LEARNING FROM THE SINGAPORE SHOPHOUSE: TOWARDS A SUSTAINABLE TROPICAL ARCHITECTURE

By

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LIST OF ABBREVIATIONS

ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BCA	Building and Construction Authority of Singapore
LEED	Leadership in Energy and Environmental Design

Abstract of Thesis Presented to the Graduate School
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The need for a sustainable tropical architecture is highlighted and the Singapore shophouse is identified as an architectural heritage to be mined for solutions for such an architecture. As a vernacular form developed before the modern era of carefree use of energy, the shophouse offers lessons in achieving urban livability on a low resource budget. The shophouse is described and then the schemes of the Green Mark, New Urbanism, Leadership in Energy and Environmental Design (LEED) Neighborhood Development, and Pattern Language are brought in to evaluate elements of the shophouse that can be borrowed and applied in a new architecture. Various adaptations for modern needs are also explored.

The limitations of the shophouse and of this study are discussed. This sets the context for a program for further study, which starts with calibrations for functional specifications versus costs. An inventory of vernacular forms will then be built up within a framework of these two dimensions to serve as a library of possible solutions.

CHAPTER 1
INTRODUCTION

Large swaths of humanity live in the tropics and are urbanizing rapidly. This tropical urban population increased from 286 to 1,515 million between 1950 and 1990 and is expected to reach 4 billion by 2025 (figures include sub-tropical) (Gupta, 2002). It will be a fascinating process to watch, and comes with the enormous opportunity of reducing the carbon footprint of billions more people coming into modern urban living. In the tropics, achieving thermal comfort under the fierce sunshine which measures 1 kW/m^2 all year round (NASA Earth Observatory, n.d.) presents further challenges. A sustainable tropical architecture which minimizes ecological demands is urgently required.

To work towards sustainability, Singapore, a modern tropical city, had in 2008 incorporated the Green Mark (Building and Construction Authority, 2010) into its building code. The Green Mark is a scheme to rate and encourage green buildings. While the Green Mark award winners (Building and Construction Authority, 2011a; Building and Construction Authority, 2011b) show various modern ways of achieving a more sustainable tropical architecture, more ideas can be mined from Singapore's heritage of traditional shophouses.

Vernacular architecture has always embodied the accumulated wisdom of millennia of using local material in the most suitable and economical way to cater to the lifestyle and livelihood needs of people within local climatic conditions. It is not an unchanging style but a continuous evolution and adaptation as needs and conditions change. As Vellinga (2007) described it, "the dynamic and dialectic nature of vernacular traditions . . . change and adapt to the cultural and environmental circumstances and

challenges of not just the past, but of the present and future" (p. 117). This tradition, however, received a total disruptive break worldwide in the modern era, with the advent of industrial processes, new construction technologies, and materials, like steel which allows buildings to grow in height virtually without limit and resulting in a proliferation of skyscrapers, and abundant oil which allows carefree use of electricity for air-conditioning and motor transport for urban sprawl. Facing collision against ecological limits, it is now time to look back to the vernacular for solutions, as, having developed before the modern industrial age, it is by definition of low carbon footprint.

The archetypal Singapore shophouse (also commonly found elsewhere in Southeast Asia), as Davison and Tettoni (2010) described, "is a two- or three-storey building with shop premises on the ground floor and living accommodation above. The ground floor is set back a little from the road, while the upper storey, supported by a brace of columns, projects forward in line with the edge of the street to create a covered verandah in front of the shop. Shophouses were always conceived as being combined to form a terrace – a row of similar units built side by side with party walls making up one side of a street or city block. This being the case, the front verandah of every shophouse at street level is contiguous with its neighbor on either side, effectively creating a continuous covered walkway or colonnade in front of the shops along which passers-by may stroll, protected from both the sun and the rain" (p. 14). This covered walkway is known locally as the "five-foot way".

The Singapore shophouse dates back over a century and to a time before air-conditioning. It used at most a minimal amount of electricity for lighting, and later, for fans, and is well adapted to the climate. The earlier Chinese courtyard houses from

which they evolve date back to a time without electricity and embody millennia of accumulated wisdom that have been neglected by the post war half-century of carbon-powered modernization. Now is the time to mine this heritage, and the research question in this study is “What elements of the traditional Singapore shophouse can we borrow to support the development of a new sustainable tropical architecture?”

CHAPTER 2
LITERATURE REVIEW

There are four classes of literature we need to review. The first are those on the shophouse. If we want to borrow from the shophouse, we need to know more about it, including how it arose, and what problems they were designed to solve. Next are those on learning from vernacular forms, to build on the experience and insights of others who have tried to do the same thing. Third are those on the various schemes to achieve sustainability in architecture. As sustainability is our aim, these schemes will help us evaluate the shophouse and guide new adaptations. Fourth are those on the density aspects that will help