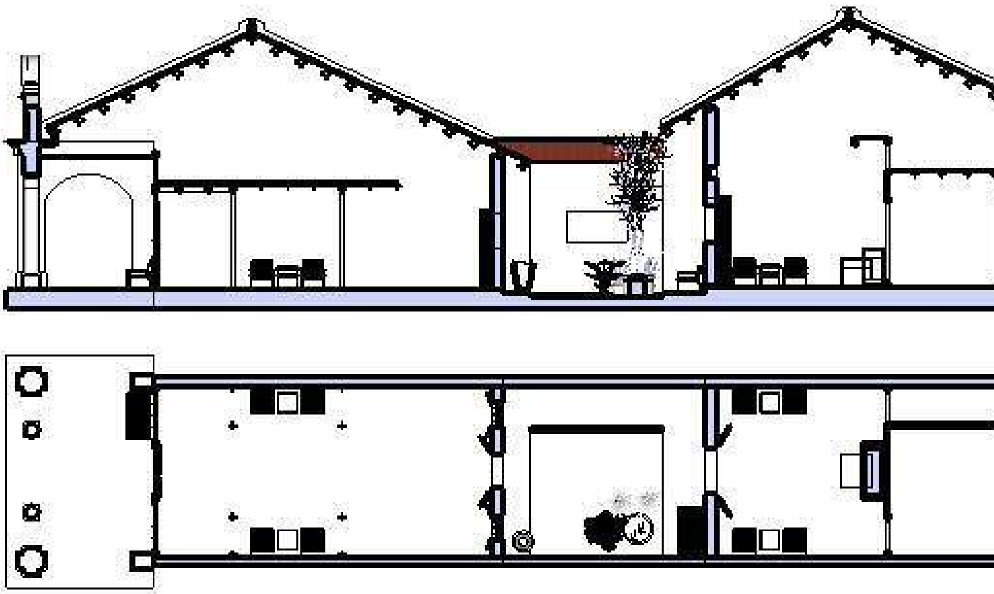
Shop Front

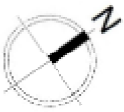
Shop Unit

Outdoor Pantry

First Courtyard

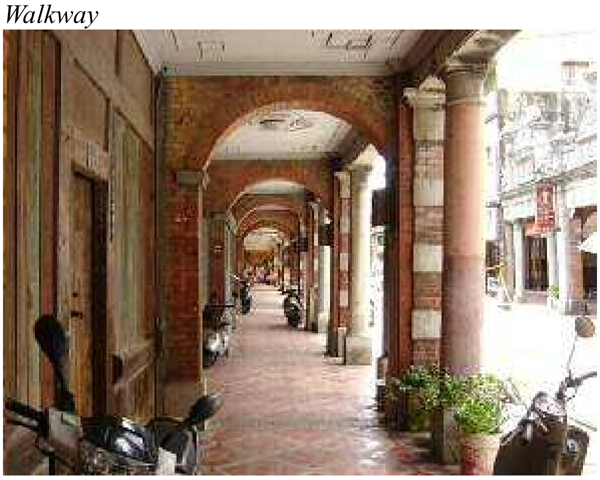






Shop Front **_Shop Unit_** ***Front Courtyard*** **_Main Hall_** **_Dining R_**

Walkway



Façade

Shop Entrance

Table 9.5 displays results regarding the point raised in comparison to respondents' view from different locations. Most of respondents from all three tourist districts (Hukou, Daxi, and Sanxia) say it is *too difficult to maintain* an old shophouse building. There are very big difference between of this response and others (Figure 9.10), as the lack of workers in the field of heritage buildings is a major problem in today's Taiwan.

			Location of Shophouse						
			TW-Beimen	TW-Hukou	TW-Daxi	TW-Sanxia	TW-Xinzhang	TW-Dihua	Total
C5 What do you think is the single most important problem facing Shophouses today?	Too old for modern use	Count	6	1	4	4	5	4	24
		% within Location of Shophouse	28.6%	3.0%	13.3%	11.1%	19.2%	16.0%	14.0%
	Too difficult to maintain	Count	9	13	13	19	11	12	77
		% within Location of Shophouse	42.9%	39.4%	43.3%	52.8%	42.3%	48.0%	45.0%
	Self-image crisis	Count	2	5	6	5	3	4	25
		% within Location of Shophouse	9.5%	15.2%	20.0%	13.9%	11.5%	16.0%	14.6%
	Difficult to jointly deal with neighborhood issues	Count	1	6	3	3	4	2	19
		% within Location of Shophouse	4.8%	18.2%	10.0%	8.3%	15.4%	8.0%	11.1%
	Social problems with sightseeing	Count	1	4	2	4	1	0	12
		% within Location of Shophouse	4.8%	12.1%	6.7%	11.1%	3.8%	0.0%	7.0%
	All of the above	Count	1	1	2	0	2	2	8
		% within Location of Shophouse	4.8%	3.0%	6.7%	0.0%	7.7%	8.0%	4.7%
	Unknown or no response	Count	1	3	0	1	0	1	6
		% within Location of Shophouse	4.8%	9.1%	0.0%	2.8%	0.0%	4.0%	3.5%
Total		Count	21	33	30	36	26	25	171
		% within Location of Shophouse	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9.5: Cross-tabulation of the single most important problem facing today in different locations.

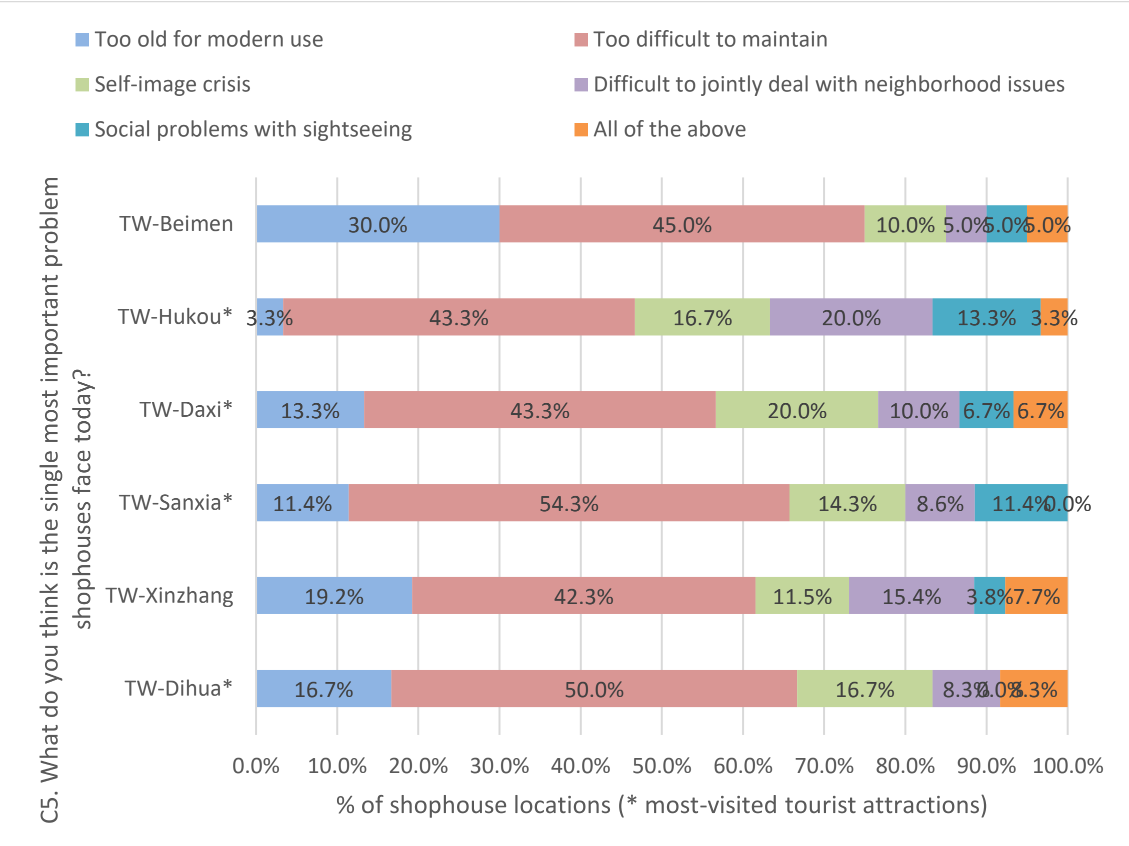


Figure 9.10: Cross-tabulation of the single most important problem shophouses face today in Taiwan.

For the best solutions to this issue, Table 9.6 presents results of the respondents from Daxi who believe that the negotiation is the best way to solve those problems. In relation to the living memory of traditional shophouses on different locations, the Dihua Street has the most experience of communication with the Government of Taipei City regarding the general affairs of historic district development.

			Location of Shophouse						
			TW-Beimen	TW-Hukou	TW-Daxi	TW-Sanxia	TW-Xinzhang	TW-Dihua	Total
C6 In your opinion, what is the best solution to this problem?	Government assistance	Count	5	7	5	7	2	5	31
		% within Location of Shophouse	23.8%	21.2%	16.7%	19.4%	7.7%	20.0%	18.1%
	Bridge the gap for common sense	Count	8	7	15	13	12	15	70
		% within Location of Shophouse	38.1%	21.2%	50.0%	36.1%	46.2%	60.0%	40.9%
	Hoping to rebuild	Count	4	9	4	7	4	3	31
		% within Location of Shophouse	19.0%	27.3%	13.3%	19.4%	15.4%	12.0%	18.1%
	Unable to communicate / No way	Count	2	6	6	4	6	0	24
		% within Location of Shophouse	9.5%	18.2%	20.0%	11.1%	23.1%	0.0%	14.0%
	All of the above	Count	2	1	0	3	1	0	7
		% within Location of Shophouse	9.5%	3.0%	0.0%	8.3%	3.8%	0.0%	4.1%
	Unknown or no response	Count	0	3	0	2	1	2	8
		% within Location of Shophouse	0.0%	9.1%	0.0%	5.6%	3.8%	8.0%	4.7%
Total		Count	21	33	30	36	26	25	171
		% within Location of Shophouse	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9.6: Cross-tabulation of the best solutions to the problems in different locations.

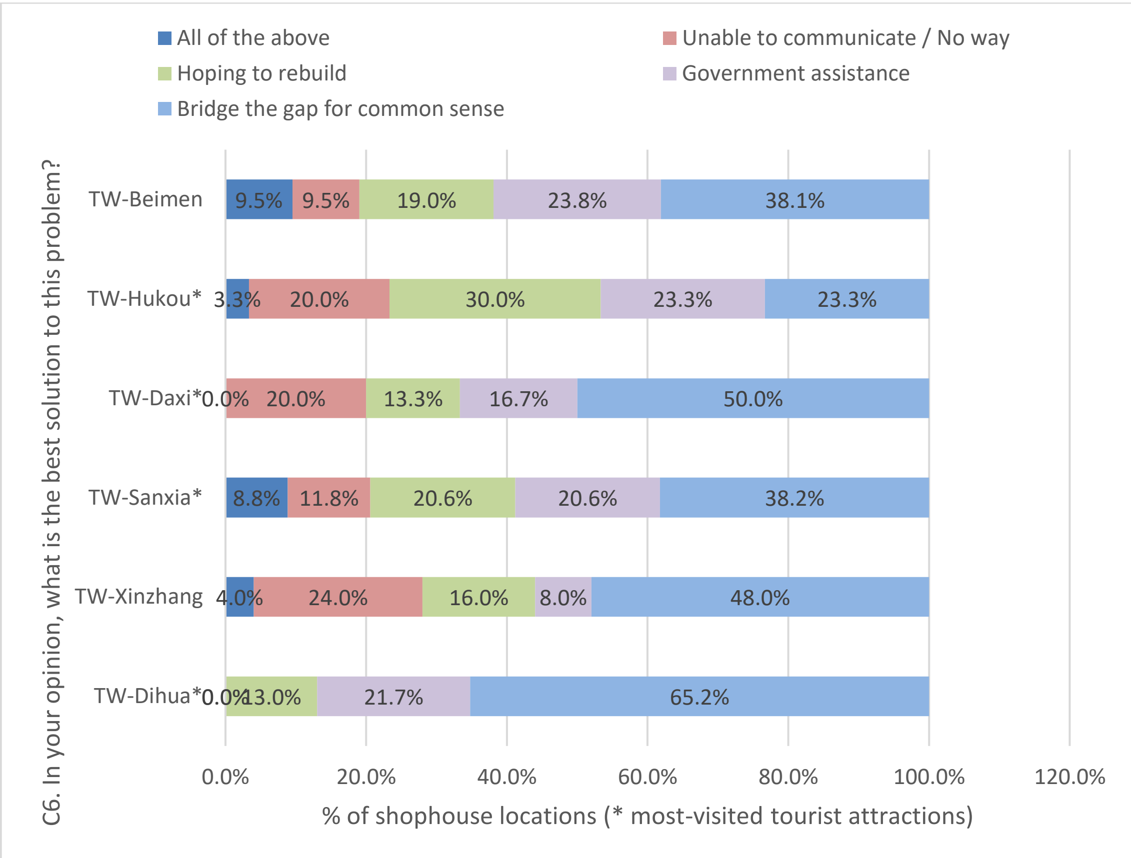


Figure 9.11: Cross-tabulation of the best solutions to the problem in different locations.

From Table 9.7, *can't live without modelling* earned the highest percentage of responses from Hukou, with 54.5%, and Sanxia, with 44.1%, and also both Beimen and Xinzhuang are over 42%. All of these 6 historic districts response at least over 30% that their old shophouses should be re-functioned.

			Location of Shophouse						
			TW-Beimen	TW-Hukou	TW-Daxi	TW-Sanxia	TW-Xinzhang	TW-Dihua	Total
C7 What is the thing you like least in shophouse living?	As descendants we must save the family property	Count	2	3	2	3	2	2	14
		% within Location of Shophouse	9.5%	9.1%	6.7%	8.3%	7.7%	8.0%	8.2%
	Can't live without remodellnig	Count	9	18	10	15	11	8	71
		% within Location of Shophouse	42.9%	54.5%	33.3%	41.7%	42.3%	32.0%	41.5%
	Don't want to live in shophouse again	Count	2	6	6	6	6	3	29
		% within Location of Shophouse	9.5%	18.2%	20.0%	16.7%	23.1%	12.0%	17.0%
	Having open spaces to breathe	Count	4	3	7	7	3	8	32
		% within Location of Shophouse	19.0%	9.1%	23.3%	19.4%	11.5%	32.0%	18.7%
	Quiet home	Count	2	2	3	2	2	1	12
		% within Location of Shophouse	9.5%	6.1%	10.0%	5.6%	7.7%	4.0%	7.0%
	All of the above	Count	2	1	1	1	2	2	9
		% within Location of Shophouse	9.5%	3.0%	3.3%	2.8%	7.7%	8.0%	5.3%
	No response	Count	0	0	1	2	0	1	4
		% within Location of Shophouse	0.0%	0.0%	3.3%	5.6%	0.0%	4.0%	2.3%
Total		Count	21	33	30	36	26	25	171
		% within Location of Shophouse	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9.7: Cross-tabulation of the least like things of shophouse living in different locations.

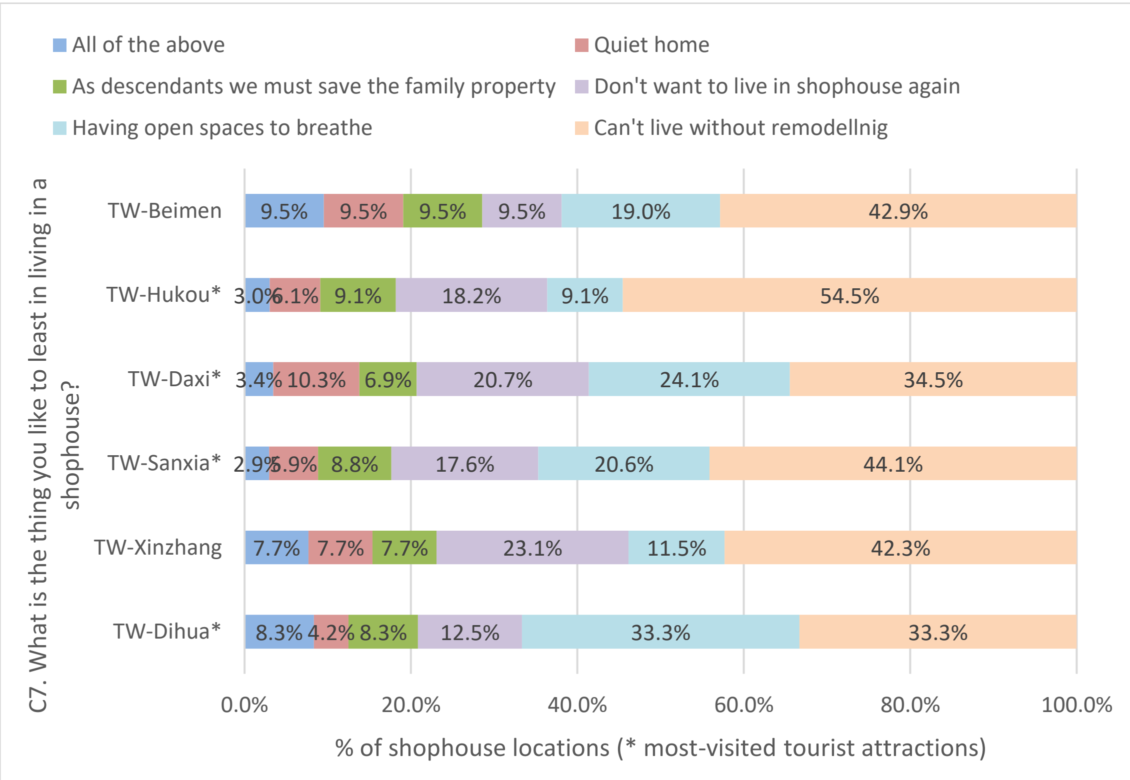


Figure 9.12: Cross-tabulation of the least like things of shophouse living in different locations.

9.3.3. An overview of historic districts

According to a recent report from UN-Habitat, the vast majority of cities all over the world share similar problems in pursuing more, better quality, and better-distributed public spaces. However, most cities in the so-called developing world face the same problems more acutely. The pace of urban growth, the persistence of vast pockets of informal settlements and the strain on resource mobilization are only some examples of this predicament (Hall and Pfeiffer 2013). In light of the above discussion and with reference to this study, can resource-poor, fast-growing cities afford to have an efficient historic districts system? And if not, what can be done about it? And also what if historic districts could be considered a resource, and not an expenditure?

Both Tables 9.8 and 9.9 focus on the views regarding the inner courtyards of both visitors and owner occupants.

As the findings depicted in Table 9.8 (Figure 9.13) show the majority of the respondents express their satisfaction with the level of the overall quality of inner courtyards. On the other hand, Table 9.9 (Figure 9.14) indicates the level of dissatisfaction of the functional efficiency of space in the main courtyard. In which 23.5% of respondents from Daxi consider themselves very dissatisfied, while 27.6% and 25.9% respondents of Sanxia and Hukou respectively expressed dissatisfaction.

It can be seen from the tables that regular maintenance might be the key issue for encouraging visitors to visit the shophouse courtyards, where, maintenance is directly related to the historic-districts system cycle: economic expansion comes from investment, and investment depends on such factors again.

From the above it is commonly understood that adaptive reuse helps extend the life of traditional shophouse buildings and prevents them from becoming forsaken and derelict. It preserves buildings by changing outdated functions into new uses to meet contemporary demand. Adaptive reuse can ‘recycle’ the building in order to regain contemporary economic value (Sanoff 1978). Adding economic value is a good reason for conservationists to cite in the preservation of old buildings since artistic and historic value alone may not be sufficient to convince the decision-makers (Pimonsathean 2002). Since adaptive reuse prevents shophouse buildings from being torn down, it can also find favour with economists. Given that the existing structure remains, the cost of new construction is not needed and this saving is one of the main motives behind conservation (Rock 1979).

			Place of Street Survey								
			TW-Hukou	TW-Daxi	TW-Sanxia	TW-Dihua	MY-Georgetown	MY-Ipoh	MY-Melaka	SG-Chinatown	Total
What visitor view on access to inner courtyards	Happy to see	Count	7	17	18	6	21	2	9	4	84
		% within Place of Street Survey	41.2%	65.4%	58.1%	66.7%	56.8%	33.3%	69.2%	33.3%	55.6%
	Unnecessary	Count	8	5	8	1	12	4	3	5	46
		% within Place of Street Survey	47.1%	19.2%	25.8%	11.1%	32.4%	66.7%	23.1%	41.7%	30.5%
	not sure or missing	Count	2	4	5	2	4	0	1	3	21
		% within Place of Street Survey	11.8%	15.4%	16.1%	22.2%	10.8%	0.0%	7.7%	25.0%	13.9%
Total		Count	17	26	31	9	37	6	13	12	151
		% within Place of Street Survey	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9.8: Cross-tabulation of the view of visitor on access to inner courtyards.

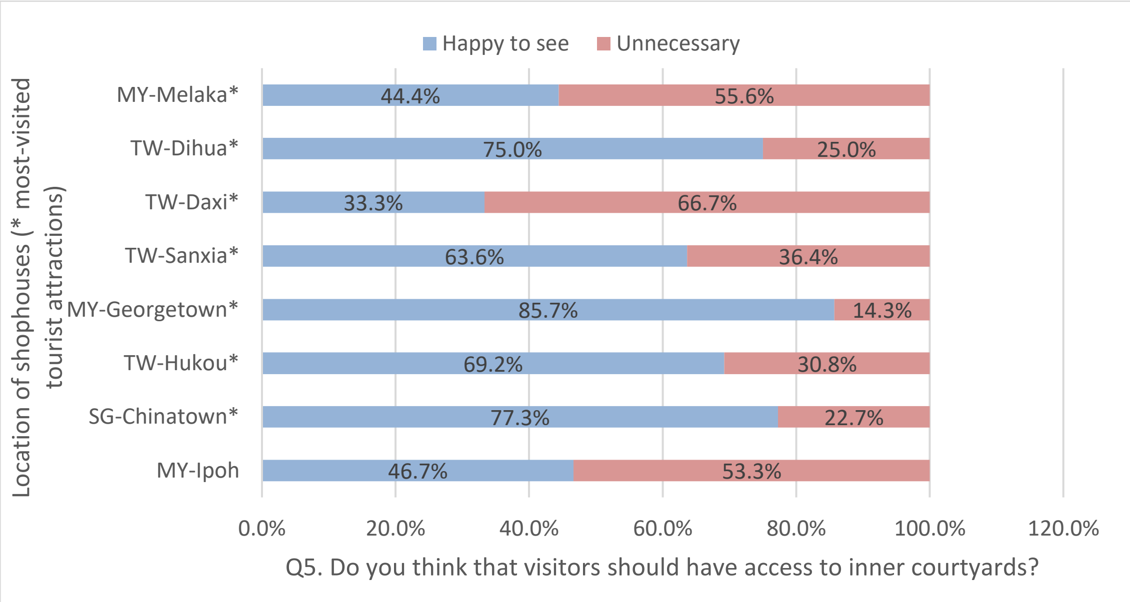


Figure 9.13: Cross-tabulation of the view of visitor on access to inner courtyards.

			Location of Shophouse							
			TW-Beimen	TW-Hukou	TW-Daxi	TW-Sanxia	TW-Xinzhang	TW-Dihua	MY-Georgetown	Total
A4 Rate (6) Functional efficiency of space in main courtyard	Very dissatisfied	Count	3	1	4	2	6	1	0	17
		% within Location of Shophouse	14.3%	3.0%	13.3%	5.6%	23.1%	4.0%	0.0%	9.3%
	Dissatisfied	Count	7	15	9	16	6	5	0	58
		% within Location of Shophouse	33.3%	45.5%	30.0%	44.4%	23.1%	20.0%	0.0%	31.9%
	Neither dissatisfied nor satisfied	Count	10	16	16	17	13	17	9	98
		% within Location of Shophouse	47.6%	48.5%	53.3%	47.2%	50.0%	68.0%	81.8%	53.8%
	Satisfied	Count	0	1	1	1	1	1	1	6
		% within Location of Shophouse	0.0%	3.0%	3.3%	2.8%	3.8%	4.0%	9.1%	3.3%
	Very satisfied	Count	1	0	0	0	0	1	1	3
		% within Location of Shophouse	4.8%	0.0%	0.0%	0.0%	0.0%	4.0%	9.1%	1.6%
Total		Count	21	33	30	36	26	25	11	182
		% within Location of Shophouse	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9.9: Cross-tabulation of the view of owner occupants on rating their courtyards.

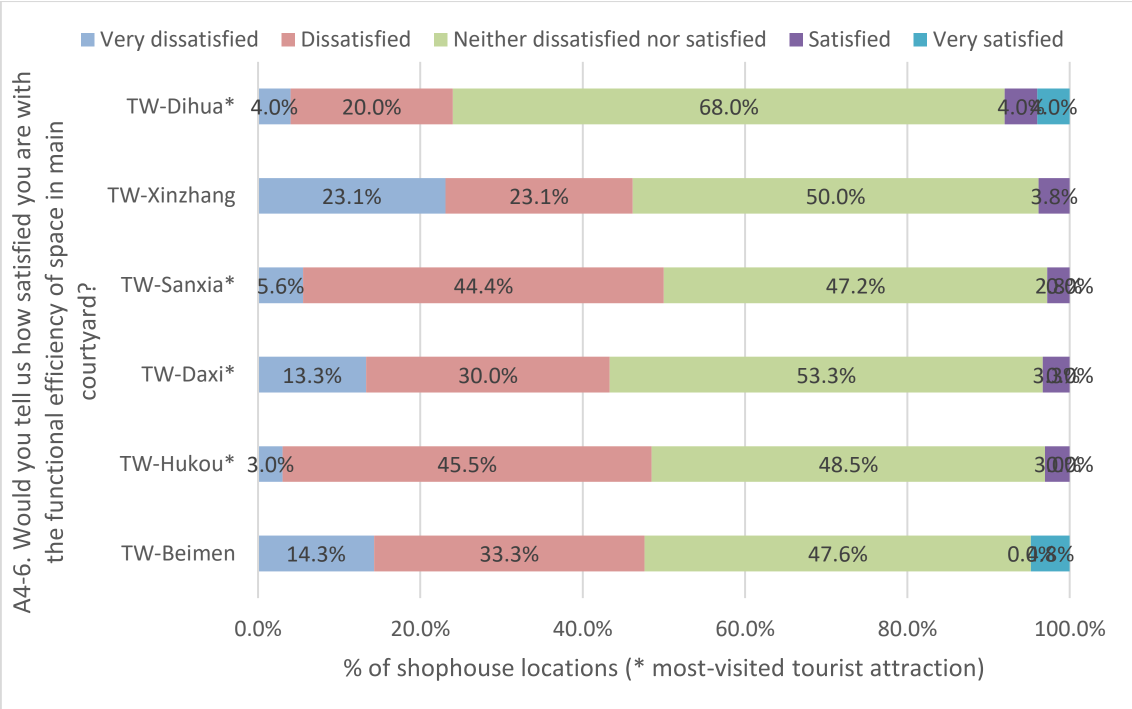


Figure 9.14: Cross-tabulation of the view of owner occupants on rating their courtyards.

There are many recommendations on possible new usage for old structures. Tiesdell (1996) has pointed out that new uses should be related to three groups of activities, i.e. cultural tourism, housing, and commerce/industry. No matter what the new uses might be, one of the most important aspects is the analysis of demand for new activities.

The existing literature does not specifically seek out to incorporate historic preservation as a mechanism in creative district planning strategies. This thesis explores the critical role historic preservation can play in the development of the creative industries, thus indicating that preservation should be considered as a component in future policy initiatives. The relationship between historic preservation and, leisure and/or arts districts (aspects of creative industry cultivation) is key in seeking to identify strategies that build effectively on historic preservation policy and arts districts as complementary components of community economic development strategy. Looking back and using Table 5.7 (Section 5.2), the business types of *food and drink* and *art and craft*, might be the critical types for retaining open courtyards. It identifies policy tools that advance both historic preservation and the development of the creative industry and describes instances in which these tools have been successfully applied in concert.

With regard to this, analysis of new uses depends heavily on the understanding of different needs of the two groups, namely tourists and residents (Nuryanti 1999). Tradeoffs between these two groups must be done with careful consideration.

9.4. Ecological design thinking

In this section, concepts, methods, and/or elements from existing practices are used to develop an approach for ecologically-based thinking for current traditional shophouses design. Assumptions and constraints that govern the development of the approach are introduced, followed by thr presentation of the individual steps of the approach. The approach is then applied to an example, demonstrating how it could work in a real design project and allow evaluation of the approach using the criteria as defined in Section 9.1.

Design thinking is a well-established participatory technique grounded in the empathic understanding of the feelings, experiences and emotions of others. It engages people in lively conversations, visually stimulated interactions and playful prototyping. It frames problems as opportunities, forms insights and generates creative and collaborative solutions in complex situations (michelle.north 2014).

The approach for selection of ecological thinking will be based on the premise that a design process contains a series of design moments. At each of these decision moments a choice is made between a number of alternative design options. Furthermore, it is assumed that these design decisions can be isolated from the rest of the design process, which makes it possible to rationalize decision-making and to provide support for making these decisions.

9.4.1. What to do: lessons and directions

Based on the knowledge from current research, the following steps appear as the essential elements of a design decision-making process on ecological design for application in shophouse reuse projects. For each step, possible options to support this specific step are discussed.

Working with older shophouse buildings can be a daunting task; it requires love, patience, determination and understanding. Shophouse buildings affect the activities of daily living, and they play a critical role in a community’s development and quality of life. This study is intended to help shophouse owners and communities assess their options and to consider their decisions in the context of community revitalization efforts. However, it must be noted that the first step in making ecologically-based design decision is dependent on the shophouse owners’ view. Regarding the shophouse occupants survey it is noted that the research presented in Chapter 5 revealed that in most responses from occupants of the old shophouses consider that further renovation is required: it was found that 41.2% of all respondents presented *can’t live without re-modelling*.

As shophouse buildings age and commercial needs change, owners may leave behind established shophouses and build new ones. Sometimes this is appropriate. But there is much to be said for renovating and reusing older neighbourhood shophouses. Experience has shown that it is generally less expensive to alter and rehabilitate an existing building rather than build a new one (Power 2008). Of course, based on the visual checks from the Southeast Asia and Taiwan, many older shophouses are in poor condition and do not meet current and future demands needs. The challenge is to determine whether these shophouses can be rehabilitated efficiently and cost-effectively to meet new century living standards.

In the context of such poor condition, the end users of traditional and older shophouses have started renovating their courtyards in many different ways. From the research, the most common practice is positioning single-sliding skylights to decrease the amount of daylight in a courtyard, but take account of heat gain at the same time. Thus, the mechanical ceiling fans were installed frequently (Figure 9.15); it cools people effectively by introducing slow air movement into the otherwise still, warm humid air of an enclosed or semi-closed courtyard, inducing evaporative cooling (Heschong 1979; Aldawoud 2008). However this is hot humid so not much capacity for this. These single-sliding skylights are available in a manual or electric operation, with a wall switch or remote control to suit occupant requirements. Figures 9.16 and 9.17 illustrates examples of well-constructed single-sliding skylights in the renovated traditional shophouse buildings.

(a) traditional coffee shop *(b) Malay kitchen* *(c) Buddhist temple*

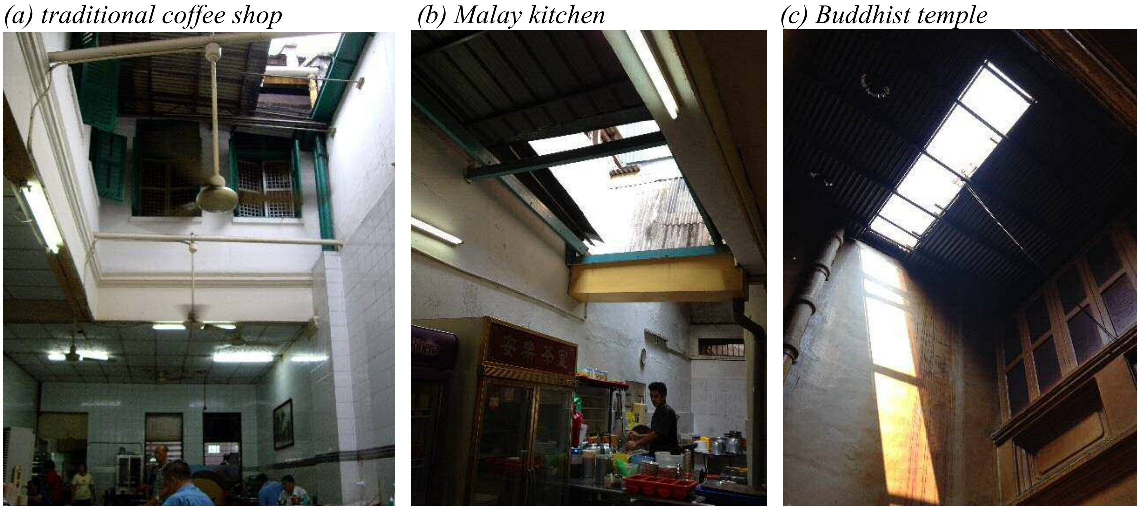


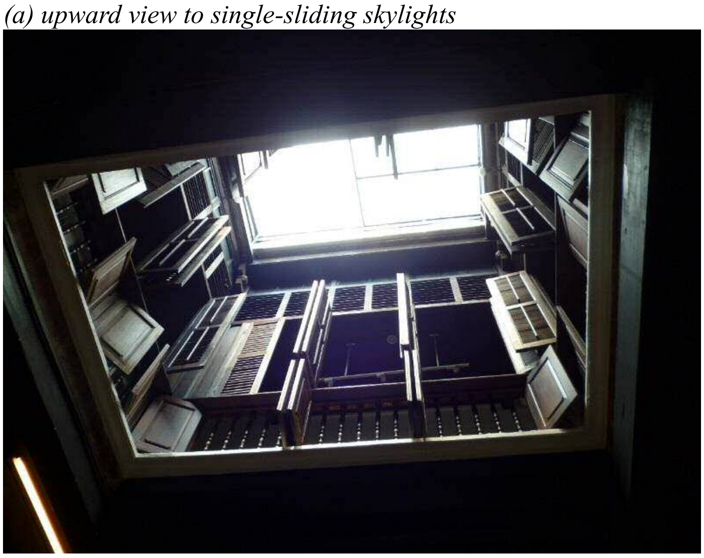
Figure 9.15: Examples of current single-sliding skylights used in Georgetown UNESCO World Heritage Site, Penang: (a) an old town coffee shop; (b) a Malaysian kitchen for daily breakfast; and (c) Chinese Buddhist temple. (Source: Photographs taken by author, 2009-12)

(a) courtyard conference hall

(b) single-sliding skylights in an electric operation

Figure 9.16: An example of luxury mechanical device installed at the side courtyard in the building of Penang Teochew Association, Georgetown of Penang, Malaysia. (Source: Interview and photographs taken by author, 2011)

(a) upward view to single-sliding skylights



(b) manual operation

(c) fully opened of single-sliding skylights

(d) a partially open clear polycarbonate sheet

Figure 9.17: An example of manual device installed at the top of main courtyard in the Cheng Hoe Seah Heritage building, Georgetown of Penang. (Source: Interview and photographs taken by author, 2012)

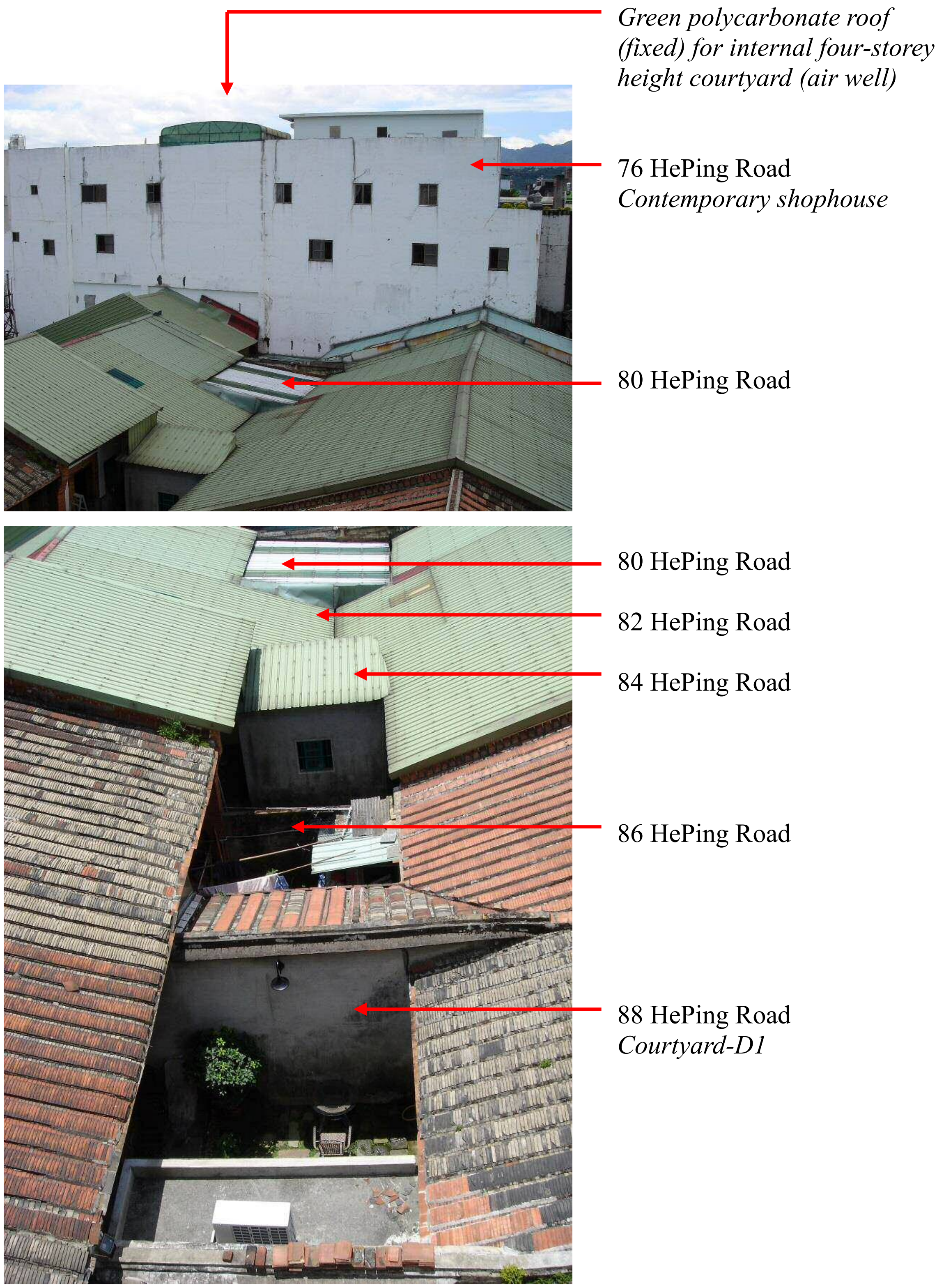
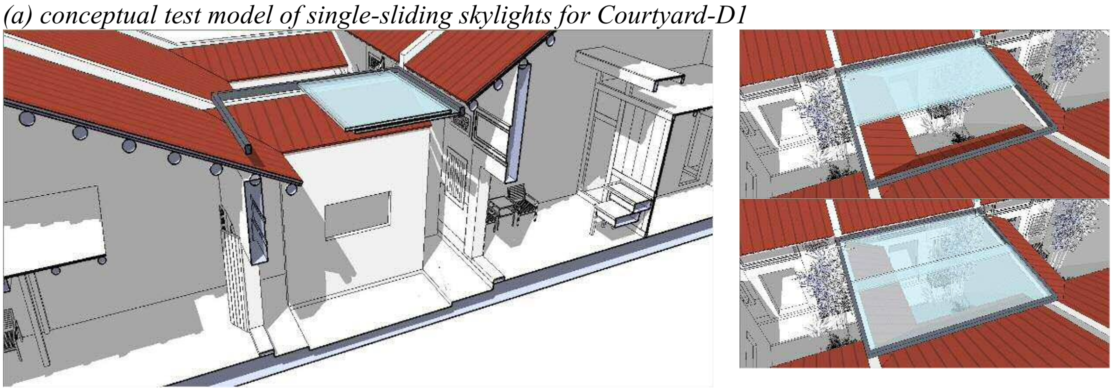


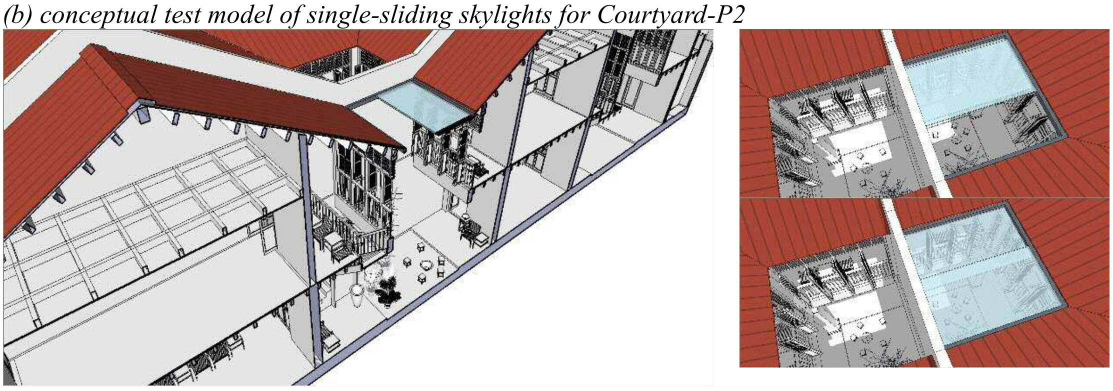
Figure 9.18: The current situation and the current approaches and methods for covering courtyards in Daxi District of Taoyuan County, Taiwan. (Source: Interview and photographs taken by author, 2008)

This kind of rainproof roofing for the traditional shophouse courtyards is rare in most of the historic districts in Taiwan. Figure 9.18 shows the general practices in Daxi Historic District of not only the covered courtyards but the entire roofs were covered as well by metal sheets. It is our understanding that they wanted to keep the cost of maintenance low, and/or once and for all solve the problem of leaking roofs. Sadly, the destruction is still ongoing there; it is really no solution for an unlisted and private shophouse buildings in the historic district of Taiwan, as the public are concentrated mostly in the public space at the shophouses frontage.

(a) conceptual test model of single-sliding skylights for Courtyard-D1



(b) conceptual test model of single-sliding skylights for Courtyard-P2



(c) conceptual test model of single-sliding skylights for Courtyard-S3

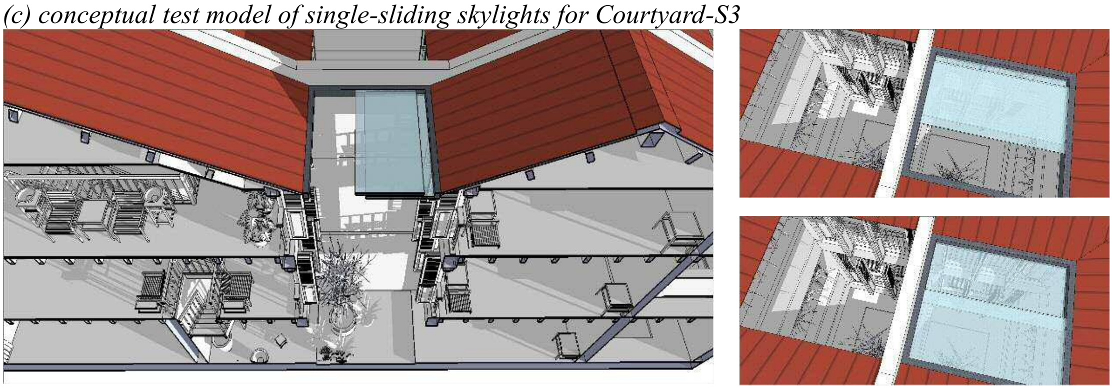


Figure 9.19: Conceptual test models of single-sliding skylights installed at top of front courtyards of the three shophouse case buildings: (a) *Courtyard-D1*; (b) *Courtyard-P2*; and (c) *Courtyard-S3*.
(Source: Illustration by author, 2015)

In this section, the general analysis of the effects of existing single-sliding skylights on airflow patterns is conducted by applying to the three shophouse case buildings considered in this thesis as shown in Figure 9.19. Generally, all of the single-sliding skylights cause reduction of indoor velocity (as the courtyards were fully covered by horizontal skylight). Yet, their reduction is small. Figures 9.20 to 9.22 show the comparison between inlet velocity and indoor velocity of front courtyards for *D1*, *P2* and *S3*. It can been seen that the average indoor velocity of *Courtyard-D1* is generally lower than inlet velocity, while the average indoor velocity of *Courtyard-S3* is higher than inlet velocity. The result of *Courtyard-P2* is seems to remain same. However, the effects on air distribution for only *Courtyard-D1* is presented in generation of venturi effect that accelerates the incoming air stream (see Figure 9.20b). The opening size of horizontal skylight reduce the air velocity by modifying the shape of the incoming air stream.

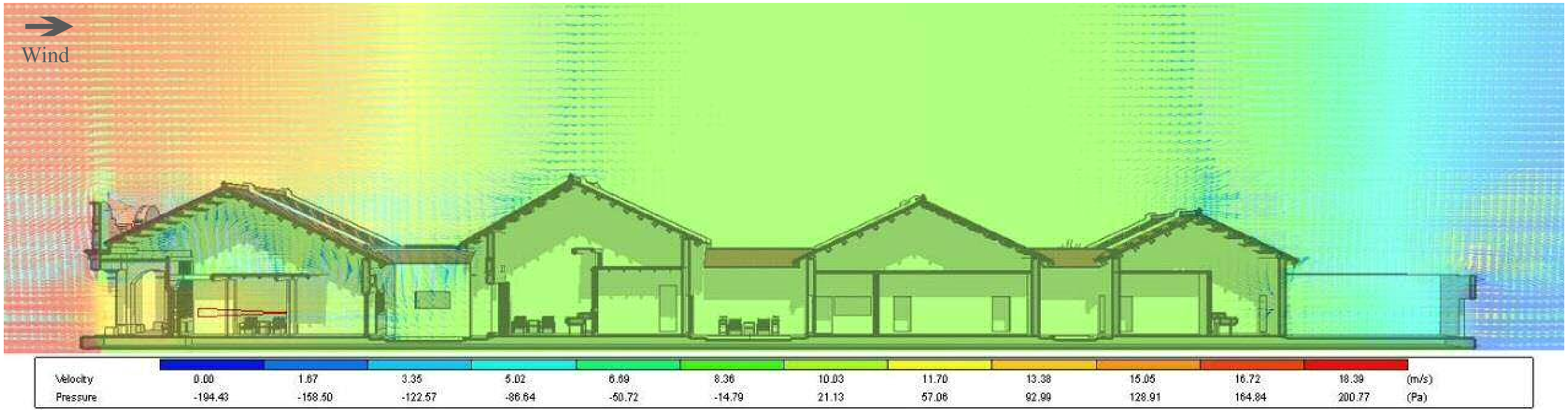


Figure 9.20a: Velocity contour on longitudinal section of *Courtyard-D1* with single-sliding skylights.

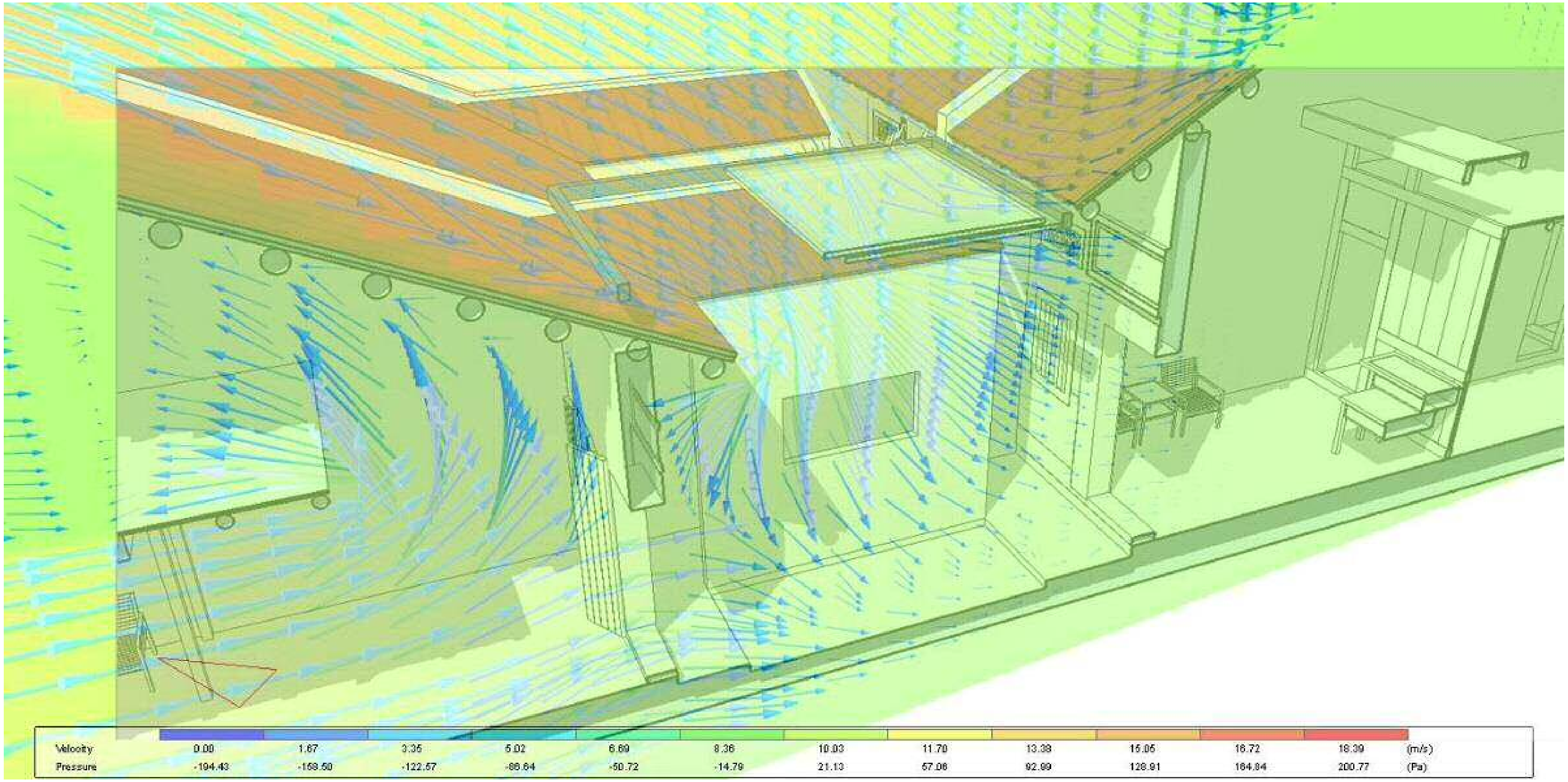


Figure 9.20b: Airflow patterns on partial section of *Courtyard-D1* with single-sliding skylights

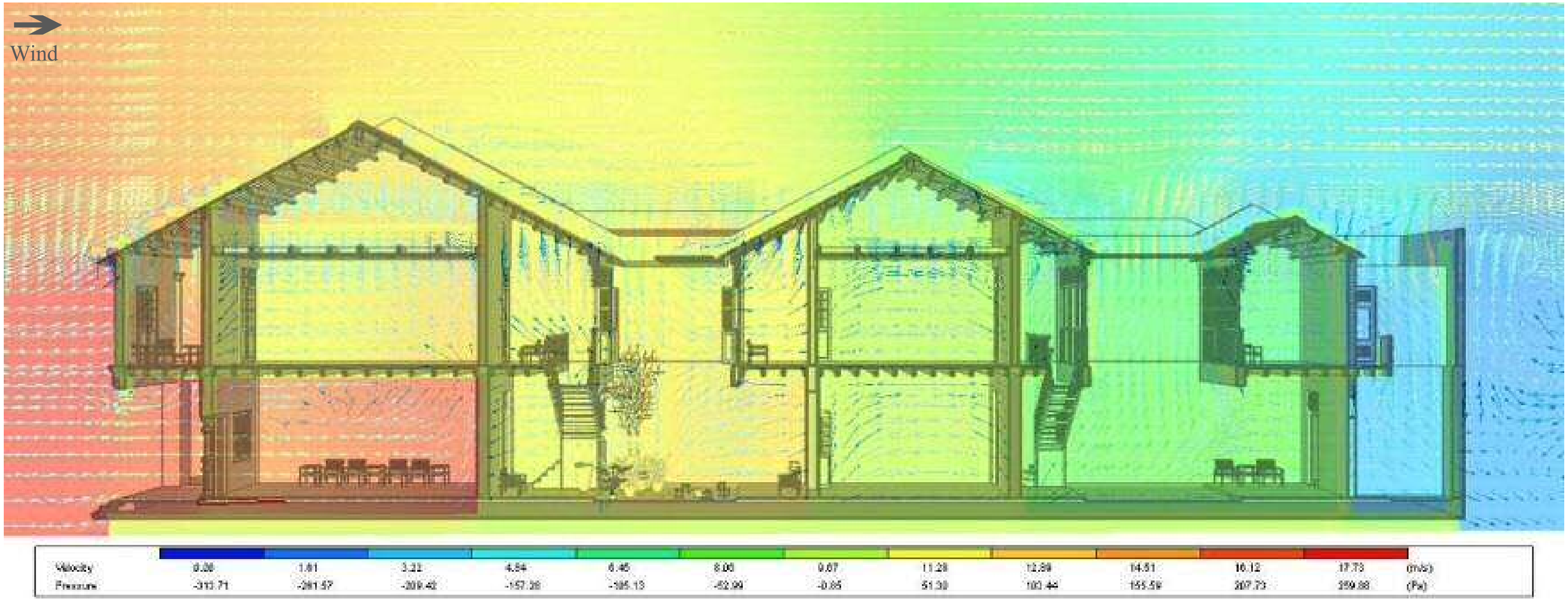


Figure 9.21a: Velocity contour on longitudinal section of *Courtyard-P2* with single-sliding skylights.

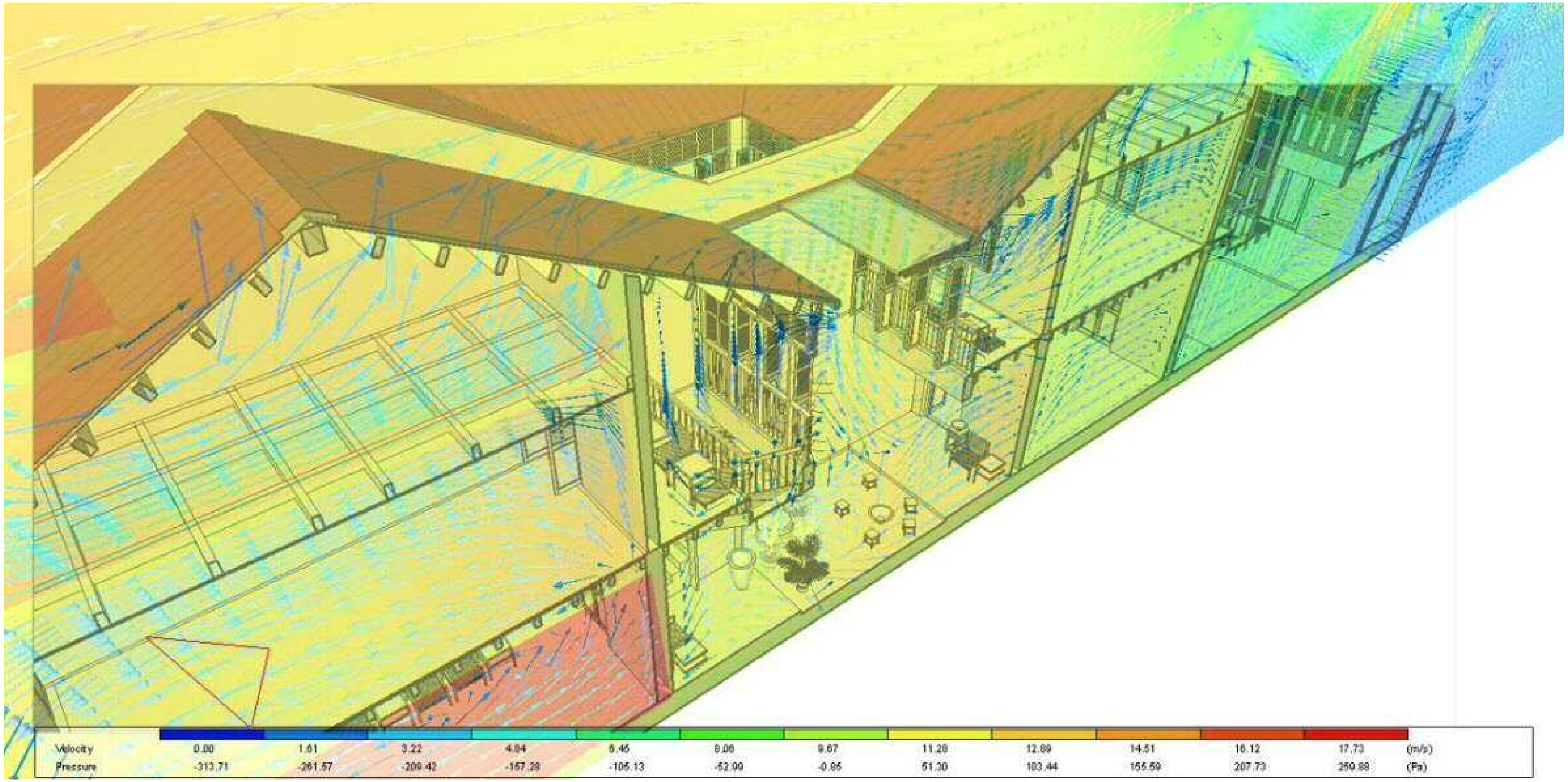


Figure 9.21b: Airflow patterns on partial section of *Courtyard-P2* with single-sliding skylights.

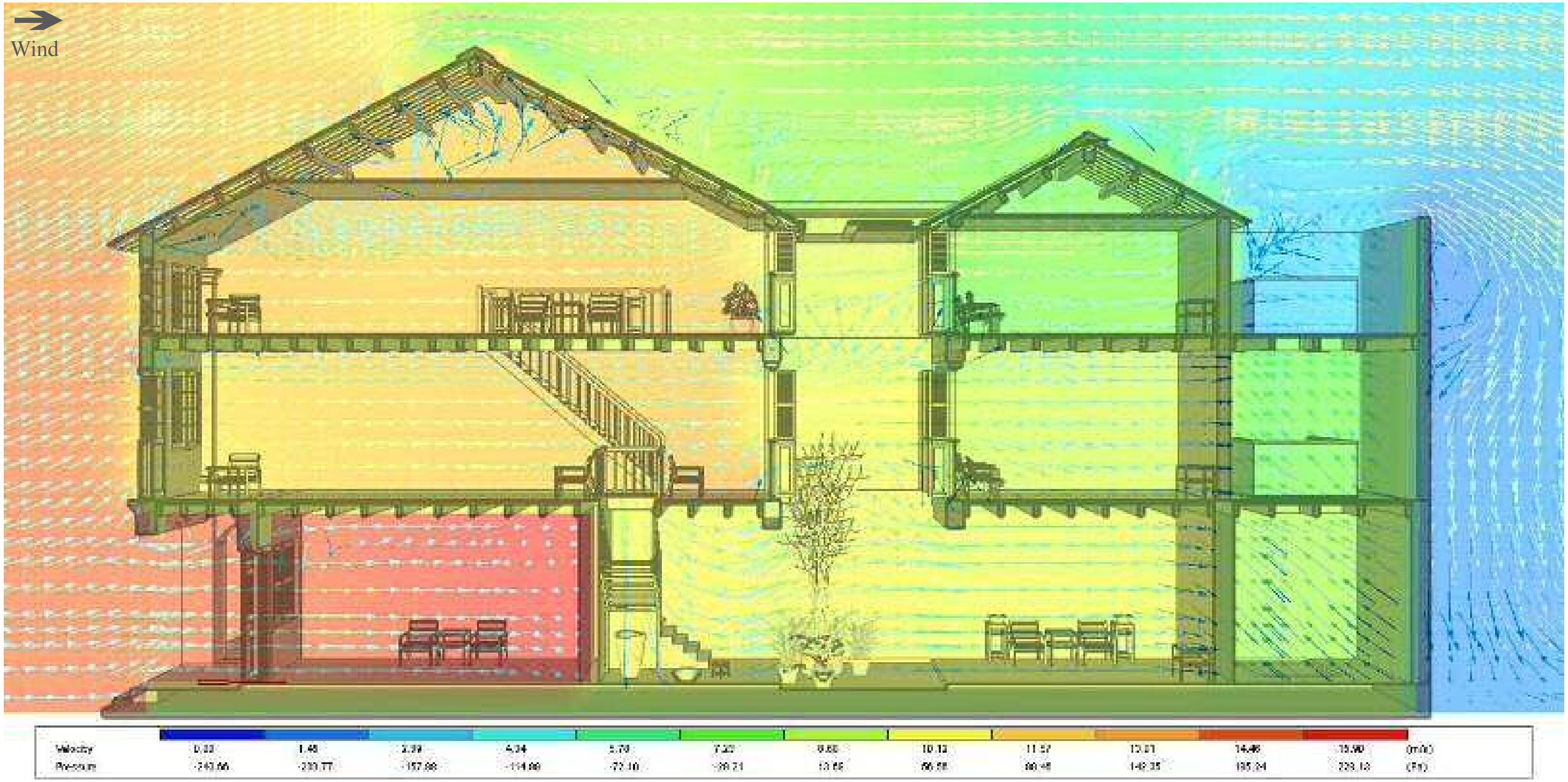


Figure 9.22a: Velocity contour on longitudinal section of *Courtyard-S3* with single-sliding skylights

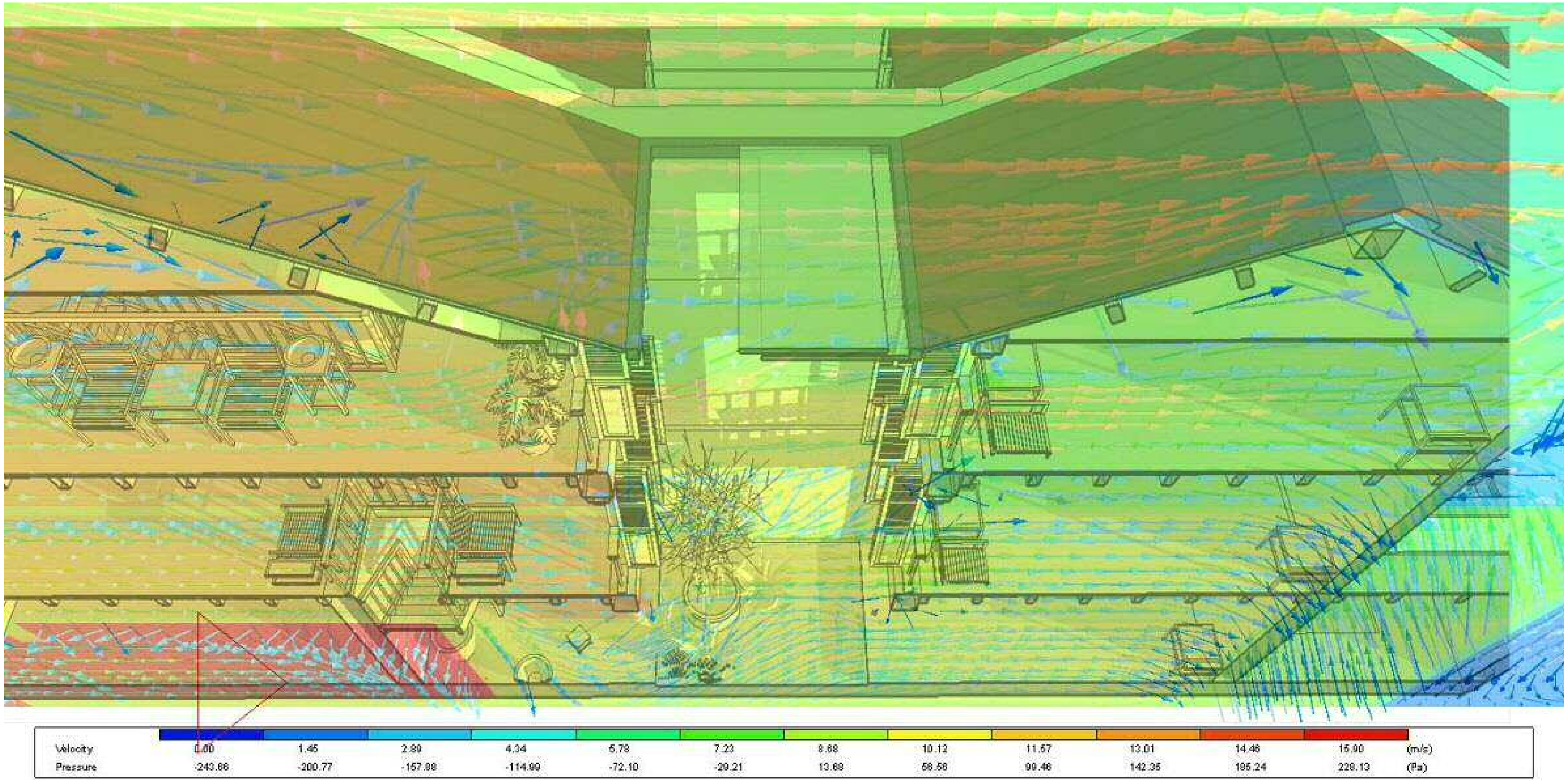
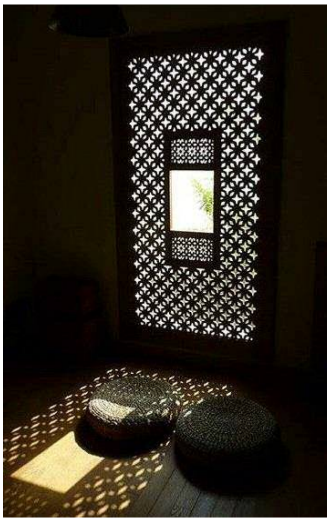


Figure 9.22b: Airflow patterns on partial section of *Courtyard-S3* with single-sliding skylights.

Presumably, the pitched roof of shophouse buildings is determining the balance between the accelerated flow on the windward side of the roof and the recirculation flow behind the building (Tominaga *et al.* 2015). However, the incoming airflow through the current single-sliding skylight is divided and deflected by the size of its openings. Moreover, if a space is fully glazed but does not have an effective solar shading system, the internal temperature can shoot up during the hotter months, due to the effects of the solar radiation (Deroisy *et al.* 2013). To improve the current design, the size of skylight opening should be enlarged and the shading device can be placed far from the side-end or edge of the courtyard wall. This will allow and give more opportunity for the airflow to enter into the lower part of courtyard. A well-designed shading system can boost the occupant's comfort and productivity by regulating the amount of heat and light entering the internal space and by reducing glare.

9.4.2. Design selection: solar shading devices

Shading is a simple method to block the sun before it can get into the building. There are many different methods to reduce the cooling load in buildings, but shading of the building is one of the most simple and sustainable methods. And there are many different types of solar shading devices available on the market. The sun-breakers generate shade to prevent the high-angle summer sun falling on the façade, but also allow the low angle winter sun to provide some passive solar heating (Reyner 1975). The sun-breaker solution refers to a permanent sun shading technique, like the simple patterned concrete walls popularized by Le Corbusier. 'Comfort is coolness, it is the current of air, it is the shade' (Le Corbusier 1957). On his first visit to India in 1951, Le Corbusier noted in his sketchbooks for Chandigarh: 'do not hesitate to make grand empty naves of shadow and air currents'. He also paid attention to the shading strategies of residential buildings, noting the relationship between roof and shadow, sun and depth of penetration (Corbusier *et al.* 1982). In his design of buildings in tropical climate wanted to make a 'pact with nature' unlike his earlier works of the cold climates where he was to 'combat the nature'. Corbusier based on the precedent of wooden screen Mashrabiya of Arab buildings (Figure 9.23) and brick louvered claustra of Morocco. He was attracted to the effectiveness of those vernacular devices to provide shading, reduce the glare and facilitate natural ventilation. Thus, this study suggests to create a similar device with the equivalent performance.



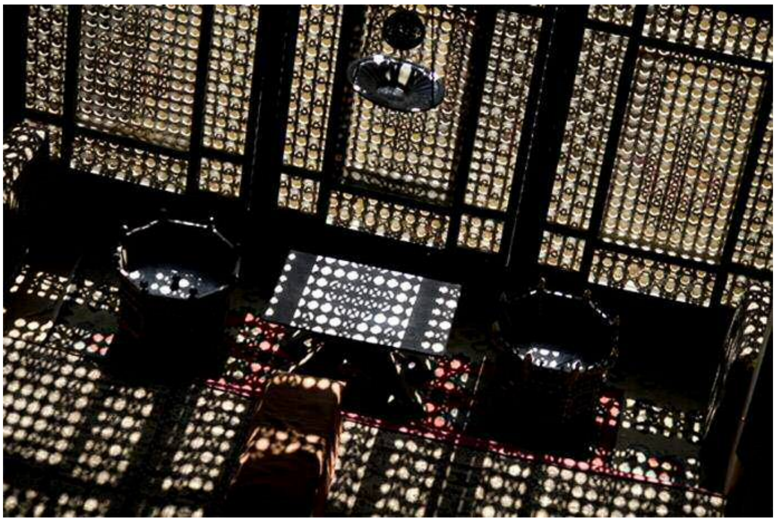


Figure 9.23: Arabic window with Mashrabiya partition. (Source: www.pinterest.com 2015)

In fact, tropical architecture is not a new concept. Countries in the Asia-Pacific region have adopted vernacular designs adopting to their climatic needs over many centuries. For instance, a high ceiling demonstrates an understanding of the stack effect. Many homes install a large roof overhang and use verandas to reduce solar gains. These design solutions also allow windows to remain open for natural ventilation in a building during the rainy season. It works to achieve thermal comfort through the use of design elements, such as sunshades, cavity walls, light shelves, overhangs, roof and wall insulation and even shading from trees (Jesus 2011). The design principles of tropical architecture include: regional evaluation; climatic elements; site selection; sol-air orientation; solar control on the environment and building; forms; wind effect and airflow patterns; and thermal effects of materials (Victor 1963). In addition, maximum cross ventilation, natural lighting, louvers and natural materials are key elements for optimizing natural ventilation to cool tropical buildings.

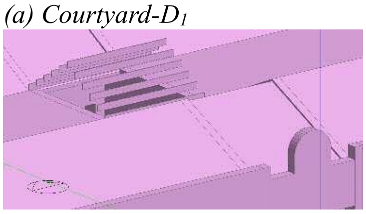
Shading is like putting a hat on the building. Givoni (1976) analyzed the efficiency of various types of fixed shading devices in different orientations and concluded that in all orientations, horizontal shading is more effective than a vertical one. Other advantages of horizontal projections over vertical projections are; (i) vertical device is not applicable for shading the whole length of façade, (ii) vertical device reduces daylight penetration more than horizontal projection, (iii) vertical projections will reduce the extent of external view (Givoni and others 1976). The criteria of shading for various climate zones are given in Table 9.10.

Climate zones	Requirements
Hot and Dry	Complete year round shading
Warm and Humid	Complete year shading, but design should be made such that ventilation is not affected
Temperate	Complete year round shading but only during major sunshine hours
Cold and Cloudy	No shading
Cold and Sunny	Shading during summer months only
Composite	Shading during summer months only

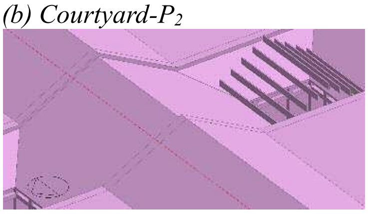
Table 9.10: Criteria of shading for various climate zones. (Source: Tiwari *et al.* 1994)

In light of the current technological conditions, this study addresses the approaches of the well-founded selection of ecological design in lighting and ventilation. The challenge of traditional shophouse architecture is to adapt it to the modern lifestyle – the transformation of traditional local cultures to those appropriate in the modern city. Considering the ambition to reduce glare and facilitate airflow, the entire courtyard space on the top side could be equipped with some sort of device, such as operable horizontal sun louvers, that could provide protection from sunlight, wind, and rain while allowing for natural ventilation (Figures 9.24). Such horizontal sun louvres reflect direct sunlight but allow diffused light through, thereby reducing solar heat gains but allowing in plenty of natural daylight.

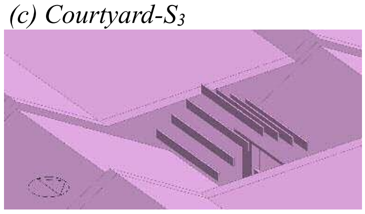
(a) Courtyard-D_1



(b) Courtyard-P_2



(c) Courtyard-S_3



(d) Prototype Model of Solar Shading Device

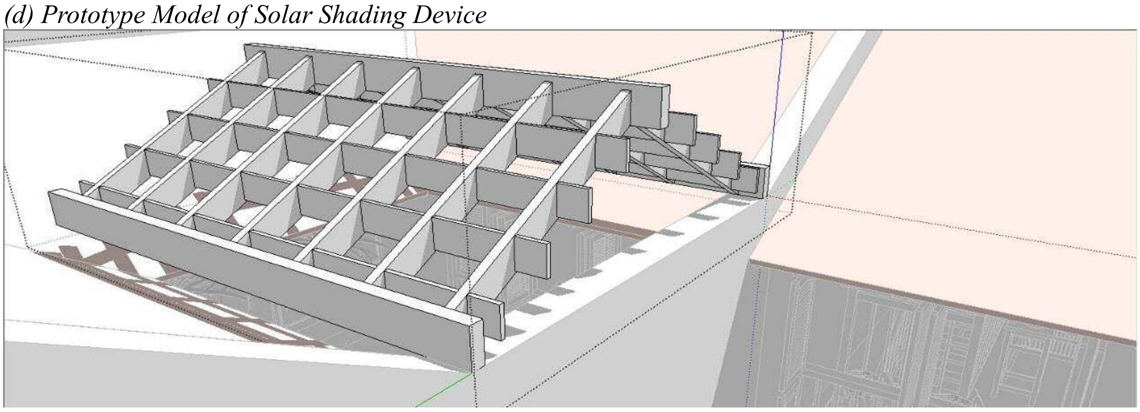


Figure 9.24: Geometry models in DesignBuilder CFD (a, b & c) and the prototype model in SketchUp (d). (Source: Illustration by author, 2015)

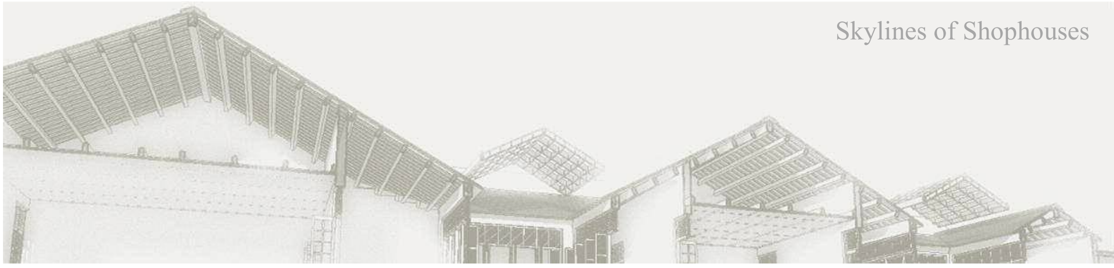


Figure 9.25: The roof style in traditional shophouses cities. (Source: Illustration by author, 2015)

(a) Diffused

(b) Shading

(c) Diffused and Shading

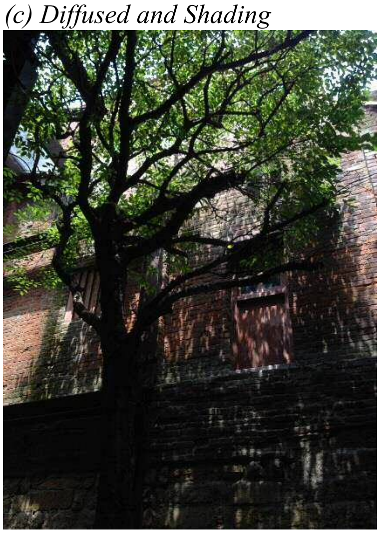
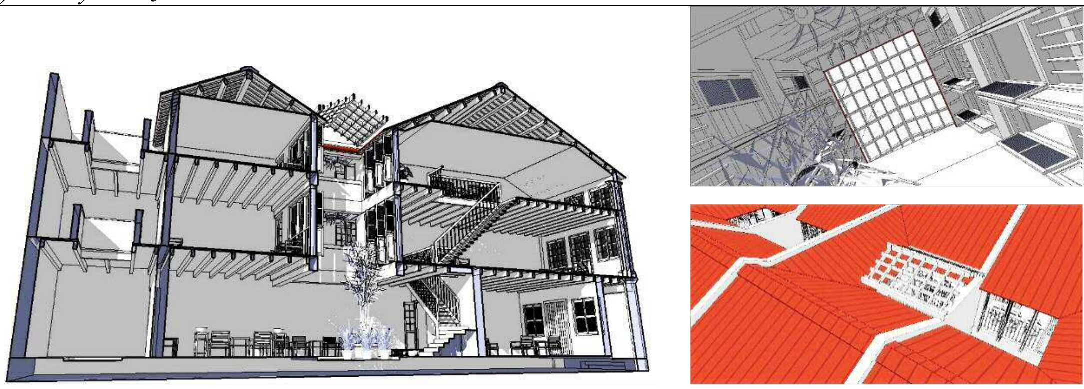


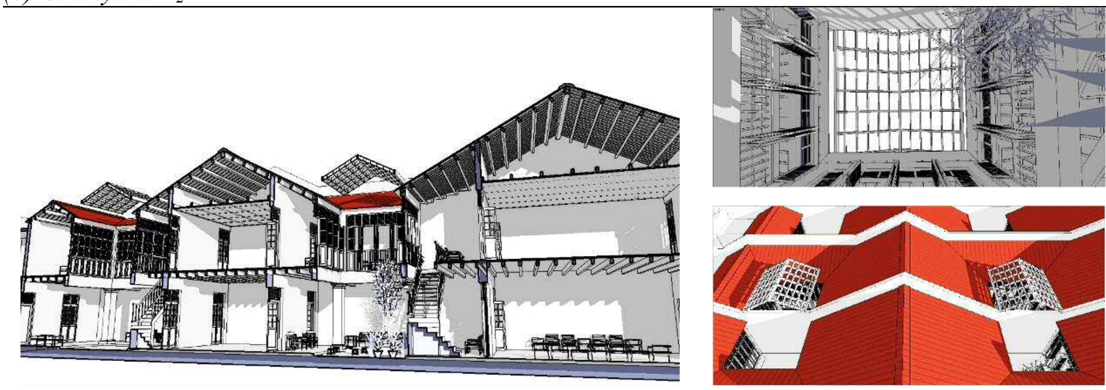
Figure 9.26: A well-designed shading system can reduce glare and generate dramatic interplay of light: (a) diffused light through horizontal louvers in a poor temple, Georgetown of Penang; (b) sun shading by wooden shutters blinds, the Cheng Hoe Seah Heritage building, Penang; and (c) sun shading by tree, the Bo Pi Liao historic district, Taipei City, Taiwan. (Source: Photographs taken by author, 2008-12)

The basic idea here is that instead of freezing the requirements before a design or coding can proceed, an initial prototype is built to understand the requirements. This prototype model is developed based from current studies. By using this prototype model, we can get an 'actual feel' of the well-founded selection of ecological design in lighting and ventilation. The shapes and forms of these solar shading device, that classic triangle, is by far the most popular roof style in traditional shophouse buildings (Figure 9.25). Moreover, numerous blade shapes, blade spacing and angle, and trim profiles allow a design selection to create diffuse light. Thus, the directed sunlight is becoming scattered light (Figures 9.26). This scattering is what causes the diffusion and softening of the sunlight. The goal of this prototype model is to provide a concept with overall functionality. Figures 9.27 illustrates the impact of the triangle shading system when applied to the three shophouse case study buildings for further analysis and discussions.

(a) Courtyard-S_3



(b) Courtyard-P_2



(c) Courtyard-D_1

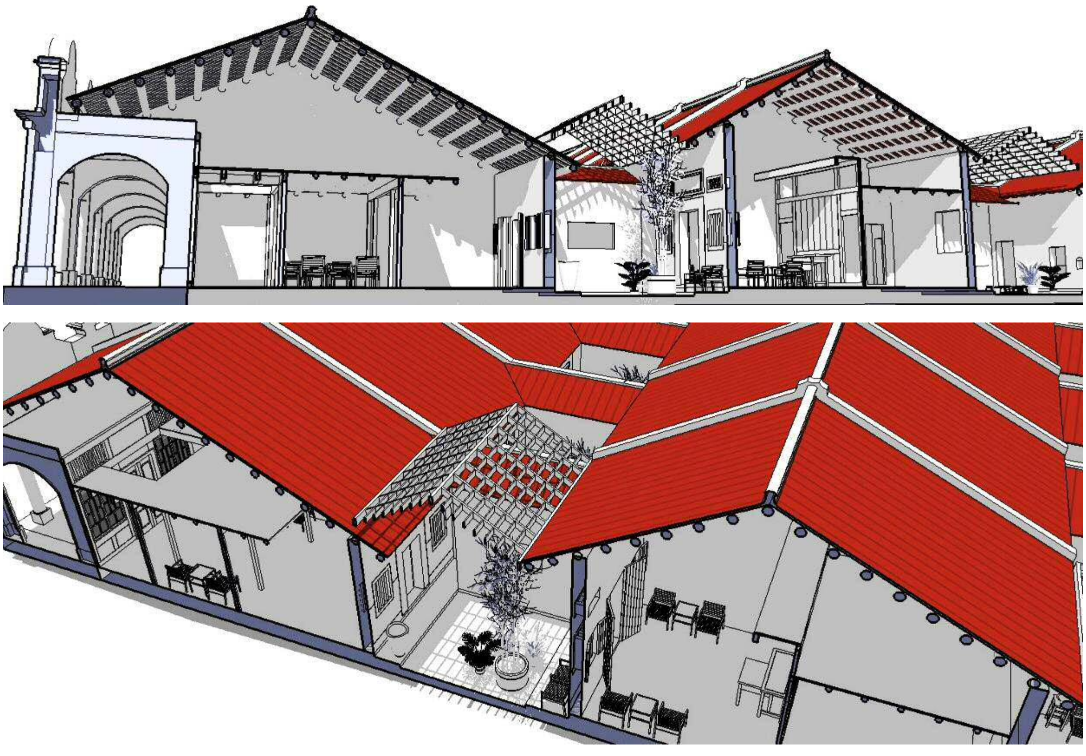


Figure 9.27: The prototype model of solar shading device were proposed at top of front courtyards of the three shophouse case buildings: (a) *Courtyard-S_3*; (b) *Courtyard-P_2*; and (c) *Courtyard-D_1*.
(Source: Illustration by author, 2015)

9.4.3. Effects of prototype models on ecological design performances

To control the effect of solar energy on the outdoor shophouse courtyards environment, it is usual to concentrate on the role played any installed shading device, which act as a filter between the outside conditions and those within the courtyard. Shading devices can be utilized to block the solar radiation before it reaches the courtyard, and are hence more effective than vertical shading devices. However, external shading devices can affect daylighting and natural ventilation performance of the inner courtyards. In terms of daylighting, there are two effects i.e. avoiding glare problem and reduction of light intensity. From the natural ventilation aspect, the shading device has a secondary role as a wind catcher. However, it must be designed and located in the right place, as otherwise this can become a barrier to air flow. Thus, the design and construction of solar shading devices require careful study and proper design to provide their effective functions.

Following the climate analysis in Sections 7.1.1 and 8.1.2 again, for summer time simulation setting, the initial temperature is 35°C, the wind condition is 6.5m/s with northeast and southeast directions based on the prevailing wind condition in Peninsular Malaysia; and for winter time setting, the initial temperature is 15°C, the wind condition is 8.0m/s with northeast direction based on the most negative condition for thermal comfort in Taiwan. Initial wind environment is generated based on the logarithmic wind profile with a reference height of 10m. The analysis of the effects of solar shading devices on ventilation and daylighting performance is conducted by comparing a model without shading device and the models with shading device.

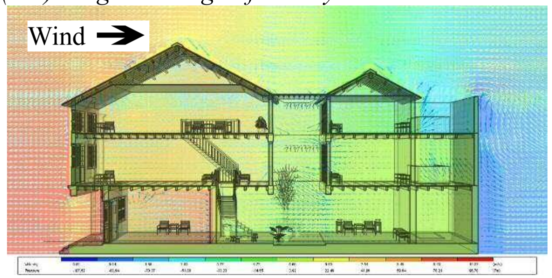
9.4.3.1. Evaluation of natural ventilation pattern

The result of DesignBuilder CFD simulation for each of the shophouse case studies is shown below, in order to explore the impact of the proposed shading prototype (solar shading device) ventilation strategy.

Original *Courtyard-S3*: The stack ventilation works effectively in the original design. The air change rate is adequate for most rooms, except the second floor rear room, which may need assistance by mechanical air extraction. The overall ventilation strategy is a combination of cross ventilation and stack ventilation (Figures 9.28.a-1 and a-2).

Prototype Model Test in *Courtyard-S_3*: The installation of the shading device above the courtyard does not result in a significant impact upon the overall ventilation strategy. Although, in the first floor rear room the circulation became slower than in the original (Figures 9.28.b-1 and b-2).

(a-1) Original design of Courtyard-S3



(a-2) Original design of Courtyard-S3 (invisible of CFD component blocks)

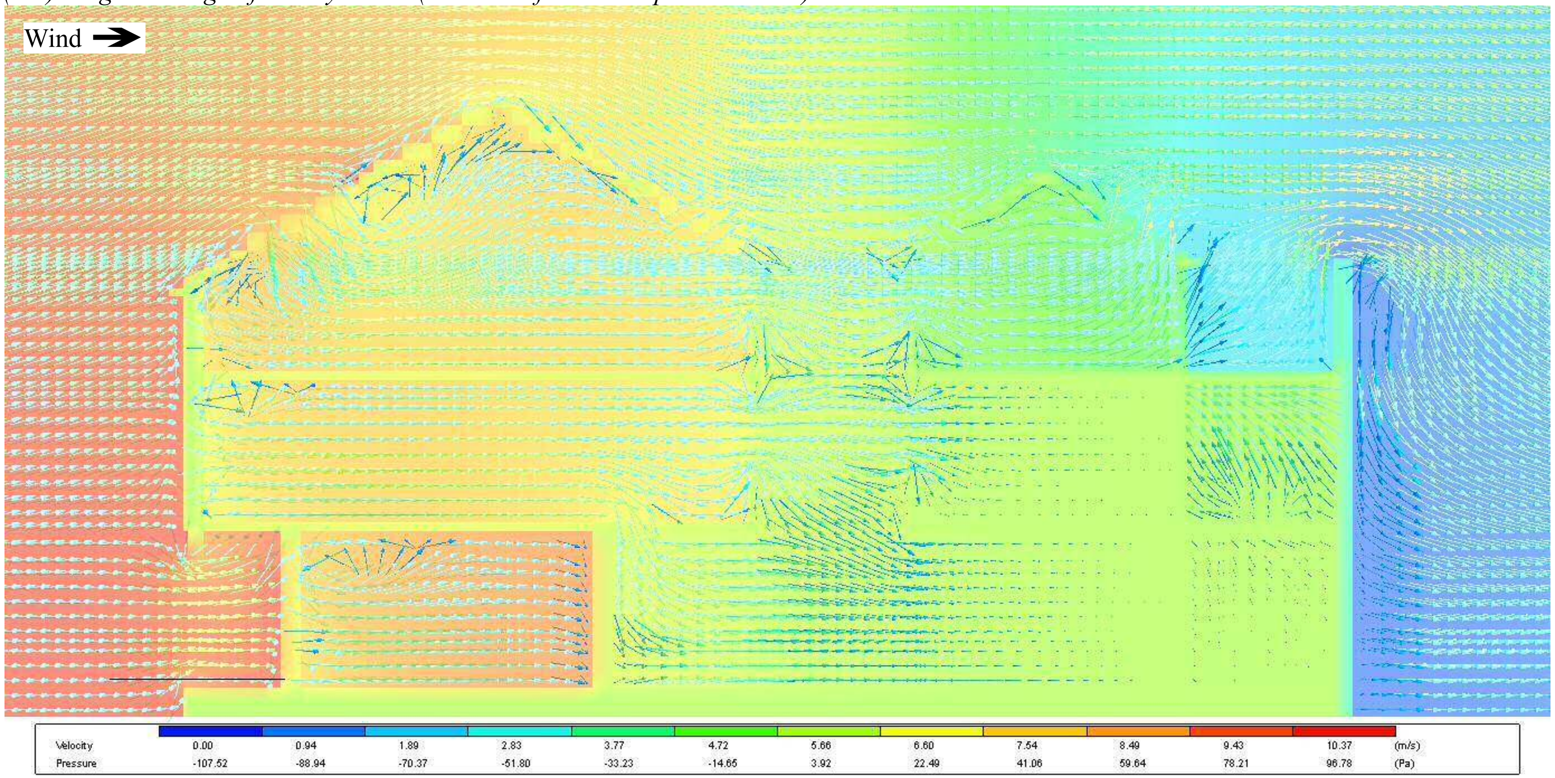
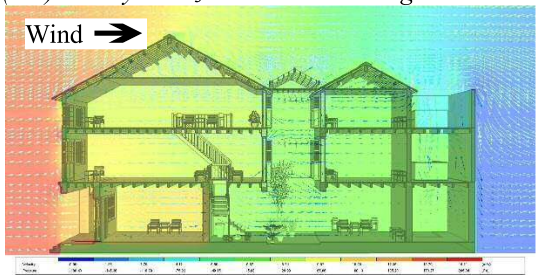


Figure 9.28a:
Vertical direction airflow patterns of *Courtyard-S3*.

(b-1) Courtyard-S_3 with Solar Shading Device



(b-2) Courtyard-S_3 with Solar Shading Device (invisible of CFD component blocks)

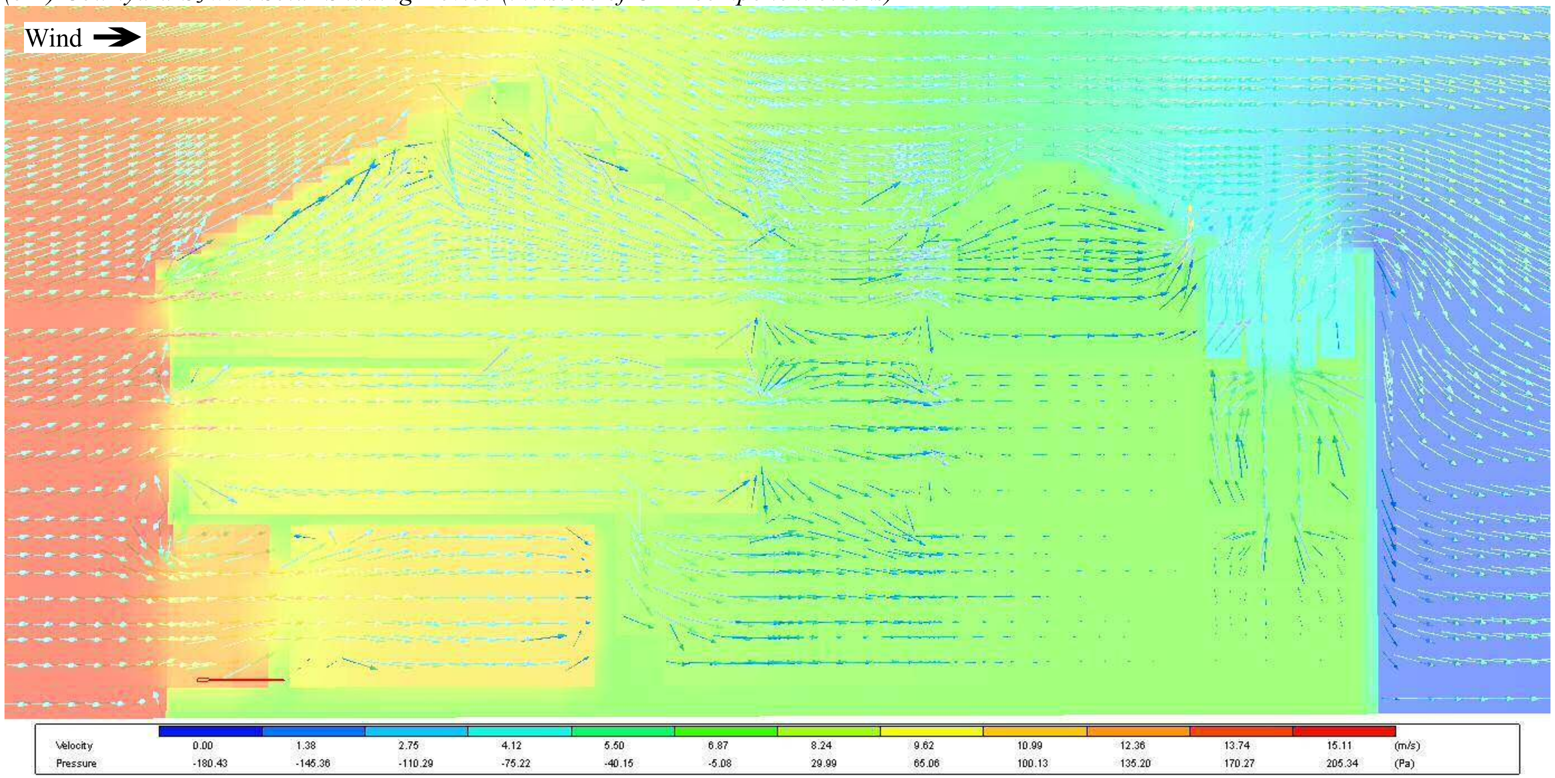


Figure 9.28b:
Vertical direction airflow patterns of *Courtyard-S_3*.

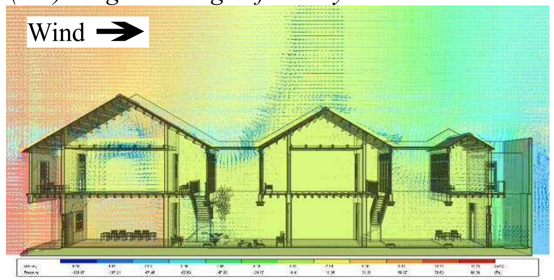
Figure 9.29: Free stream flow around shading device at *Courtyard-S_3* by the display of CFD component blocks.

For wind flowing in an oblique angle that coming down from the pitched roof, Figure 9.29 shows it causes the air stream to strike the shading blades and retard it before the air enter into the space. The shading devices therefore reduce the air velocity by modifying the shape of incoming air stream. However, the overall airflows in both cross ventilation and stack ventilation are found to be around the same level.

Original *Courtyard-P2*: As the floor plan layout of the first building block, stack ventilation is barely affected while cross ventilation for both floors is enhanced. On the other hand, the incoming airflows in both front courtyard and rear courtyard play an important role for stack effects on the rear part of the shophouse building. However, the effect of cross ventilation for overall spaces reduces (Figures 9.30.a-1 and a-2).

Prototype Model Test in *Courtyard-P_2*: Even after placing the shading device, the airflows in both cross ventilation and stack ventilation remain around the same level, while the air change rate of the second building block remains normal. The prototype shading device reduces the air velocity and the incoming airflow is divided and deflected by shading blades, it causes the air stream to strike the side wall and divert into the courtyard. It also results in the reduction of incoming airflows and buoyant force at rear courtyard (Figures 9.30.b-1 and b-2).

(a-1) Original design of Courtyard-P2



(a-2) Original design of Courtyard-P2 (invisible of CFD component blocks)

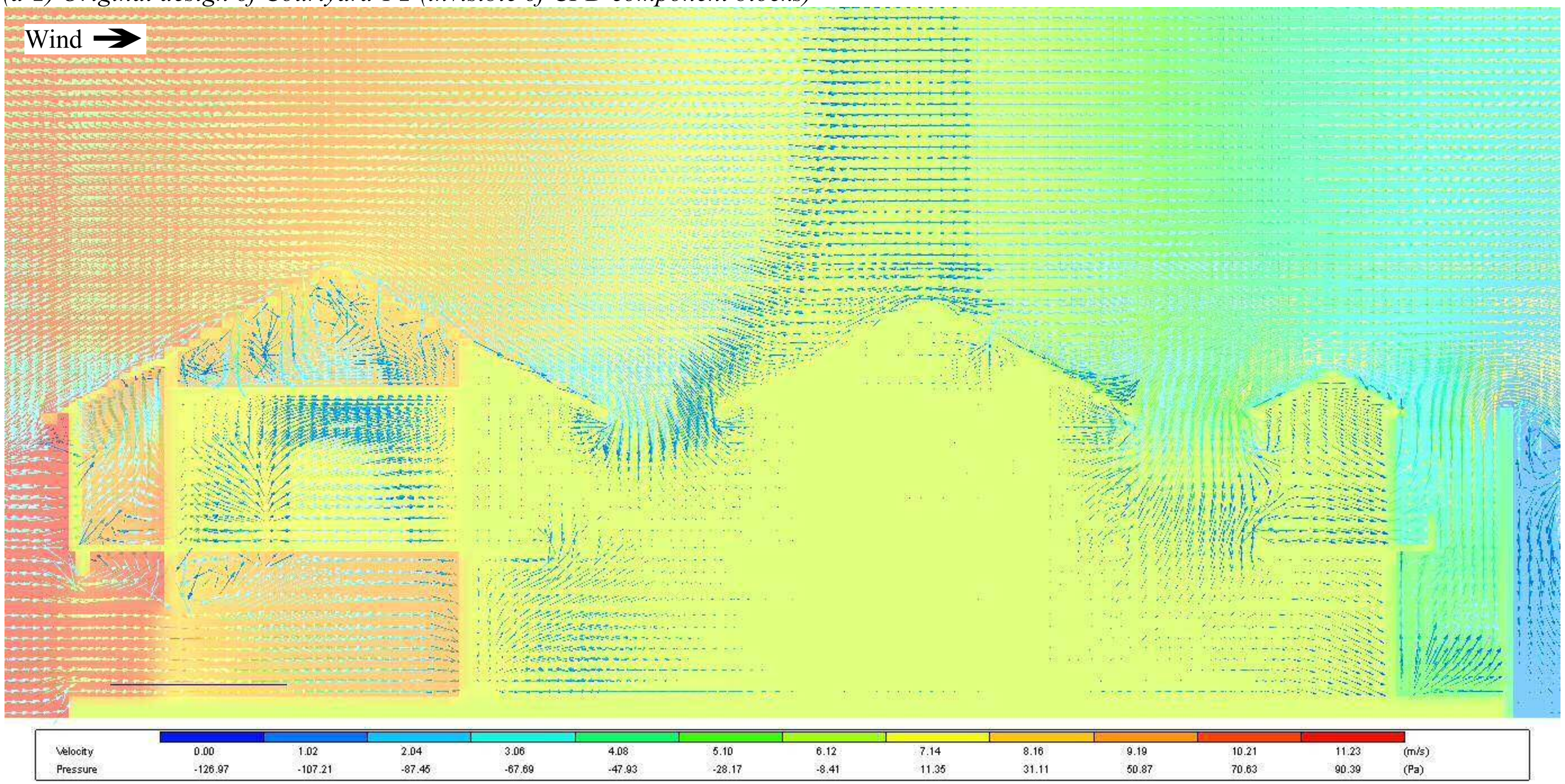
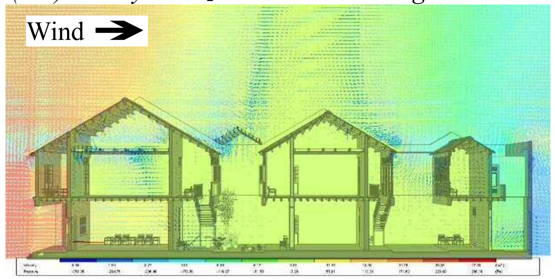


Figure 9.30a:
Vertical direction airflow patterns of *Courtyard-P2*.

(b-1) Courtyard-P_2 with Solar Shading Device



(b-2) Courtyard-P_2 with Solar Shading Device (invisible of CFD component blocks)

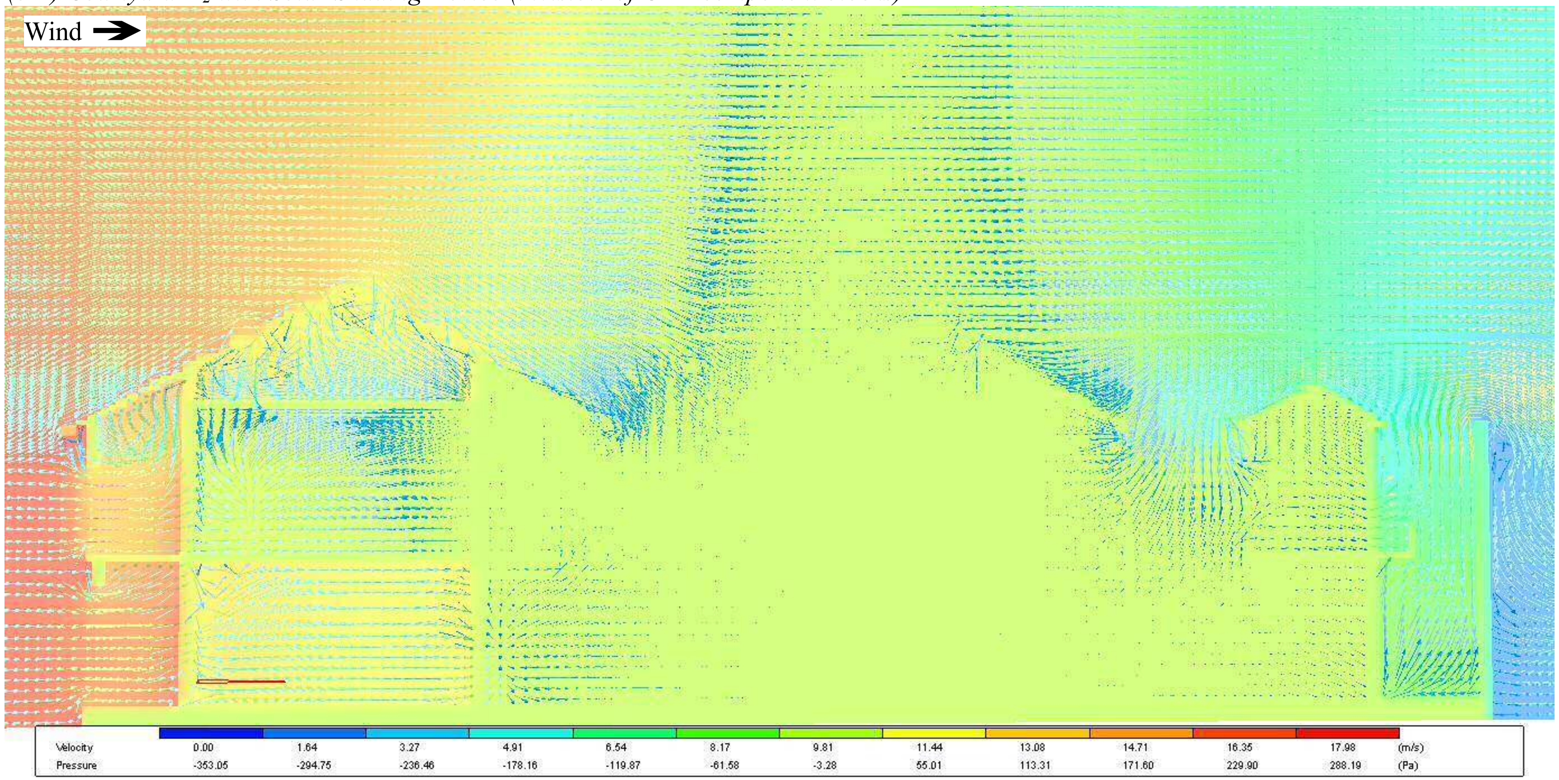


Figure 9.30b:
Vertical direction airflow patterns of *Courtyard-P_2*.

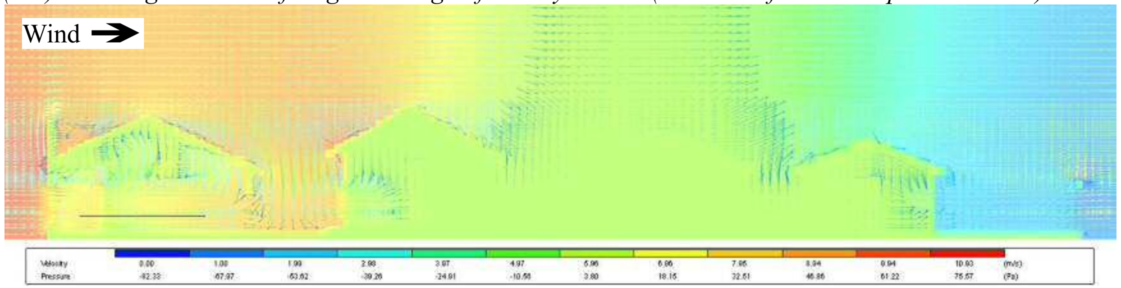
Figure 9.31: Free stream flow around shading device at *Courtyard-P*$_2$ by the display of CFD component blocks.

It is observed that the shading blades can equalize the high pressure and subsequently control airflow in the middle level of the shading devices to allow airflow to enter the courtyard smoothly (Figure 9.31). It causes air velocity at the upper level to be high, with lower velocities at the lower level (see Figure 9.30.b-2). This could be improved by placing the shading device further above the top of the courtyard opening; where it is more likely to divert the airflow towards the floor.

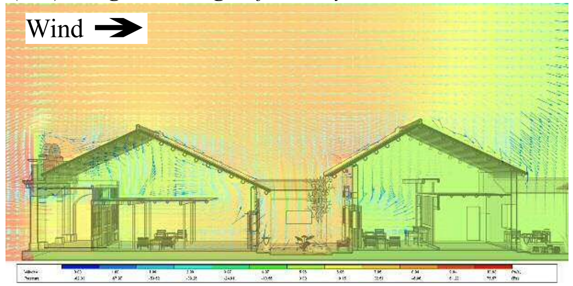
Original *Courtyard-D1*: The stack ventilation works quite effectively in the first two building blocks in the original design, except in the third building, which requires assistance by mechanical air extraction. According to the shophouses occupants's interviews, window fans and table fans circulate air within this room (owner's workshop, see Figure 9.9) for the purpose of reducing the warm air rises. The overall cross ventilation is not affected in the horizontal direction. The effects of stack ventilation reduce and cross ventilation becomes dominant (Figures 9.32.a-1 and a-2).

Prototype Model Test in *Courtyard-D*$_1$: There is no major influence on the front courtyard airflow pattern after placing the shading device, but the amount of airflow has been increased so that it becomes dense at lower level (Figure 9.32.b-2). It is because of the only one-storey height of courtyard wall around the inner space. Thus, the overall cross ventilation remain around the same level (Figure 9.33).

(a-1) Full length section of original design of Courtyard-D1 (invisible of CFD component blocks)



(a-2) Original design of Courtyard-D1



(a-3) Original design of Courtyard-D1 (invisible of CFD component blocks)

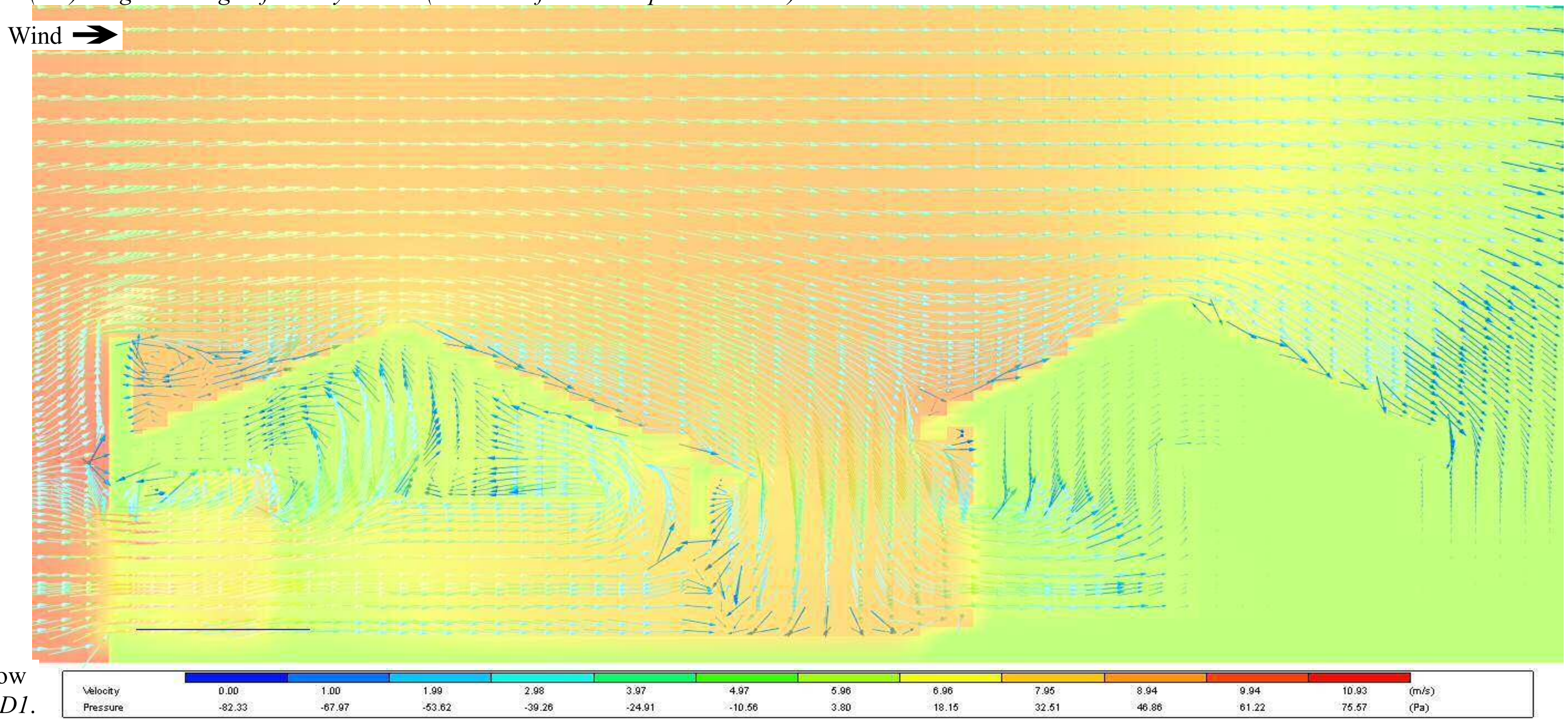
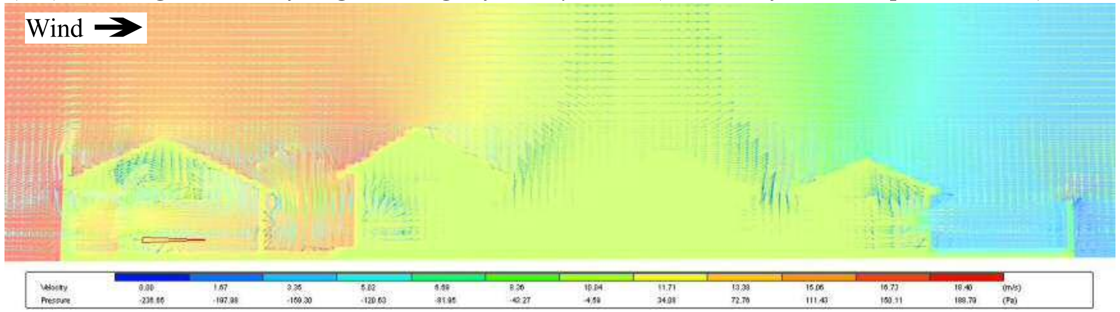
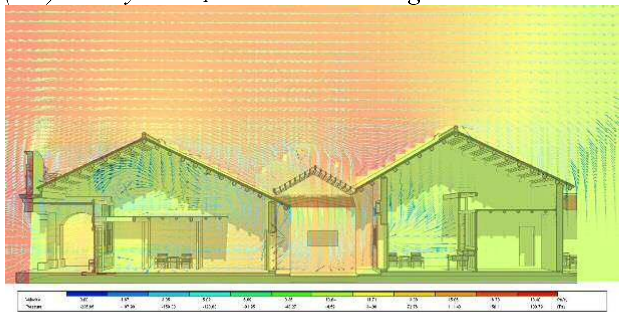


Figure 9.32a:
Vertical direction airflow patterns of *Courtyard-D1*.

(b-1) Full length section of original design of Courtyard-D_1 (invisible of CFD component blocks)



(b-1) Courtyard-D_1 with Solar Shading Device



(b-2) Courtyard-D_1 with Solar Shading Device (invisible of CFD component blocks)

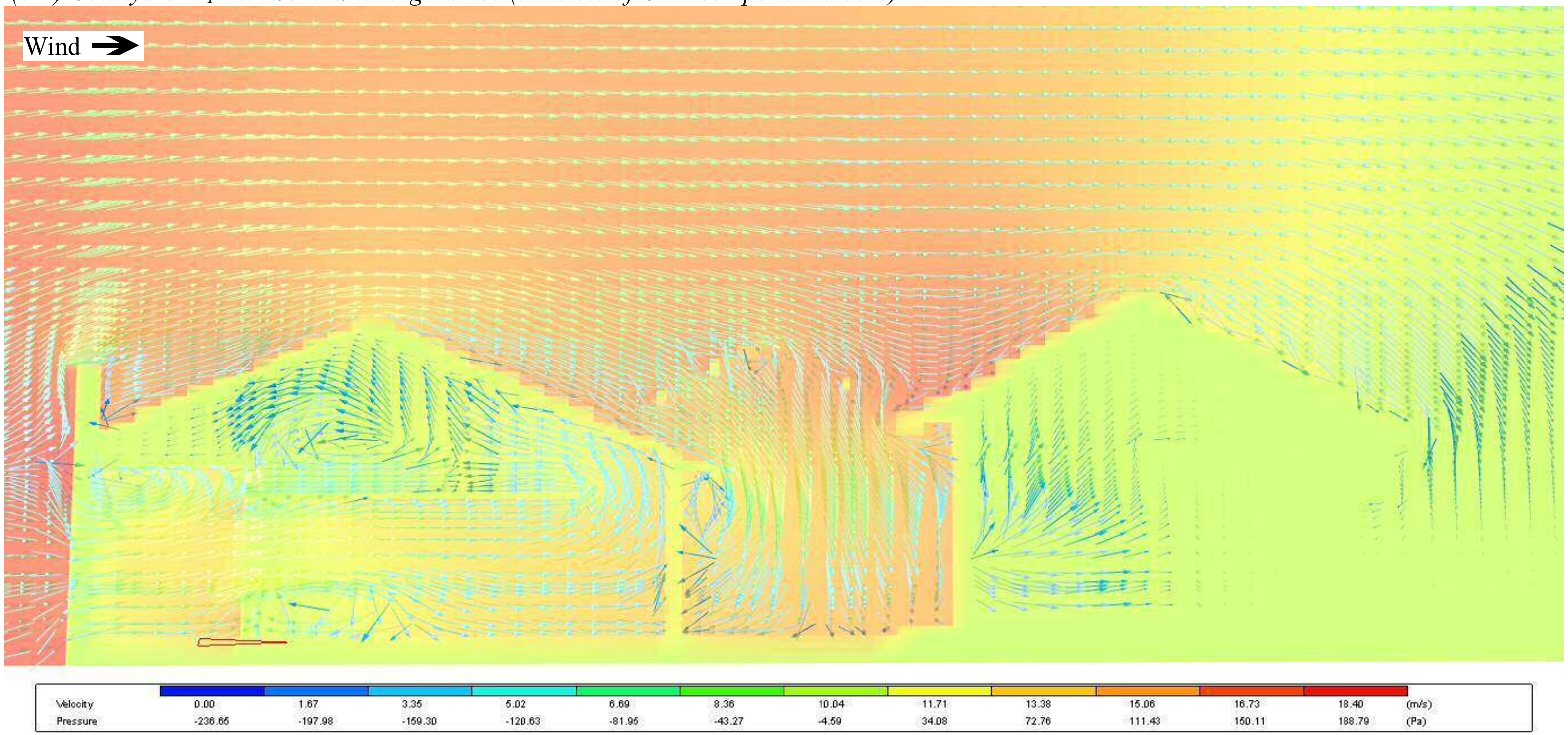


Figure 9.32b:
Vertical direction airflow patterns of *Courtyard-D_1*.

CFD Display of Component Blocks

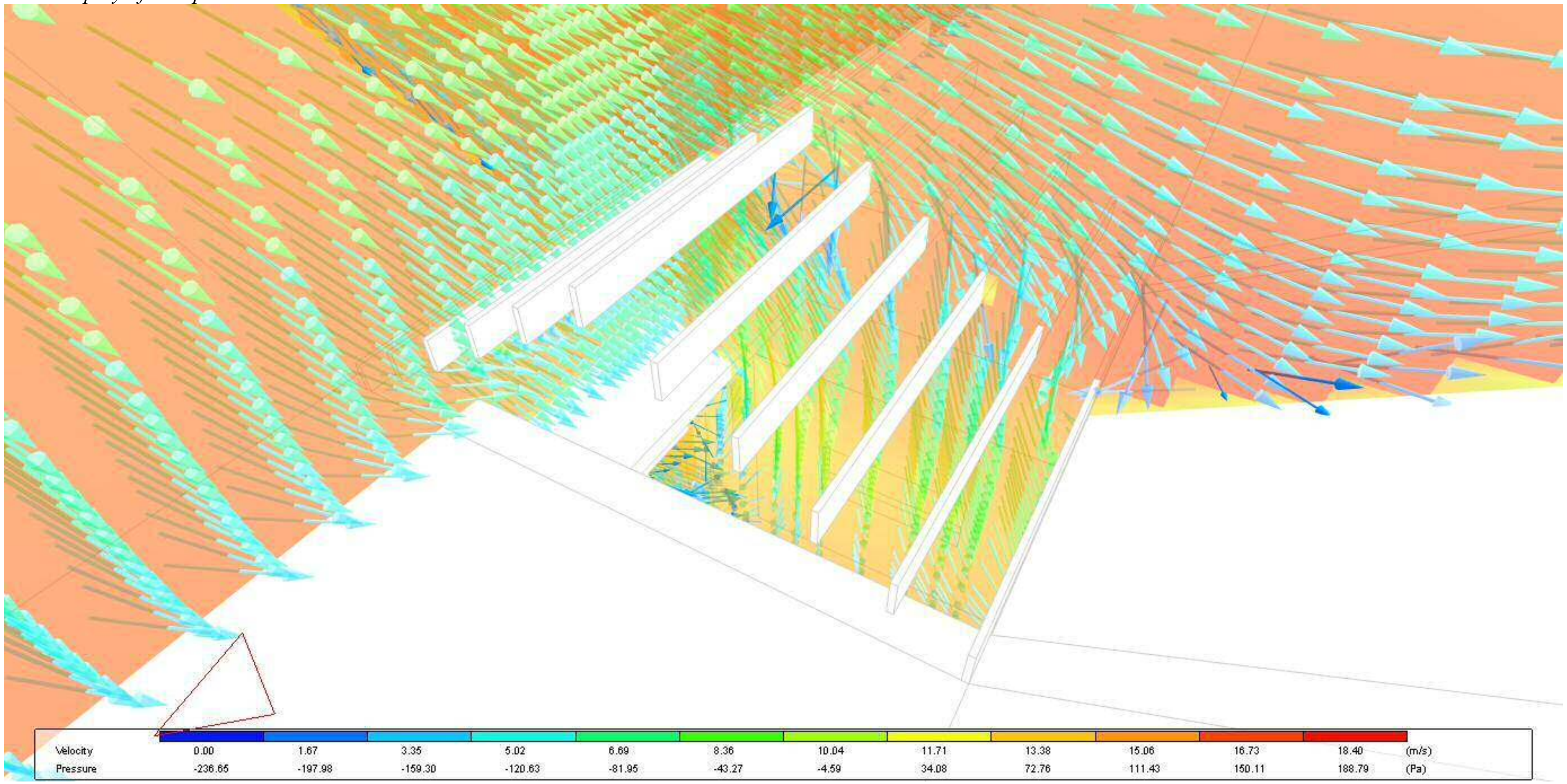


Figure 9.33: Free stream flow around shading device at *Courtyard-D*$_1$.

Invisible of Component Blocks

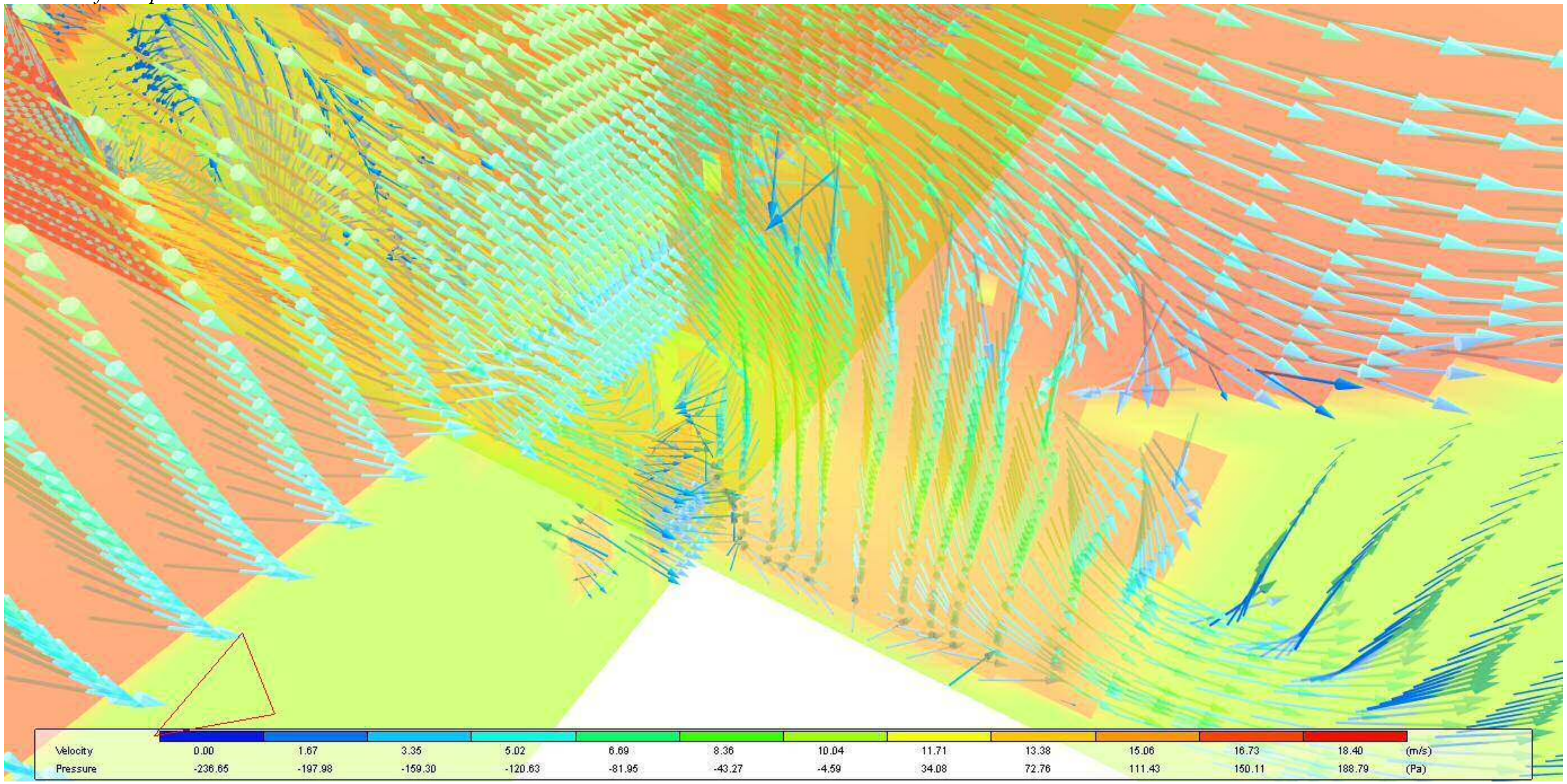


Figure 9.34: Free stream flow around shading device at *Courtyard-D₁.*

From the evaluation of ventilation pattern, this study also revealed that the shading devices do reduce the incoming air velocity though not significantly. Computational fluid dynamics simulation is a tool to test the effectiveness of the natural ventilation design. The relationships among the solar shading devices and how these prototype models react to one another are the most important aspects of the natural ventilation design. Alexander (2005) have illustrated and suggested that the universe is not made of 'things', but of patterns – of complex, interactive geometries. A 'Pattern' is a set of relationships that solves a recurring problem. To form an effective pattern, designers can start from choosing local models, and move forward by reforming relationships among these models, test the effectiveness and end up with an ecological design.

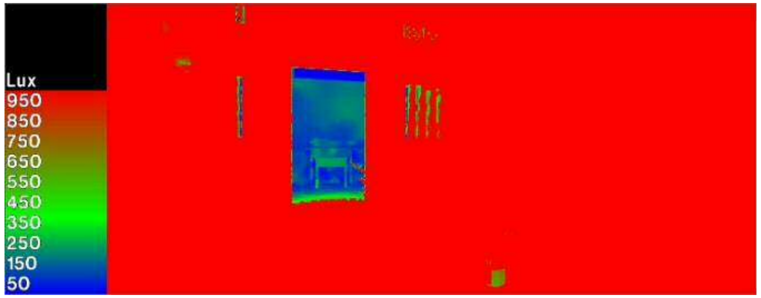
9.4.3.2. Evaluation of solar shading

The result of selected Radiance rendering for each shophouse buildings case is shown in the following for an indicative evaluation of how the prototype shading model (solar shading devices) could bring impacts upon the total visual comfort strategy.

Original *Courtyard-D1*: Judging from the images of the front courtyard, glare is intensive in the exterior wall of the main hall, but thanks to roof shades from the first building, sunlight only extends almost half of the open courtyard. Through these frames, it emerges that the highest risk of glare, especially at noon, when the luminance values on reflected faces are ranging between 8k lux and 70k lux almost over 70% in a field of view (Figures 9.35.B1 and B2).

Prototype Model Test in *Courtyard-D_1*: Installation of the shading device just above one floor height the courtyard will bring a significant impact upon the overall sunlight control strategy, when the luminance values on same area are just in the range of 5k to 6.5k lux. This shading device can prevent direct light and diffuse light, and admit the threshold level of illuminance (Figures 9.35.A1 and A2).

(A1) With shading device, view to Main Hall Entry at 13:00, 22 September



(B1) Without shading device

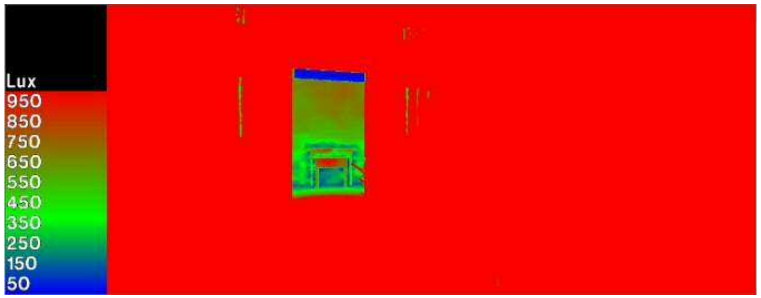
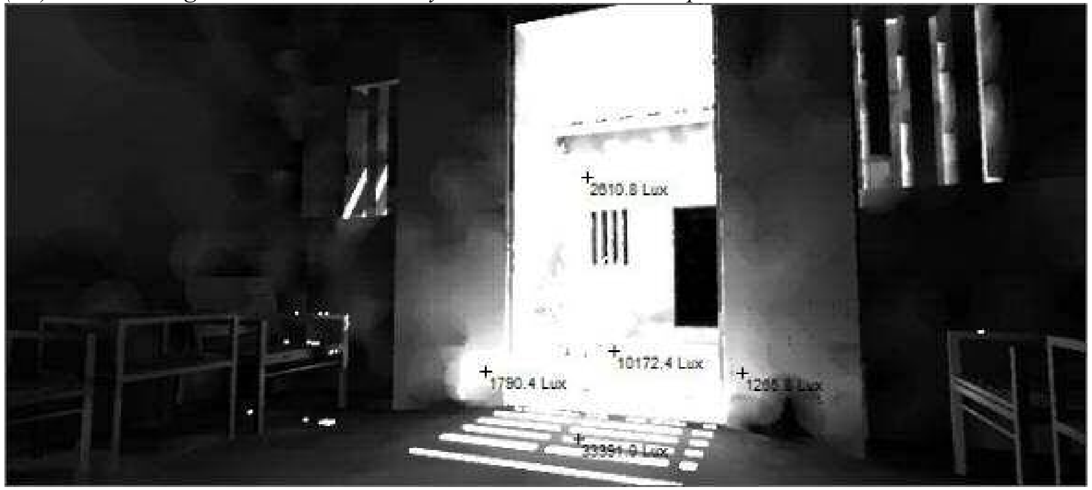
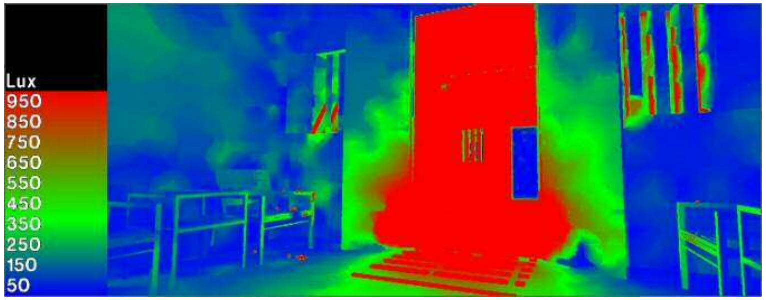


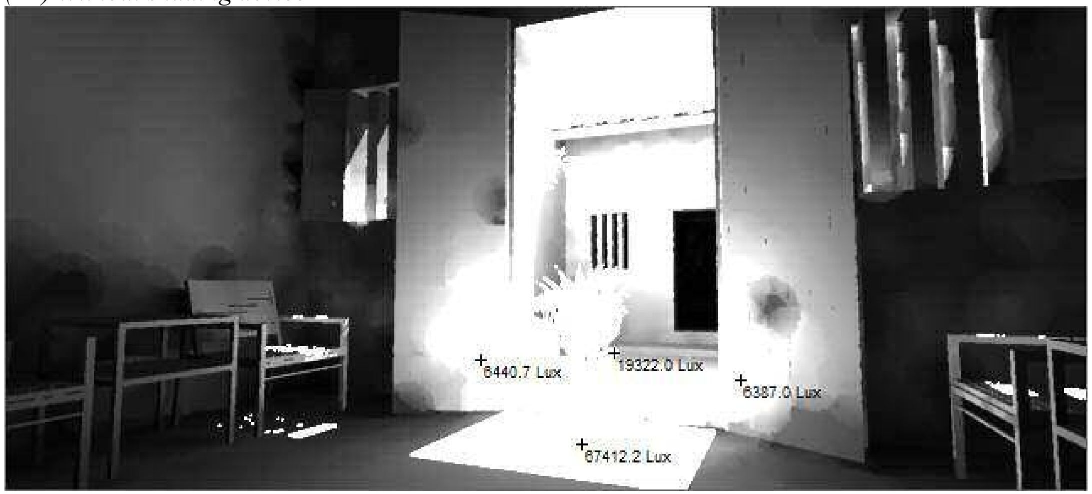
Figure 9.35 (A1 and B1): Selected Radiance renderings (false colour and grey tone) of *Courtyard-D1* with adequate sunlight.

(A2) With shading device, view to Courtyard-D1 at 13:00, 22 September





(B2) Without shading device



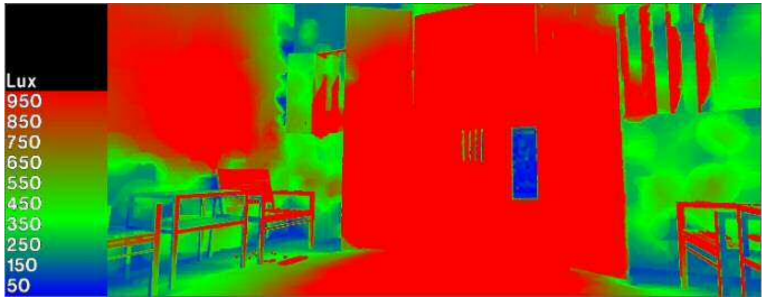
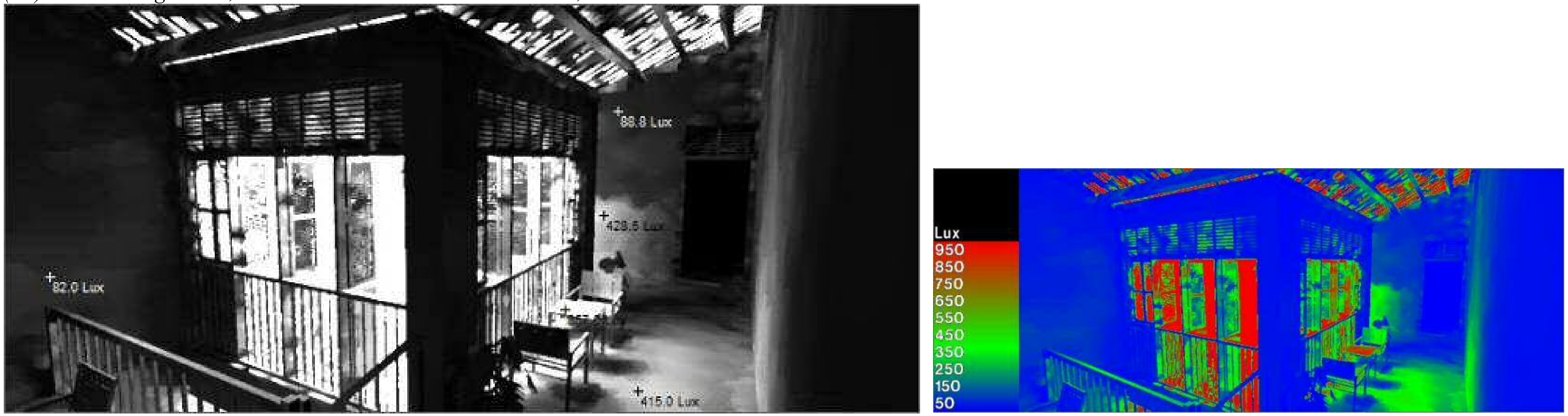


Figure 9.35 (A2 and B2): Selected Radiance renderings (false colour and grey tone) of *Courtyard-D1* with adequate sunlight.

fall at the ground level.

Prototype Model Test in *Courtyard-P_2*: There is no major influence on the void light distribution after placing the shading device, just a slightly difference in about 100 lux on the floor and walls of corridor. As an original design of self-protection, the effect shows that these existing louvered door shutters admit the comfortable level of illuminance at first floor (Figure 9.36.A1). For the void at ground level again, even after placing the shading device, glare is expected less than original design but it still remains intensive in the surrounding walls of the courtyard (Figure 9.36.A2) due to the high angle of the sun.

(A1) With shading device, view to First Floor Corridor at 14:00, 15 March



(B1) Without shading device

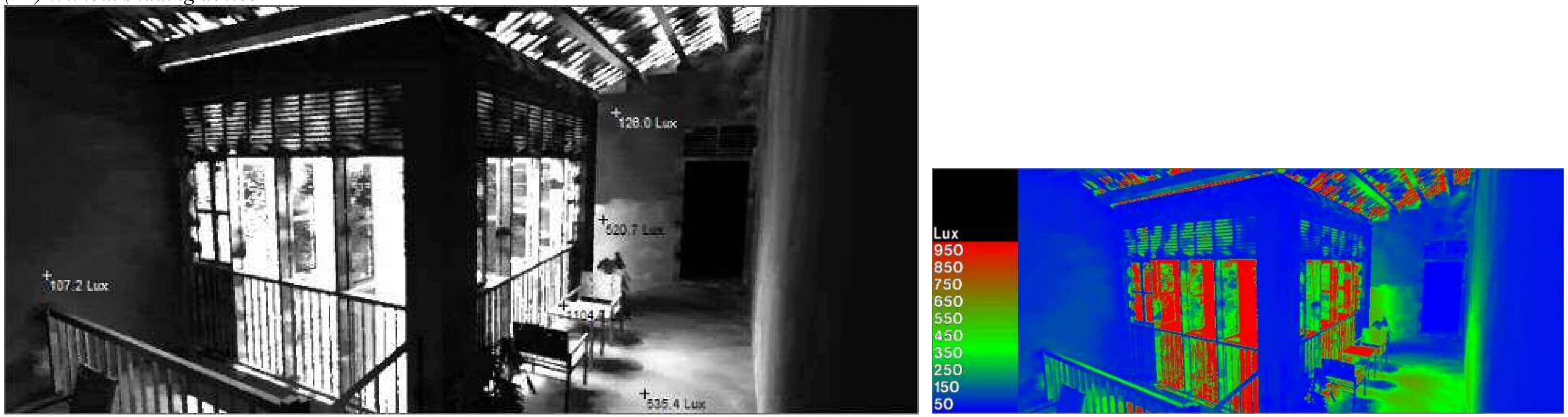
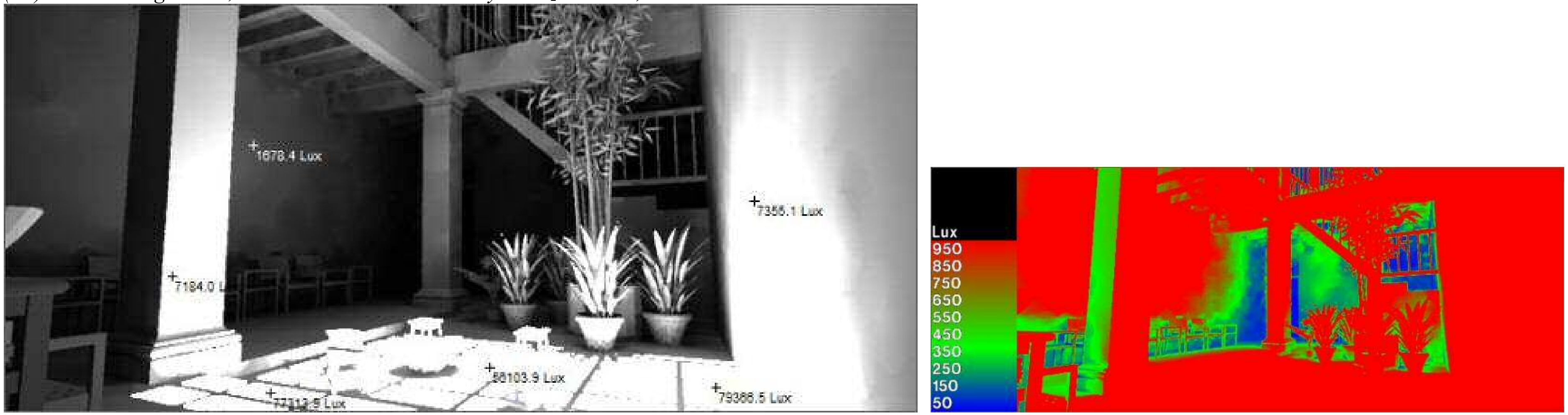


Figure 9.36 (A1 and B1): Selected Radiance renderings (false colour and grey tone) of *Courtyard-P2* with adequate sunlight.

(A2) With shading device, view to Ground Level Courtyard-P_2 at 14:00, 15 March



(B2) Without shading device

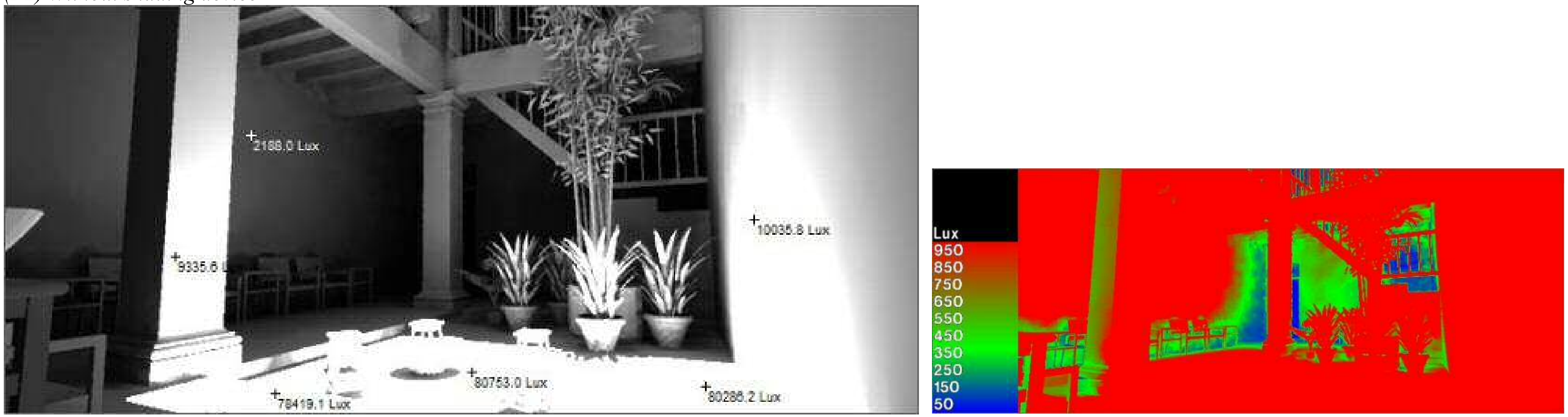
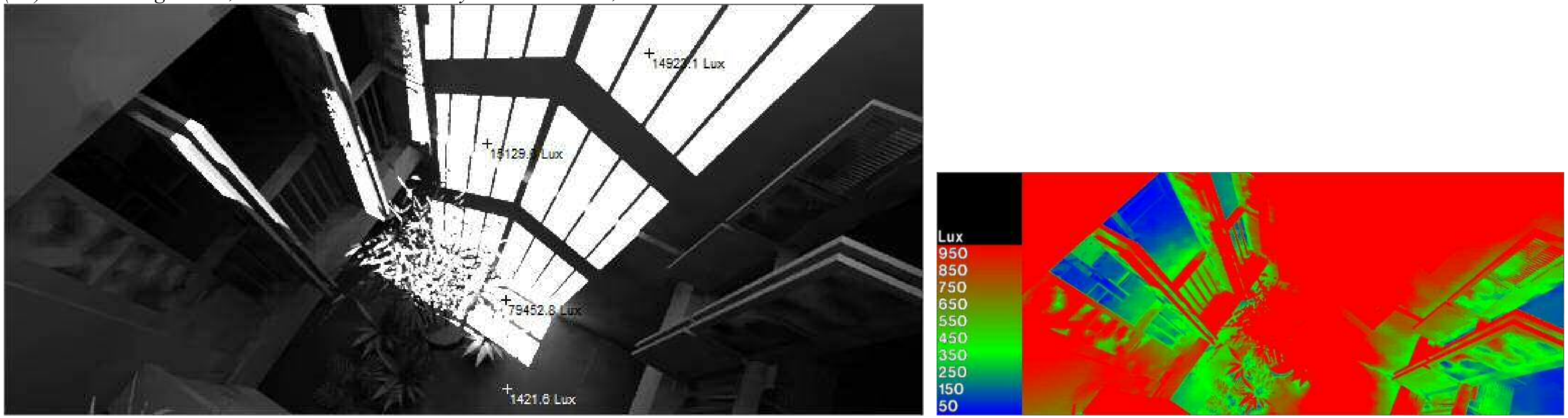


Figure 9.36 (A2 and B2): Selected Radiance renderings (false colour and grey tone) of *Courtyard-P2* with adequate sunlight.

on the side wall. Other from Figure 9.37.B3, the result indicates that direct light and high intensity of diffuse light illuminate the whole area of the courtyard on the distribution of daylight.

<u>Prototype Model Test in *Courtyard-S_3*</u>: The observer position in the first and the second floors rooms which is furthest from the void of courtyard, causes the observer to see smaller exposed area of the window so that it produces low glare effects. The effects of solar shading devices on glare also show different values for each wall. The shading devices do not always reduce glare problem. It may even increase the glare, for example in corridor and the side wall of courtyard (Figure 9.37.A2). This could be due to the indoor luminance that decreases as a result of the effects of shading devices. On the other hand, the voids in courtyard often also serves a highly functional role in a shophouse – for circulation. This serves a dual function of keeping the courtyard active and giving all member of family a reminder of the larger communal connections in the shophouse buildings. With shading device, Figure 9.37.A1 try to keep courtyard active around the edges, viewing active living space on the edge of the courtyard creates more dynamic experience.

(A1) With shading device, downward view to Courtyard-S3 at 15:00, 15 October



(B1) Without shading device

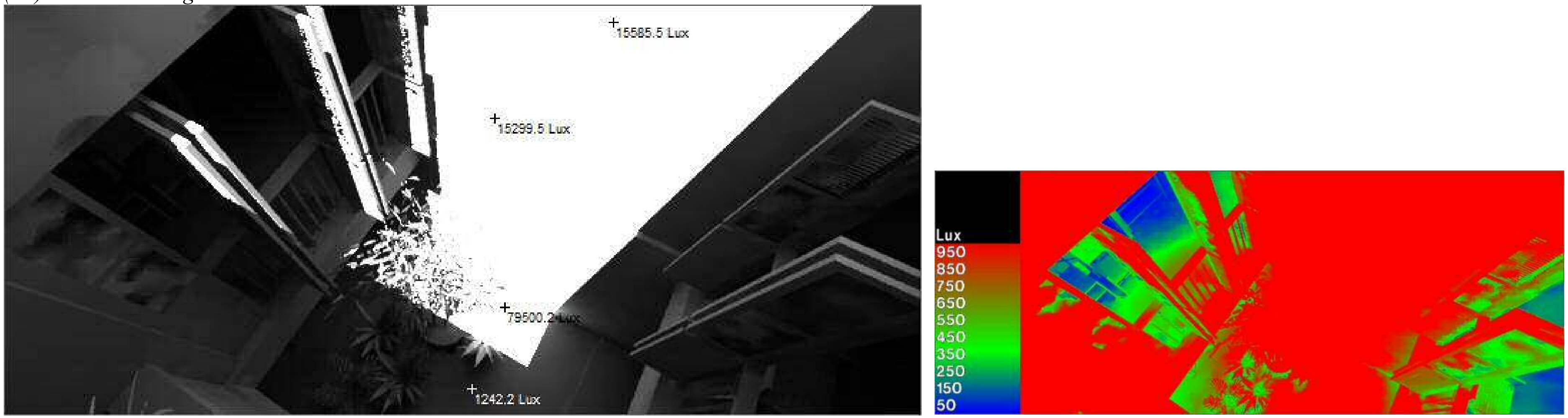
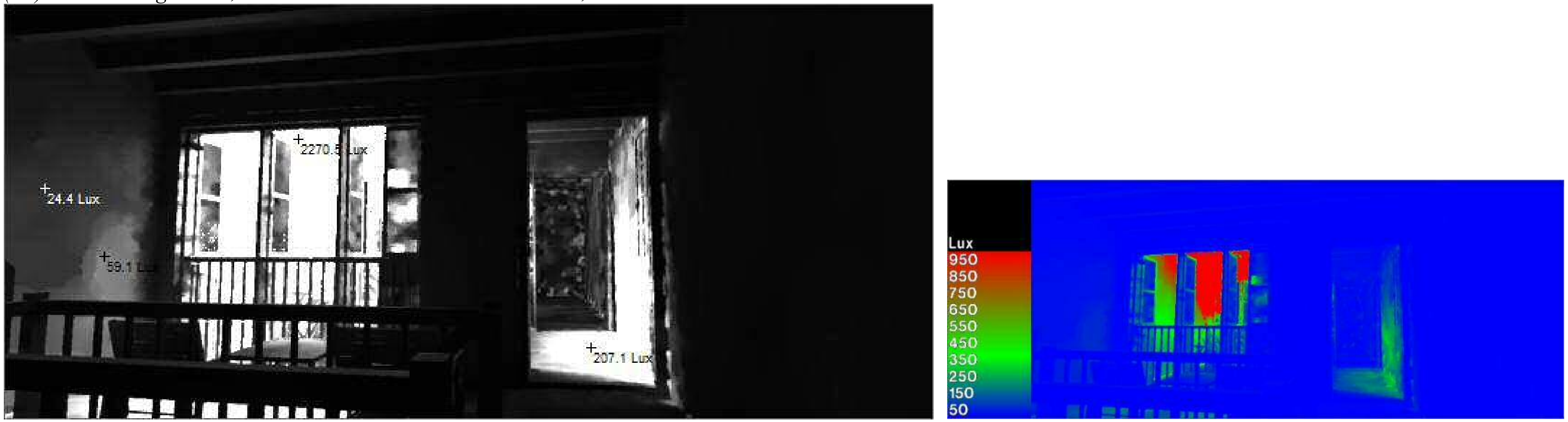


Figure 9.37 (A1 and B1): Selected Radiance renderings (false colour and grey tone) of *Courtyard-S3* with adequate sunlight

(A2) With shading device, view to First Floor Corridor at 15:00, 15 October



(B2) Without shading device

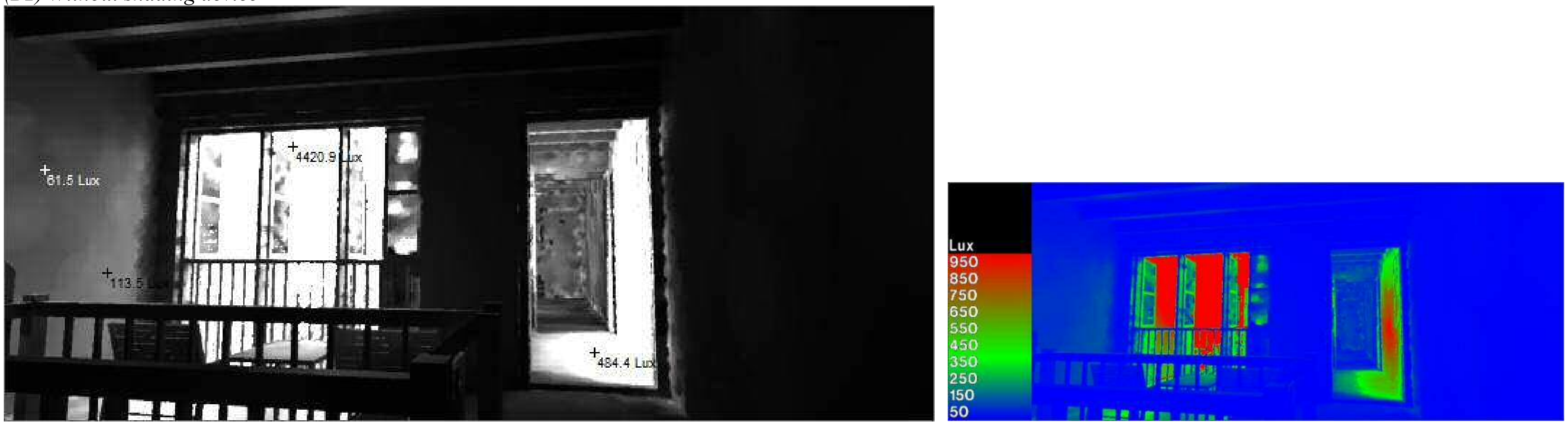
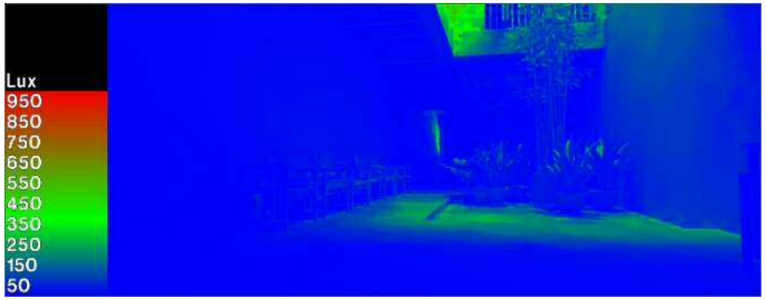


Figure 9.37 (A2 and B2): Selected Radiance renderings (false colour and grey tone) of *Courtyard-S3* with adequate sunlight

(A3) With shading device, view to Ground Level Courtyard-S₃ at 15:00, 15 October



(B3) Without shading device

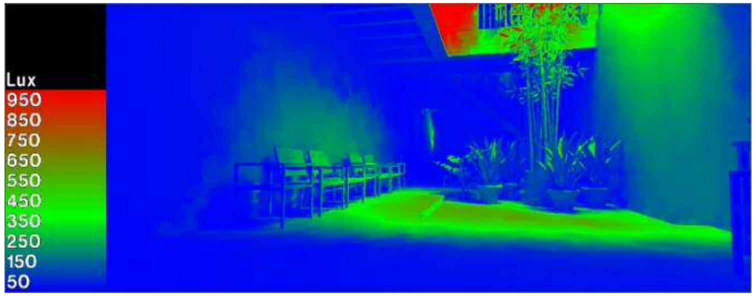


Figure 9.37 (A3 and B3): Selected Radiance renderings (false colour and grey tone) of *Courtyard-S3* with adequate sunlight.

For the tropical region where the average luminance of the sky is often high, glare from the sky could be a critical problem. The shading devices can reduce glare but it is not always successful, since glare is not only a function of the exposed area of the opening but also of the outdoor and indoor luminance and the view angle of the observer. The analysis suggested that solar shading is quite useful to development of passive cooling system to maintain indoor room air temperature lower than the conventional building without shade (Kumar *et al.* 2005). Mechanical devices such as fans and evaporative coolers can supplement our cooling needs and cost less to install and run the air conditioners. If correctly selected and used, solar shading devices may decrease the overheating and cooling demand of buildings significantly without largely increasing the electrical lighting demand. The solar shading devices should be as flexible as possible so they can adapt to the outdoor conditions. According to their position on the courtyard, they may be categorized in internal, interpane and external (Bülow-Hübe *et al.* 2003). The external solar shading devices are the most efficient in reducing the cooling loads. As they are placed outside they reflect the solar rays before they enter the room.

9.4.4. Visual effects: modelling and shading

Based on the shophouse building case studies, the following screenshots appear as the essential elements of a miniature piece of art (Figures 9.38a, 9.38b, 9.39, and 9.40). It should process on selection of ecological design. Building a set-up that obeys the laws of physics can help to produce a controllable and predictable result (Bigi 2014).

For the purpose of investigating the effects of solar shading devices on daylighting performance, this study used a standalone render engine: Indigo Renderer. It is a 3D rendering software that uses unbiased rendering technologies to create photo-realistic images. In doing so, Indigo uses equations that simulate the behaviour of light, with no approximations or guesses taken. By accurately simulating all the interactions of light, Indigo is capable of producing effects such as: depth of field, spectral effects, refraction, reflections and caustics (Indigo 2012 and 2015). It features Monte-Carlo path tracing, bidirectional path tracing and MLT on top of bidirectional path tracing, distributed render capabilities, and progressive rendering (image gradually becomes less noisy as rendering progresses).

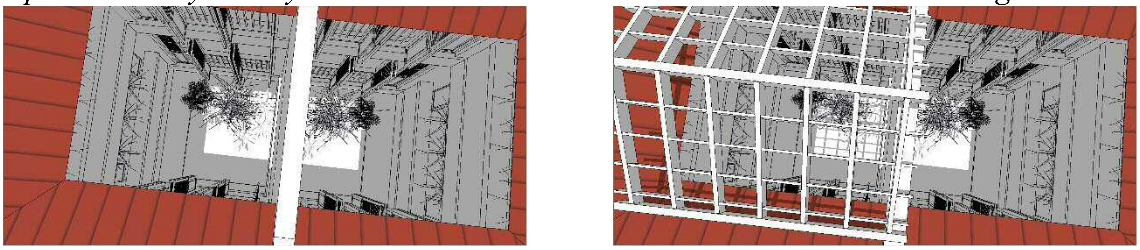
Considering modelling, it is more of a general statement that this study wish to make here, rather than a technical manual. This section aims to get the models as accurate as possible. Get the general proportions and the fine details right and that will do the job.

And for considering shading, the real world is a highly reflective place. Pure diffuse is pretty hard to come by actually, whereas in the CG world it is very easy to diffuse the scenes unlimitedly (Rode 2013). One thing that it is important to pay attention to here and understand, besides the world being reflective, is that the world is also a very grey place. It is just that it is all shades of grey. To make the image consistent in colours it should have a clear concept of colouring. The easiest way of course is having all shades of grey and one key colour (white). Only this way it was possible to get the really subtle shadow-gradient on the wall and the around part of the shophouse courtyards.

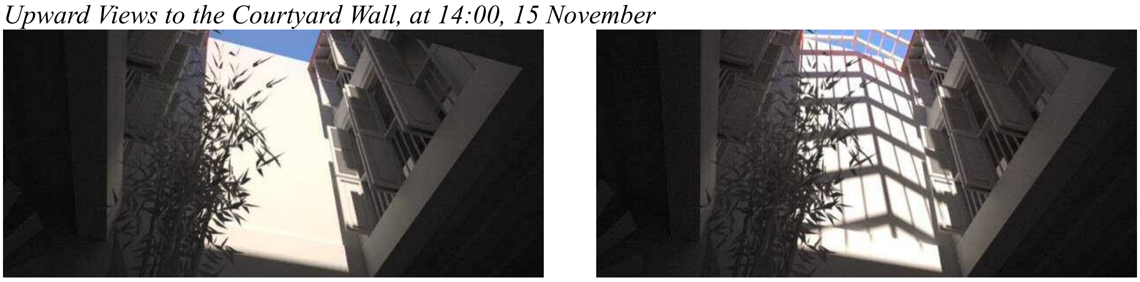
Courtyard-S3 vs. Courtyard-S_3

Part I

Open to the Sky Courtyards… *…with Solar Shading Device*



Upward Views to the Courtyard Wall, at 14:00, 15 November



Views to Courtyard from the First Hall, at 12:00, 22 October

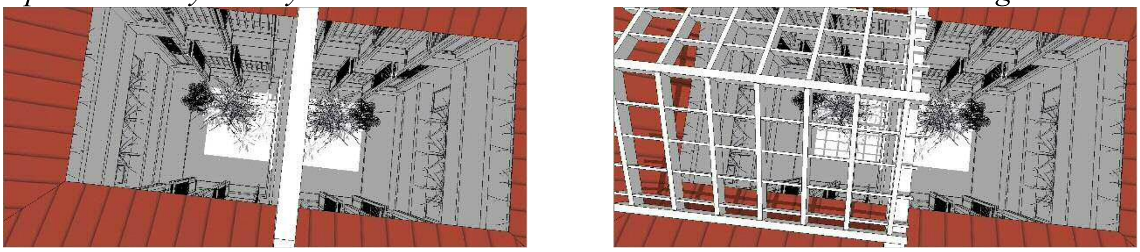
Views to Courtyard from the Rear Hall, at 15:00, 22 October

Figure 9.38a: Selected Indigo rendering of *Courtyard-S3*: geometry models in SketchUp (top) and three different views to courtyard from the ground level (bottoms). (Source: Illustration by author, 2015)

Courtyard-S3 vs. Courtyard-S_3

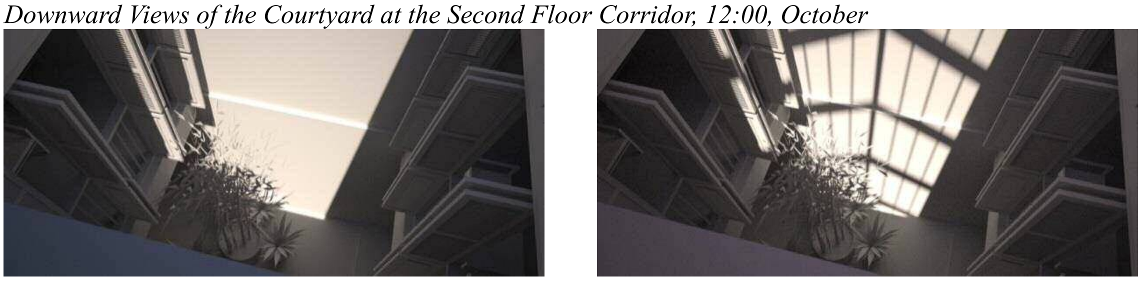
Part II

Open to the Sky Courtyards… …with Solar Shading Device

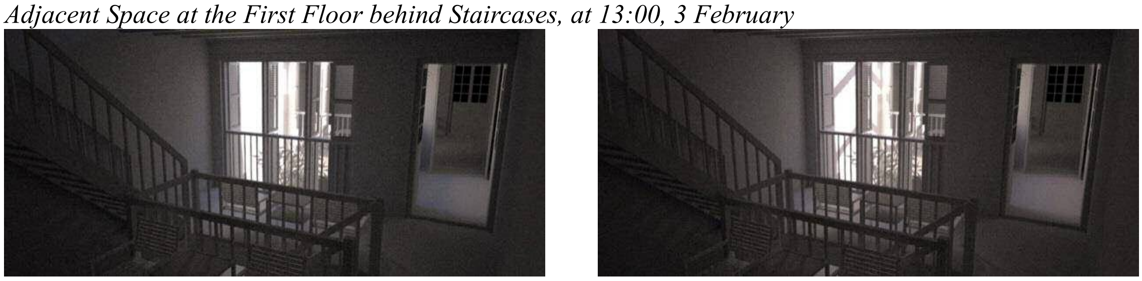


Views to Courtyard Wall at the Second Floor Corridor, at 12:00, 22 October

Downward Views of the Courtyard at the Second Floor Corridor, 12:00, October



Adjacent Space at the First Floor behind Staircases, at 13:00, 3 February

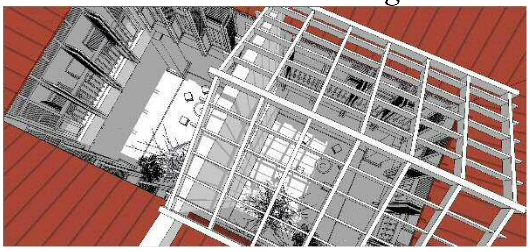


Adjacent Rear Bedroom at the First Floor, at 13:00, 3 February

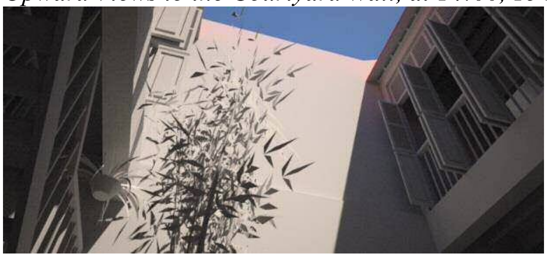
Figure 9.38b: Selected Indigo rendering of *Courtyard-S3*: geometry models in SketchUp (top) and four different views to courtyard at the first floor level (bottoms). (Source: Illustration by author, 2015)

Courtyard-P2 vs. Courtyard-P_2

Open to the Sky Courtyards… *…with Solar Shading Device*



Upward Views to the Courtyard Wall, at 14:00, 15 March



Upward Views to the First Floor, at 9:30, 15 March

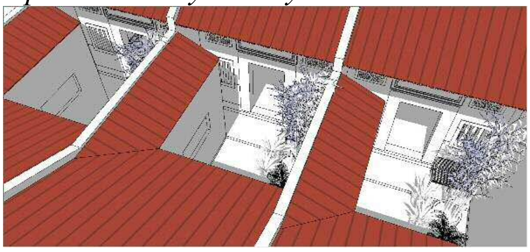
Views to Courtyard from the Second Hall, at 14:00, 22 March

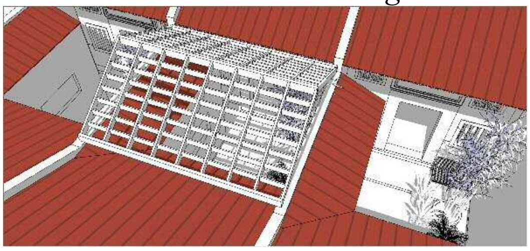
Views to Courtyard from the Shop Section, at 14:00, 22 March

Figure 9.39: Selected Indigo rendering of *Courtyard-P2*: geometry models in SketchUp (top) and four different views to courtyard from the ground level (bottoms). (Source: Illustration by author, 2015)

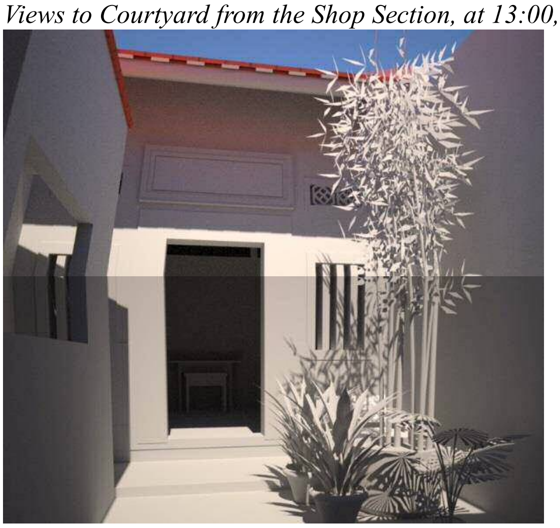
Courtyard-D1 vs. Courtyard-D_1

Open to the Sky Courtyards… *…with Solar Shading Device*





Views to Courtyard from the Shop Section, at 13:00, 22 September



Views to Courtyard from the Main Hall, at 13:00, 22 September

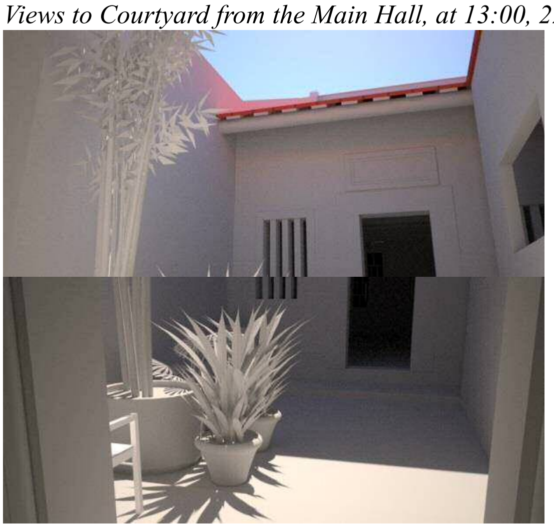


Figure 9.40: Selected Indigo rendering of *Courtyard-D1*: geometry models in SketchUp (top) and two ground level views to courtyard (middle and bottom). (Source: Illustration by author, 2015)

9.5. Summary and discussion

The main goal of this chapter is to develop an approach for well-founded selection of ecological design. In order to reach this goal, the existing practices for making a design selection (like the selection of adaptive reuse and solar shading devices) have been assessed. Using elements from existing experiences in the Southeast Asian shophouses, an approach for performance-based selection of lighting and ventilation has been developed. The approach has been applied to an example and has been evaluated for meeting the requirements for a well-founded choice.

There is a procedure that addresses the making of well-founded choice and selection for adaptive reuse of traditional shophouses. Experiences from the existing practices can be used to develop an approach for a well-founded selection of ecological design. This approach consists of the following main steps:

1. Definition of an open to the sky courtyard, that identifies which combinations of a given building design with one or more climate responses are to be considered.
2. Identification of the relevant functions of all reuse options, in order to find the relevant criteria for the selection.
3. Prediction of the performance of all selections through execution of virtual experiments using building performance assessment tools.
4. Evaluation of predicted performance, in which a subjective assessment is made of how well each design selection performs each individual function, and where a trade-off between the performance of different functions can be made as well.

Through the creation of a set of different shophouse building types that include ecological design is still dependent on experience. Selection will be based on clear criteria, using objective performance prediction methods, and subjective values will be made explicit, allowing discussion of these values between architect, contractor and user. Also, in the approach the use of performance analysis tools to predict building performance is an essential part of the preparation of the selection of ecological design.

Based on the consideration given in this thesis to the development of a strategy to provide computational support during the shophouse building reuse process for rational design decisions regarding the selection of climate responsive components, an explicit choice has been made to apply existing practices to this problem and to develop a general approach for the selection of these components. Another possible line of research would be to make a concise model-based, comprehensive study of all aspects that need to be considered when selecting specific ecological building components from a finite set (for instance from a set of design alternatives that includes a shop section and covered walkway). Such a study will reveal the different performance aspects that need to be considered in the specific case. Some feeling for this type of research can be obtained from the example in section 9.4.4. However, there is a need for more comprehensive research efforts along these lines that will contribute new insights to the groundwork presented here. The knowledge obtained from such studies will be of direct use for well-founded selections that involve the ecological design of lighting and ventilation that have been widely studied.

10. Conclusion

The general problem addressed in this thesis was the potential for retention of traditional shophouse courtyards in Southeast Asia, especially in Taiwan. Within this field, the work has focused on the preservation of continuity, but not necessarily the preservation of the past. Within this context it has been argued that courtyards play an important role in efforts to regulate the sun and the wind to heat and cool and to define the character and quality of the human relationship with a place. However, today's design challenge is to meet new standards of sustainable performance and cause a shift in social consciousness that will enable people to 'see profoundly' into a new future (Guzowski 1991). Traditional shophouses alone cannot solve our ecological problems. Rather, the way people live in this building type also has to change and evolve.

The outcomes of the research presented in this thesis are a result of the development of a strategy to provide computational support during the traditional shophouses re-design process to enable rational design decisions regarding the selection of ecological issues to address. Therefore, the production of the prototype described in Chapter 9 was undertaken in order to turn the emerging ecological approach, advocated by the work undertaken in the thesis, into a design process that is more concrete and material and that can inform future design interventions in shophouses based on the data collected and presented here. The purpose of the prototype is, as far as possible, a question of 'giving form to what could be' in terms of lighting and ventilation requirements, that until this point had only been described in terms of abstract ideas. It is not the intention of the author that this proposal be applied without further, contextual, critical judgment of its implications, requiring validation by professionals or experts in conversations with potential users.

The following main research activities can be divided into three sections (Section 1.4) providing the key elements towards solving the problems:

Case study physical examination and history: to establish a theoretical empirical understanding of the environmental performance of shophouse courtyards. This is followed by a review of the spatial and physical characteristics of traditional shophouses, in terms of the vernacular design strategies employed in shophouse courtyards.

Data collection and analysis: to understand occupants' perception of comfort and environmental conditions in shophouses and their courtyards; and to evaluate visitors' attitudes towards the retention of inner courtyards.

Process of synthesis: to establish and evaluate design strategies that provide remedial responses to occupant and empirical understanding of shophouse performance in order to provide strategies for environmental enhancement of their courtyards and adjacent spaces.

In this final chapter section, 10.1 addresses the importance of the subject and provides an overview of all research activities conducted in this research project. Section 10.2 presents the conclusions from these research activities, thereby answering the main research questions. Section 10.3 identifies issues that deserve further attention and describes proposed aspects for future research. Section 10.4 presents the closing remarks that conclude the thesis.

10.1. The importance of the subject

Heritage shophouses are of intrinsic importance to everyone in Taiwan. They connect us with our past – physically, historically, emotionally, and in many other ways. According to Swarbrooke (1999), heritage is vital to one country's tourism industry: it is a major attraction for foreign visitors and consequently provides jobs and earns foreign exchange currency; it provides leisure opportunities for day trips, especially for the domestic market; it provides revenue for the conservation of many historic buildings and sites; and it provides an up-market image and identity for a country which differentiates it from many other competing destinations.

Moreover, this study has recognized the importance of traditional shophouses to the economics of historic districts and/or old streets across Southeast Asia and Taiwan respectively. As argued previously, the success of many of these historic districts depends on the unique characteristics of traditional shophouses, including their overall streetscape and skyline, building façade and decoration, and the special inner courtyards. With particular reference to Singapore's Chinatown, it was argued that it is impossible to deny the contribution of tourism to the national income. Indeed, a country/city like

Singapore could not afford to overlook the economic benefits associated with tourism being one of the main pillars of the economy. This indeed has dominated the planning approaches for the development of tourism, which, in turn, could not be neglected but has to be taken into consideration during the planning process.

The work presented in this thesis consists of three main research activities, all focusing on the use of simulation tools and the logic of reasonable inferences to support the continued active use of traditional shophouses: analysis of current traditional shophouse occupations; development of an approach for well-founded selection of ecological designs in lighting and ventilation, as well as an analysis of the suitability of existing practices and experiences to support the selection process; and a development of a strategy as well as a proof-of-concept prototype that provides support for the selection of ecological issues and that demonstrates the viability of the proposed changes.

The analysis of current traditional shophouses was initiated by a lack of unbiased information in a way in which ecological issues are selected in current practice, as well as of information of the role of computational tools in this selection process. The goal of the analysis was to establish a current approach to historic preservation across Southeast Asia, how this came about, and what roles tools played in supporting that approach.

In order to attain this goal, three shophouse building case studies were selected and a series of surveys were conducted. The case studies provided in-depth information on three current situations. The surveys demonstrated the representativeness of these cases for a larger sample of current early shophouse buildings.

The development of an approach for well-founded selection of ecological design in lighting and ventilation had a goal to improve the current way of selecting these ecological approaches. Requirements and constraints for making well-founded choices have been identified and used to assess existing practices for making design decisions. An approach for performance-based selection of ecological issues has then been developed, using applicable elements from existing practices or examples to define the essential steps. The viability of the resulting approach has been demonstrated through the application of the approach to an example.

The prototype development demonstrates how the proposed framework for a selection procedure and for support environments leads to better integration of design and simulation, and thereby shows the viability of these ideas to support the selection of ecological issues.

10.2. The research objectives

In the first chapter of this thesis, the major research problem of this research was developed: *'to evaluate the retention of traditional shophouse courtyards in Taiwan, with a focus on the preservation of continuity rather than the preservation of the past'*. To address this question, three major objectives from the outcomes of this research were identified and divided into five segments for the present study. In this research, each segment will be considered in turn, to provide the principle conclusions from the research.

To review and identify the spatial and physical characteristics of traditional shophouses ***(Refer to Aim I, Chapter 3)***.

Through literature analysis and review, it has been established that Taiwanese shophouses are based on a vernacular architectural building type that originates from local needs and construction materials as well as reflects local traditions. In terms of the forms of historic urban settlement, traditional shophouses only exist in Taiwan's historic districts, but they are present throughout the cities of Peninsular Malaysia. It is the linear space and plane grid that differs across these locations.

There are two apparent features with strong sustainability aspects that can be identified: one is that the traditional Southeast Asian shophouse has details that help cool the house and ensure ventilation, like overhanging eaves, jack roofs, and courtyards; another is that its covered five-foot-ways make walking and browsing more pleasant despite the intense sun and intermittent heavy rain, again contributing to walkability and efficiency in all types of weather.

From the appearance of view, it is amazing how the originality of the shophouses in terms of architectural aspects still remains, although minor renovations have been made to ensure that the building typology continues to suit present times. It is important to know that these shophouses can be used for adaptive reuse by injecting new trades or new forms of living without having to disturb the structure and the outlook of the shophouse, although modern technology has made construction and living more comfortable and aesthetic. Such effort can be seen in some of the shophouses in Malacca; George Town in Penang, and Chinatown in Singapore, where the interior of the shophouse had been designed for an upbeat economy and modern living lifestyle whilst still retaining the original façade and main structures.

There is much scope here for updatability. A low rise form like the shophouse, in contrast to all high-rise forms, has the unsurpassable advantage of each unit having its own roof and courtyard. There is much potential here for capturing rainwater and groundwater, reprising the earliest shophouses wells in their courtyards; sunlight for gardens, natural light, and photovoltaic energy; and fresh air. This could be important if the form is to be adapted to other locales in the tropics where water and power distribution systems are non-existent, insufficient, or leaky.

For ecological design, we have learnt that beyond some of the shophouse's various elements that can be borrowed for a sustainable tropical architecture, its basic concept is worthy of inventory, as generations have proven it to be conducive to an urban lifestyle and source of livelihood, while existing buildings are still highly coveted, lovingly restored, and used. Architecture, after all, aims to enable life to be lived to its fullest and most comfortable, and any form which has proven itself and still makes little demand on environmental resources deserves our careful attention.

To understand occupants' perceptions of comfort and environmental conditions in shophouses and their courtyards ***(Refer to Aim II, Chapter 5)***.

The way people live in these shophouses must continue to change in the future. From the examples of successful reuse in Southeast Asia, refurbished shophouses once again are able to play a central role in the lifestyle of local people as well as in tourism promotion. Eventually, the traditional shophouses can only continue to survive, which can be perceived as an attractive and successful shopping mall.

In Northern Taiwan, the majority of shophouse occupants have been found to appear reasonably satisfied with their living conditions in traditional shophouses, but also wish to make changes in the near future. In general, they are worried about the context in which their quality of life has become worse over the past few years.

From the interviews, a large number of the original owners have been found to have moved out of the shophouses, where they now only work and live during the daytime, but live with their families elsewhere during the night-time. People have changed their viewpoints and perception of the values of traditional shophouses. This resulting crisis is a main mechanism to attract the community forward to convert shophouse buildings into modern urban housing. Here in historic districts of Taiwan, a balance between development and conservation has yet to be found; there is still no inventory of shophouse buildings, let along regulation or zoning to protect them. Consequently, the future for the island's few surviving traditional shophouses looks very bleak indeed. Looking at the analysis, it is apparent that one of the business types, *leisure services*, is most suited to the continued reuse of traditional shophouses. This could indicate that it might be the best business type to survive in an old street or historic town centre.

The overall finding is that in the current situation, courtyards do not typically play an important role in the re-development of traditional shophouses, while modern and powerful mechanical facilities are widely employed to provide comfort. Hence, there is a need to improve both the selection procedure for ecological strategies to promote comfort as well as the tools that support that selection.

To evaluate visitors' attitude towards the retention of inner courtyards ***(Refer to Aim II, Chapter 5)****.*

A number of other surveys were conducted in the Malay Peninsula, located in Southeast Asia, the majority of respondents of which were international visitors, providing a basis for an understanding of attitude in the area towards traditional shophouses and historic districts. The findings from these surveys provided a useful context when comparing with the related findings from Northern Taiwan. Throughout the study, the two locations, the Malay Peninsula and Northern Taiwan, were linked together for discussion; especially in the three shophouse case studies.

It was found that the intention to travel was highly influenced by the traditional shophouse image and especially the perception of a comfortable streetscape. In this context, potential travellers, when faced with access to the inner courtyards, were typically happy to see that they could enjoy some different open spaces within such dense building blocks. In comparison, the need to do so in Northern Taiwan was less necessary than in Southeast Asia.

It was found that the respondents had interesting views on the future developments of the old streets, especially from the responses from the international travellers in Southeast Asia. These could be categorized into the following eight major responses.

Three of these responses appeared only in Southeast Asia:

1) avoid sightseeing pollution,
2) retain the cultural characteristics of this area, and
3) take advantage of public facilities and traffic management.

For shophouses accessibility and cultural issues, Southeast Asia is one of the areas of high cultural mix, so that these travellers are likely to pay more attention to the existence of one’s culture. Most visited and attractive shophouses are located in different sizes of building blocks. Thus, these responses were concerned with the points for urban management.

Other types of responses were focused on the building itself, such as:

4) need for renovation,
5) shophouse future must not be compromised to modern things,
6) hope to change inappropriate commercial spaces,
7) change usage for tourism, and
8) increase local activities to attract crowds.

The overall attitudes toward historic districts demonstrated that visitors were very interested in and hoped for the maintenance of tradition, and the improvement of the urban environments.

To establish a theoretical empirical understanding of the environmental performance of shophouse courtyards ***(Refer to Aim I, Chapters 7and 8)***.

Southeast Asia is typically warm, even hot, throughout the year, and in the subtropical region of Taiwan there are only about three months (from December to February) included in the winter period. Thus, it was decided to focus the simulation undertaken here and the associated discussion on summer data. After all, this is the period for which results represent the most significant climatic challenge faced by occupants of shophouses in term of their comfort: associated with lighting / solar gain control and ventilation or air flow.

However, to recall this simple form of shophouse, it appeared in different areas during the same period, informing the selection of the three shophouse case study buildings, located in: Northern Taiwan (1-storey), Penang (2-storey), and Singapore (3-storey). Although the climate of the three locations is not the same, many aspects are common, such as: cultural backgrounds, including similar ways of thinking of ideas; use of spaces; business types; as well as the concept of preservation.

In relation to natural lighting, daylighting systems are seen to provide three major functions:

1) solar shading,
2) protection from glare, and
3) redirection of daylight.

Although fixed systems, such as deep overhangs, sun shades, horizontal blinds, and balconies are useful for solar shading (Section 3.3), they do not control glare; therefore, another system that controls glare needs to be added to make these design solutions work. Although the fundamental design concept of the integrating of courtyards within shophouses was beneficial in terms of daylight performance, a designer can reach an optimum form and size of the courtyard when considering a sun path diagram or the location where the house will be built. An intensive analysis of the sun radiation penetration can considerably enhance the daylight performance within the building enclosure and, at the same time, control the total energy consumed by the structure. As a result, thermal comfort can be enhanced and economic cost cut down.

In computational fluid dynamics simulation, using the DesignBuilder CFD, the effect of the overall airflow pattern was examined in the context of different schedules for open and closed doors and/or windows: where in both cases, of course, any building openings were conducive to the overall air circulation. However, the schedules of closed or open doors/windows were not the main factor, which were rather the profiles of traditional buildings. The traditional shophouses have sloping roofs buildings that can generate wind shadow where wind is forced over buildings. The negative pressure behind pitched roofs and differential heights in buildings can draw air from the free-running zone to the courtyard ground plan. This was consistent with Givoni's (1969) argument and suggestion (please refer to Section 2.1.3). Moreover, in comparison to three different heights of the courtyard, at least two storeys of height can be slightly adjusted to control the wind speed.

Therefore, the traditional shophouse courtyard was found to be potentially effective in its role for the introduction of natural lighting and ventilation.

To establish and evaluate design strategies that provide remedial responses to occupant and empirical understanding of shophouse performance in order to provide strategies for environmental enhancement of their courtyards and adjacent spaces ***(Refer to Aim III, Chapter 9)***.

A procedure for the selection of ecological issues has been developed through a synthesis of existing knowledge from different sustainable domains together with findings from the work undertaken in this thesis, resulting in a performance-based approach for the selection of these issues. This proposed design process, presents an approach that rationalizes the selection procedure for appropriate solutions, and makes the role of subjective assessment explicit. Since it is based on performance prediction, it provides an optimal context for the appropriate use of computational tools.

In current traditional shophouse renovation projects, most powerful modern facilities are selected based on inappropriate functional space use. It appears that there is a lack of ecological thinking in relation to lighting and ventilation that ultimately might result in the long term in the total disappearance of traditional shophouses. A prototype Solar Shading Device has been developed that demonstrates the feasibility of better integration of shophouse building design process through the use of a layered process-centric approach. Though still limited in scope, this prototype illustrates that the approach is supported effectively by computational modelling, promoting the selection of ecologically appropriate solutions.

This study aimed to develop an approach for better solution to the main problem of solving the issues associated with intensive sunlight ingress into the courtyards, causing discomfort, thermally and in terms of glare, without hindering the secondary original function of promoting natural ventilation. Thus, the resulting work focused on the performance-based selection of solutions to control daylighting while promoting beneficial ventilation.

In response to the main aim: *'to evaluate the retention of traditional shophouse courtyards in Taiwan, with a focus on the preservation of continuity rather than the preservation of the past'*.

The main goal of this research has been achieved, where the proposed prototype illustrates how the proposed design process can be employed as an interface between the building re-design process and the computational analysis of the performance of traditional shophouses in order to inform decisions that enable continued and comfortable occupation of this building typology. However, it must be noted that the introduction of fully functional workbenches in vernacular architecture design practice still requires a lot of research and development efforts.

As discussed above, the Taiwanese Old Streets or Southeast Asian Old Towns are rich in their humanities resources and comfortable streetscapes. These are combined with an extensive heritage of cultural and traditional shophouse buildings. This has resulted in a unique and diverse tourism image that characterizes 'Shophouses Cities', such as those considered in this thesis: Singapore, Penang, and cities in Taiwan.

Traditionally, tourism to cultural and historic sites, such as old streets or towns, dominated the tourists' motivations to travel. However, after the 1960s, this was replaced by recreational, relaxation, and water-based activities as the primary motivation for tourism. This reflects the importance of protecting cultural environments to ensure the continuous attraction of tourists and the realization of sustainable economic benefits from tourism. Therefore, a prerequisite is to realize a balance between acquiring economic benefits from tourism whilst maintaining and even achieving considerable environmental performance improvements. It is however, important to understand that the two facets are compatible, at least in theory:

Retention of Courtyards	>>	*Traditional & Sustainable Shophouses*	>>	*Economic Benefits*
Degradation of Courtyards	>>	*Traditional Shophouses Failure*	>>	*Economic Losses*

Where the degradation of courtyards is perceived to have been initiated by a cycle where the loss of physical resources may be followed by the continuous disintegration of the shophouses and their context, the streets, and the wider historical neighbourhood of the city. Where the overall degradation of courtyards along the old streets has been found, not only to affect the surrounding spaces and immediate contexts, but could also have significant impacts on the surrounding areas. Therefore, it is necessary to identify that tourism development along the old streets could be positively impacted by the retention of courtyards.

Drawing on previous critical shophouse courtyard studies, this thesis set out the complex process of construction involved in ecologization, analysing the way in which physical narratives are shaped in certain social, economic, and tourism contexts. Incorporating concepts central to specific history, this process was viewed in the light of the dynamic relationship between past, present, and future. This central concern was then evaluated through literature review, drawing out the implications of the interaction of different facets or layers of heritage shophouses in relation to inner courtyards. Combining these approaches highlighted the construction of physical and temporal distance involved in ecologization, which linked the more practical process of the transition to inner courtyards at the three case studies with more theoretical concerns regarding how meaning is made from the past in the present, and/or from the past for the future.

Three main conclusions from this research are suggested as evidence of an original contribution to knowledge:

1. Firstly, it has been established that the concept of 'ecological design' of traditional shophouses in the historic district informs a stronger analytical and management tool to inform and direct the future of urban re-development in this context.
2. Secondly, it has been shown that an understanding of both occupants' and visitors' perceptions of the potential positive impact of tourism in historic settlements or streets, such as achieved in this study, provides empirical evidence that can contribute a new dimension to definitional debates: for example, informing an understanding of what is meant by 'heritage' in the context of shophouses and what does this might mean both now and in the future.
3. Thirdly, this study has taken forward the typology of traditional shophouses as developed by the three case studies, using empirical data to show what different occupants feel about the relative importance of different aspects of inner courtyards.

10.3. Next steps and suggestions

As suggested previously, there is always a limited extent to which we can generalize from case study research. However, as this study argued, rather than uncritically interpreting concepts like courtyards, this work needed to be situated in particular contexts in order to enable more rigorous analysis. By drawing on three different shophouse case studies, this thesis has provided an empirical basis for some wide-ranging conceptual questions. From this research, it is possible to draw some broader theoretical conclusions as well as further questions, which have implications across a range of disciplines; public attitudes versus occupants' perceptions, domestic buildings versus urban development, and physical environmental studies (lighting versus ventilation). Through the thesis, it has been suggested that there are closely related fields of inquiry which would benefit from greater cohesion in order to draw out the relationship between courtyards and traditional shophouses in broad terms.

The lack of concern in the field of temporal affairs in general is a major problem of Taiwan's heritage management. Moreover, traditional and temporal shophouses research targeting inner courtyards is yet to be conducted by various scholars. In this context, this thesis is amongst the macroscopic and is a rare study in the field. It has also brought up some fundamental ideas of further research opportunities, described below, to be considered by those who are interested in inner courtyards promotion between Southern Mainland China and Southeast Asia:

This thesis has taken a limited view of decision-making in shophouse buildings re-design, only discussing the selection of ecological issues, and only assessing one exemplary tool for the limited cases. However, further studies to establish the match and mismatch between the analysis requirements, such as environmental comforts, from a novel heritage building design perspective as well as integrating the capabilities of the existing tools are now necessary.

Continuation from the above restrictions, most of the environmental analysis works undertaken here are independent of each other, such as the lighting, ventilation, thermal, and acoustic. All analyses and discussions are presented to an extent in isolation. However, the environmental experience of any kind of space is a mixture of all of these physical properties. Thus, for the example in courtyard analysis again, further studies on how to connect the modelling results of lighting and ventilation, by using cross-tabulation analysis and under the criteria of the language concept of space (light well versus air well, refer to Section 2.1.2) might be very interesting.

In this thesis, the use of building performance prediction by computational tools in the re-design process has been described without the consideration of uncertainties. Yet, it remains unclear how the combination of uncertainty in the building design itself and in the performance of lighting and ventilation can play a role. Further research to define these borders for the use of computational tools is urgently needed.

Regarding crossroads of process management, prototype modelling, and use of tools that can be used in different stages of one and the same design process seems challenging. However, due to the interrelation of different performance aspects, this probably is a difficult issue.

10.4. Personal reflections

My personal perspective on carrying out this research has given me some good insights into the research process and the circumstances in which I have worked.

The things I have learnt and touched me the most were through the hands-on and practical experience of conducting the questionnaire surveys over a period of about two years. This has given me many insights into the real problems, as compared to the purely academic studies, though both are highly interdependent. The opportunity to select a long shophouse in Taiwan as a case study led me to experience the journey both as a researcher and as an occupant. I could engage with local activities and events and I often felt part of an inclusive community; this was a great benefit for a researcher working alone.

When I began this study, I was happy if I saw the courtyards were covered, which was always wanted to bring about improvements such as lighting and ventilation. As a matter of fact, the problem was not a single physical factor, but a change in lifestyle. When the external society and material world were changing, there was no reason to ask the residents to maintain their old ways of life. And thus, they used their own ways to change to meet their own needs. Therefore, I fully felt the feeling of helplessness.

However, since the change is inevitable, I wonder if there is a way out. Again, my architectural training pushed me to the idea of design: the essence of the courtyard is to solve the building's natural lighting and ventilation needs, and thus to produce an Ecological Design application in the rebirth of traditional shophouses.

On the other hand, although today's Taiwanese old streets are no longer an important business district, its cultural assets can still attract a large number of tourists. From this point of view, the collection of visitors' attitudes toward shophouses became the issue of cultural heritage tourism. There is not only the possibility to develop a cultural tourism market, but also a high potential to attract moral/cultural tourists to traditional shophouses, at least in theory.

As long as the courtyard still exists, it is still a traditional shophouse.

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Appendix A: Urban Shophouses Spatial Use Survey (Pilot Survey)

Cardiff University Research Project
URBAN SHOPHOUSES SPATIAL USE SURVEY

This is a survey for concerning urban shophouses spatial use issues in your dwelling for Cardiff University Research Project on *Ecological Design of Lighting and Ventilation in Traditional Shophouses*. The information gathered will be used to identify spatial use pattern, and problems in order to suggest ways that visual and thermal comfort could be improved in future. While the general conclusions of the study may be used to help formulate government policy recommendations, all the specific information you provide will be treated confidentially. We hope that you will be willing to help us with this study.

1. How many stories are there in the dwelling? ❑One ❑Two ❑Three ❑More than three
2. What is the type of shophouse ownership? ❑Public ❑Private ❑Rent ❑Others (please specify)
3. In what year was the building constructed? ❑pre 1770 ❑1771-1830 ❑1831-1890 ❑1891-1950
4. Does the building in heritage listing? ❑Yes ❑No ❑Others (please specify)
5. Originally, how many courtyards do you have? ❑Yes (please specify) ❑No
6. What are the important reasons for you appreciating the courtyards? (please check all that apply)
   - ❑Daylight introduction
   - ❑Fresh air ventilation
   - ❑Gardening to have good atmosphere
   - ❑Others ____________________
7. What are the important reasons for you enclosing the courtyard? (please check all that apply)
   - ❑Get strong sunlight on wall
   - ❑Get strong wind on windows and doors
   - ❑Water leakage at the connection
   - ❑Too much noise and dust from streets
   - ❑Differential settlement of home structure
   - ❑Floors and stairs slippery when raining
   - ❑Too open to prevent robbery
   - ❑Mosquitoes flying in easily
   - ❑Increase space for multiple usage
   - ❑Enlarge the shop Section
   - ❑More rooms for living
   - ❑Others ____________________
8. Would you tell us how satisfied or dissatisfied you are with the following aspects of your shophouse?

	Very Dissatisfied	*Neutral*	*Very Satisfied*
1. Personal appreciation of old shophouse			
2. Expression of Chinese art and cultural			
3. Location of shophouse in district area			
4. Working atmosphere in shop section			
5. Living atmosphere in main courtyard			
6. Functional efficiency of space in main courtyard			
7. Consideration of personal safety and security			

9. Over the past year, do you think the quality of life in the Shophouse has become...?
   ❑Become better ❑Stayed the same ❑Become worse ❑Not applicable
10. How would you rate the Shophouse as a place to live, compared to other living types in the nation?
   ❑Much better ❑Fair ❑Much worse ❑Not applicable
11. Does your current shophouse meet your particular living needs?
   ❑Mostly meets needs ❑Somewhat ❑Not at all ❑Not applicable
12. What would you consider the overall condition of the building to be?
   ❑Good ❑Fair ❑Poor ❑Not applicable
13. What do you think is the single most attractive feature of the Shophouse today?
14. Would you like to change anything about your courtyards?
15. What do you think is the single most important problem facing the Shophouse today?
16. In your opinion, what is the best solution to this problem?
17. What are the things you like least about in shophouse living?
18. What gender are you? ❑Male ❑Female
19. Including you, how many household members are in each of these age group?
   ❑___ under 18 ❑___ 18 to 39 ❑___ 40 to 64 ❑___ 65 and over

Thanks for your help. If you'd like to be kept informed about the progress of this project, you can provide your contact information here. If you do not wish to identify yourself – there is no need to do so. In either case, we will not publicly identify you or your opinions and will use your information exclusively to inform this research project. For questions or further information about the research project, about the questionnaire, or on other issues connected with this survey, please feel free to contact me.

傳統店屋之使用與維護研究調查

Cardiff University Research Project
URBAN SHOPHOUSES SPATIAL USE SURVEY

此份住戶問卷針對「傳統店屋之使用與維護研究」相關研究所需之使用者問卷。希望能借重您的生活經驗，以提供對街屋生活的空間評價模式建構之相關因素進行評估與篩選。本研究極需　您的寶貴意見與協助，敬請能於百忙之中撥冗惠賜卓見。填寫內容僅供本研究學術使用，絕不挪移他用。衷心感謝！敬祝　萬事如意

1. 本棟店屋共有多少個樓層？ ❑一層 ❑兩層 ❑三層 ❑三層以上
2. 本棟店屋的持有狀況？ ❑公有財產 ❑私有財產 ❑承租 ❑其他
3. 本棟店屋建於何年？ ❑ 1770 以前 ❑ 1771-1830 ❑ 1831-1890 ❑ 1891-1950
4. 本棟店屋有被列入「古蹟」保護？ ❑有 ❑沒有 ❑其他
5. 本棟店屋原有多少的中庭空間？ ❑有( ) ❑沒有
6. 請說明您個人「重視」庭園的因素？（可複選作答）
   - ❑ 充足的日光　❑ 新鮮對流的空氣
   - ❑ 綠美化　❑ 其他
7. 請說明「圍封」庭園的因素？（可複選作答）
   - ❑ 陽光過烈　❑ 有太強的風勢
   - ❑ 牆上有漏水現象　❑ 有太多的噪音與灰塵
   - ❑ 建築物結構的差異　❑ 雨後會路滑
   - ❑ 太開放以致難於防盜　❑ 蚊蟲易於入侵
   - ❑ 改成多用途的空間　❑ 擴大營業空間
   - ❑ 增加房間　❑ 其他
8. 請填入或圈選您個人對以下各項目之滿意度。

	非常不滿	不滿意	普通	滿意	非常滿意
1. 個人對傳統店屋的評價					
2. 傳統藝術與文化的接受度					
3. 本棟店屋的區位關係					
4. 店舖區域的工作氣氛					
5. 中庭或庭園的生活氣氛					
6. 中庭或庭園的使用功能					
7. 個人安全上的考慮					

9. 經過這些年以來，請談談店屋的「改變」情形？
   ❑變的更好 ❑維持現況 ❑變的更差 ❑無法回答
10. 在比較其他的住屋類型下，請說明您對「店屋」的看法？
   ❑相當好的住家 ❑一般性的住家 ❑相當不好的住家 ❑無法回答
11. 本棟店屋是否「滿足」您的特定生活需求？
   ❑大部分是有的 ❑有一些吧 ❑完全沒有 ❑無法回答
12. 您認為本棟店屋的整體現況大致如何？ ❑良好 ❑一般 ❑很差 ❑無法回答
13. 就您認為店屋的「最吸引人」之處？
14. 您是否計畫對中庭空間作任何的「改變」？
15. 就您認為店屋所「面對的問題」為何？
16. 就您的看法，其問題的「最佳解決」之方法為何？
17. 就生活在店屋中，可否提出幾件值得一說的事情？
18. 您的性別： ❑男 ❑女
19. 本棟店屋的成員與年齡分布： ❑ __ 18 以下 ❑ __ 18 to 39 ❑ __ 40 to 64 ❑ __ 65 以上

【本問卷到此全部結束，再次非常感謝您的撥冗作答】

Appendix B: Urban Shophouses Spatial Use Survey

CARDIFF UNIVERSITY RESEARCH PROJECT

Urban Shophouses Spatial Use Survey

傳統店屋的空間使用與維護調查

April 2010

Questionnaire:

[Part A] 生活天井 **Your Living Courtyards**

[Part B] 生活觀感 **How Do You Feel … …**

[Part C] 經驗與看法 **How Do You Think … …**

==

This is a survey concerning urban shophouses and spatial use issues in your dwelling. This work is being undertaken as part of a PhD Research Project at Cardiff University on Ecological Design of Lighting and Ventilation in Traditional Shophouses. The information gathered will be used to identify spatial use patterns and problems in order to suggest ways that visual and thermal comfort could be improved in the future. All the specific information you provide will be treated confidentially. We hope that you will be willing to help us with this study.

親愛的店家： 您好！

此份住戶問卷是針對「傳統店屋之使用與維護研究」相關研究所需之使用者問卷。希望能借重 您個人的生活經驗，以提供對生活在店屋的空間評價模式建構之相關因素進行評估與篩選。本研究極需 您的寶貴意見與協助，敬請能於百忙之中撥冗惠賜卓見。填寫內容僅供本研究學術使用，絕不挪移他用。衷心感謝！敬祝

萬事如意

==

ID Number:

Date of Survey:

Interviewer: [SFLi]

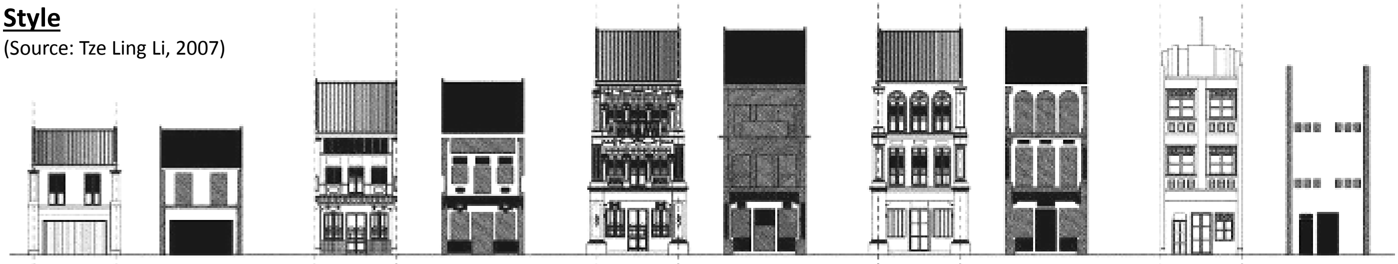
Mode: [face-to-face]

Location: [Penang] [Malacca] [Singapore]

[Taiwan]

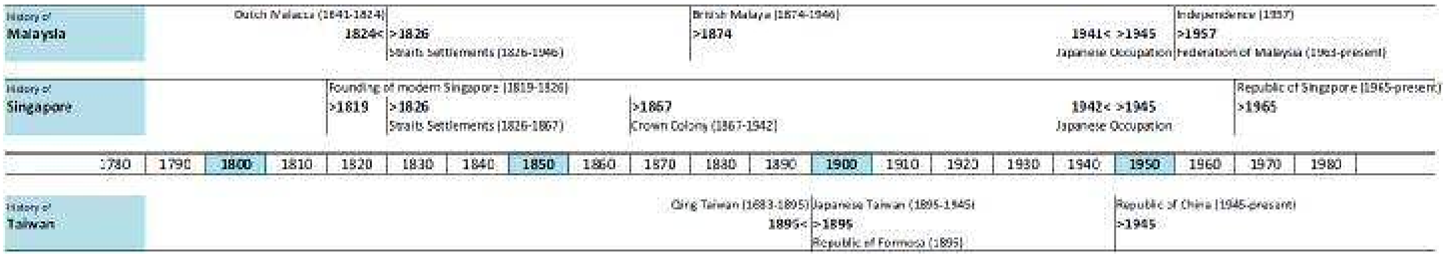
Style

(Source: Tze Ling Li, 2007)



[Classical] [1st Transitional] [Chinese Baroque] [2nd Transitional] [Art Deco]

Year Constructed



Visual Check

Shop Section (Open) (Closed)

First Courtyard (Open) (Covered)

Other Courtyards ____________

Functions __________________

Modifications _______________

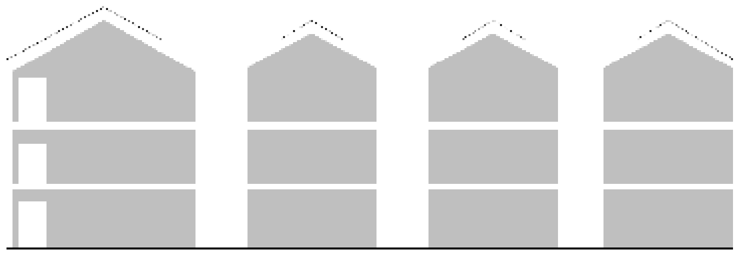
Additions __________________

Structural Conditions
(Fair) (Good) (Poor) (Derelict)

Building Facts

Ownership Type (Owner Occupier) (Occupier)

Heritage Listing (No) (Yes ____________________)



Typology Drawing

Part A — Your Living Courtyards 生活天井

A1. What things do you like most about the existing courtyard? (please check all that apply) **就天井之用途，那些事項是您所欣賞的...(可複選)**

Daylight introduction 引進日光

Fresh air ventilation 自然通風

Gardening for good atmosphere 園藝景觀

Storage space 儲藏空間

Others 其他 ____

A2. What were your main reasons for covering the existing courtyard? (please check all that apply)
請問您想將天井加以覆蓋的原因有... (可複選)

Get strong sunlight on wall 強烈的陽光

Get strong wind on windows and doors 易造成強風

Increase space for multiple uses 擴增室內空間

Water leakage at the connection 漏水問題

Floors and stairs slippery when raining 雨後濕滑

Others 其他 ____

A3. Would you like to change anything about the Courtyard? 在將來，請問您是否要對天井的區域進行變更...

A3

A4. Would you tell us how satisfied you are with the following aspects of your shophouse?

請圈選以下有關在店屋生活中之個人滿意度 ... ...

A4	Very Dissatisfied 非常不滿				Very Satisfied 非常滿意
(1) Personal preference towards old shophouses 個人對傳統店屋的評價	+	+	+	+	+
(2) Expression of Chinese art and culture 中國藝術與文化的接受度	+	+	+	+	+
(3) Location of shophouse in district area 本棟店屋的區位關係	+	+	+	+	+
(4) Working atmosphere in shop section 對外營業區域的工作氣氛	+	+	+	+	+
(5) Living conditions in main courtyard 中庭或天井的生活氣氛	+	+	+	+	+
(6) Functional efficiency of space in main courtyard 中庭或天井的使用功能	+	+	+	+	+

Part B 感觀生活 How Do You Feel ... ...

B1. Is there an overall lighting mood or feeling you want to set within the courtyard? ... ... What?

在天井空間中，是否需要特別的照明氣氛...

B1

B2. Are there particular spaces that should have a specific lighting mood? ... ... Where?

就照明氣氛與設計，有那些空間是特別需要的...

B2

B3. Do you prefer a particular style of lighting? (e.g.: direct or indirect, wall-lights or table-lights, etc.)

對照明型式的偏好，如直接或間接光源、壁上或桌上照明等...

B3

B4. For air circulation in summer time, do you prefer windows, a fan or air conditioning?

就通風的要求與方式，那些類型(窗戶、風扇、空調)是您所偏好的...

B4

B5. How about the indoor climate of the shophouse? What is it like in summer and winter?

在冷熱天的差別下，
請描述在店屋內的氣候狀況或感受 ... ...

B5	Summer 夏季: Too Cold 太寒冷				Too Hot 太悶熱	Winter 冬季: Too Cold 太寒冷				Too Hot 太悶熱
AM 午前	+	+	+	+	+	+	+	+	+	+
PM 午後	+	+	+	+	+	+	+	+	+	+
Evening 晚間	+	+	+	+	+	+	+	+	+	+
Night 入眠	+	+	+	+	+	+	+	+	+	+

Part C 經驗與看法 How Do You Think … …

C1. Has the quality of life in the shophouse changed over the past year? 這些年來的生活品質是否有所改變...

Yes (If it has changed, has it become…?) 有的…

- Better 變得更好
- Stayed the Same 維持現狀
- Become Worse 變的更差
- Not Applicable 無法作答

No 沒有

C2. How would you rate your shophouse as a place to live, compared to other types of homes in the nation?
相較於其他類型的住居環境，傳統的店屋是...

- Much Better 比較好的
- Fair 都差不多
- Much Worse 比較差的
- Not Applicable 無法作答

C3. What would you consider the overall structural condition of your shophouse to be?
目前的建築物，其整體的結構狀況是...

- Good 良好的
- Fair 一般性的
- Poor 破舊的
- Not Applicable 無法作答

C4. Does your current shophouse meet your particular living needs? 目前的店屋，是否都能夠符合您的生活需求...

	Day Time 日間	Evening 晚間	Night Time 入眠
(1) Mostly Meets Needs 大部分有符合需求			
(2) Somewhat 有某一些吧			
(3) No Longer Meets Needs 都不符合需求			
(4) Not Applicable 無法作答			

C5. What do you think is the single most important problem shophouses face today?
依閣下的看法，傳統店屋正面臨何種問題...

C5

C6. In your opinion, what is the best solution to this problem? 再依閣下的看法，是否能有最佳的解決方式...

C6

C7. What is the thing you like least in living in a shophouse? 最後在店屋的生活上，有那些事項是值得一提的

C7

Thanks for your help. If you'd like to be kept informed about the progress of this project, you can provide your contact information here:

Name: Mailing Address:
Phone: Email:

<u>**If you do not wish to identify yourself – there is no need to do so.**</u>
In either case, we will not publicly identify you or your opinions and will use your information exclusively to inform this research project. For questions or further information about the research project, about the questionnaire, or on other issues connected with this survey, please feel free to contact:

本問卷到此全部結束，再次非常感謝您的撥冗作答

閣下如有意知悉本研究案之後續發展，請在上方填入通訊方式，或直接聯絡本人： 李少甫（專任講師）
地址：台灣新竹市五福路二段 707 號
中華大學建築與都市計畫學系

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Email: LiS15@cardiff.ac.uk

B1

Is there an overall lighting mood or feeling you want to set within the courtyard? … … What?

在天井空間中，是否需要特別的照明氣氛。

Hard Light 硬光

Soft Light 柔光

Hard Lighting	Soft Lighting	Combined Lighting	Don't Care …
硬光照明	柔光照明	混光照明	並不在意
☐	☐	☐	☐

B2

Are there particular spaces that should have a specific lighting mood? … … Where?

就照明氣氛與設計，有那些空間是特別需要的。

Conventional Lighting 通用式照明

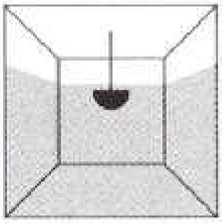
Mood Lighting 計劃式照明

Zone 區域	Conventional Lighting 通用式照明 … Mood Lighting 計劃式照明	WHY 原因
Shopping Sections 店鋪區域	+ - - - - - + - - - - - + - - - - - + - - - - - +	
Courtyards 天井	+ - - - - - + - - - - - + - - - - - + - - - - - +	
Living and Dining 起居空間	+ - - - - - + - - - - - + - - - - - + - - - - - +	
Kitchen and Toilet 餐廚與衛浴	+ - - - - - + - - - - - + - - - - - + - - - - - +	
Bedrooms 臥室	+ - - - - - + - - - - - + - - - - - + - - - - - +	
Other 其他	+ - - - - - + - - - - - + - - - - - + - - - - - +	

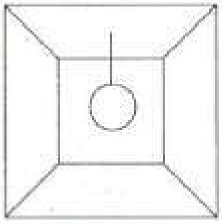
B3

Do you prefer a particular style of lighting?
(e.g.: direct or indirect, wall-lights or table-lights, etc.) 對照明型式的偏好，如直接或間接光源、壁上或桌上照明等。

Direct
直接照明



Indirect
間接照明



General Diffused
全般擴散

Direct Lighting 直接照明	Indirect Lighting 間接照明	General Diffused 全般擴散照明	Don't Care ... 並不在意
☐	☐	☐	☐

B4

For air circulation in summer time, do you prefer windows, a fan, or air conditioning? 就通風的要求與方式，那些類型是您所偏好的。

(North Bridge Road, Singapore)
Windows 窗戶

(Au Parc, Ho Chi Minh City)
Fan 風扇

(Haji Lane, Singapore)
Air Conditioning 空調

	Windows 窗戶	Fan 風扇	Air Conditioning 空調
AM 午前			
PM 午後			
Evening 晚間			
Night 入睡			

B5

How about the indoor climate of the shophouse? What is it like in the Summer and Winter?

在冷熱天的差別下，請描述在店屋內的氣候狀況或感受。

(George Town, Penang)

	Summer 夏季	Winter 冬季
	Too Cold 太寒冷 … Too Hot 太悶熱	Too Cold 太寒冷 … Too Hot 太悶熱
AM 午前	+ - - - - - + - - - - - + - - - - - + - - - - - +	+ - - - - - + - - - - - + - - - - - + - - - - - +
PM 午後	+ - - - - - + - - - - - + - - - - - + - - - - - +	+ - - - - - + - - - - - + - - - - - + - - - - - +
Evening 晚間	+ - - - - - + - - - - - + - - - - - + - - - - - +	+ - - - - - + - - - - - + - - - - - + - - - - - +
Night 入眠	+ - - - - - + - - - - - + - - - - - + - - - - - +	+ - - - - - + - - - - - + - - - - - + - - - - - +

Appendix C: On-Street Visitor Survey

Cardiff University Research Project

ON-STREET VISITOR SURVEY

歷史街區之空間認知訪查

此份遊客問卷針對「歷史街區之空間認知」相關研究所需之街頭問卷。希望能借重您的旅遊經驗，以提供對此舊城區傳統建築空間評價之公眾意見。本研究極需您的寶貴意見與協助，敬請能於百忙之中撥冗惠賜卓見。填寫內容僅供本研究學術使用，絕不挪移他用。衷心感謝！敬祝 萬事如意

This is a survey concerning urban shophouses spatial use issues in Historical Streetscape for a Cardiff University Research Project on Ecological Design of Lighting and Ventilation in Traditional Shophouses. The information gathered will be used to identify spatial use patterns, and problems, in order to suggest ways that visual and thermal comfort could be improved in future. All the specific information you provide will be treated confidentially. We hope that you will be willing to help us with this study. *April 2010*

Q1. Based on your experience as a 'VISITOR' at this historic street and traditional shophouse, how would you rate each of the following? 作為訪客，請圈選您個人對以下項目之接受程度... ...

		Very Dissatisfied 非常不悅 ... Very Satisfied 非常欣賞
(1) Expression of local art and culture	本地的民間藝文印象	+ - - - - - + - - - - - + - - - - - + - - - - - +
(2) Local foods and special goods	本地的飲食與特產	+ - - - - - + - - - - - + - - - - - + - - - - - +
(3) Integration of walkway into the surroundings	街區中的騎樓等步行空間	+ - - - - - + - - - - - + - - - - - + - - - - - +
(4) Quality of open courtyards	店屋內的天井或中庭空間	+ - - - - - + - - - - - + - - - - - + - - - - - +
(5) Quality of building façade and decorations	建築外觀樣式與裝飾	+ - - - - - + - - - - - + - - - - - + - - - - - +
(6) Personal appreciation of historical streetscape	個人對歷史街區的整體評價	+ - - - - - + - - - - - + - - - - - + - - - - - +

Q2. In your opinion what are the three most favourable elements of this historical street? (please tick 3 only) 請勾選出街區中三項較為「嘉許」的元素

- Building façade and decoration 建築外觀樣式與裝飾
- Covered walkway 騎樓等步行空間
- Inner courtyards 店屋內的天井或中庭
- Overall streetscape and skyline 整體街區的氛圍
- Shopping selection 購物環境
- Art and culture 藝術與文化
- History 歷史因數
- Other 其他 ________________________________

Q3. Your reason for coming to the historic streets? (please check all that apply) 請問你來舊街區的「原因」為何

- Business 經商或辦公
- Visiting 探訪親友
- Recreation 旅遊或休憩
- Atmosphere 整體環境的氛圍
- Shopping 純粹購物
- Cultural 藝文特色
- Eating and drinking 本地飲食
- Other 其他 ________________________________

Q4. Do you like these historic buildings? 請問你個人會「喜歡」街區中的「歷史建築」嗎?

Yes, because of (please check all that apply) **是的，因為**

- Historical characteristics 有舊時代的特色
- Combine several functions 仍然集合了多種功能
- Atmosphere in courtyards 天井的氛圍
- Environment in courtyards 天井的環境
- Other 其他 ______________________________

No, not at all. 全都不喜歡

Please specify 請簡要列舉 ______________________

Q5. Do you think that visitors should have access to inner courtyards? 請問您，天井對外開放的看法?

- Happy to see 樂觀其成
- Unnecessary 無此必要

Q6. How many times have you been here? 請問你來這一類歷史街區的「次數」...

- First time 第一次
- Regular 經常性
- Very few 甚少
- Daily 幾乎每天

Q7. Your gender? 您的性別...

- Male 男性
- Female 女性

Q8. Your age group? 您的年齡分布...

- under 18
- 40 to 64
- 18 to 39
- 65 and over

Q9. Your educational level? 您的教育程度...

- High school 中學
- Postgraduate 研究所以上
- University 大專
- Not Applicable 無法回答

Q10. Where do you come from? 請問您是來自... ...

City or Country 國家/地區

Q11. What activities and services would you like to see changed, added or improved? 就這類的歷史街區而言，請問您是否希望有任何的「改變」或「改進」?

Q11

Thank you for taking the time to complete this survey.
本問卷到此全部結束，再次非常感謝您的撥冗作答

Location:	ID Number:
	Date of Survey:

ON-STREET VISITORS SURVEY
歷史街區之空間認知訪查

台灣三峽老街 Sanxia, Taiwan

馬來西亞檳城 George Town, Penang

Appendix D: Poster for LoLo Energy Demand in Building Conference 2013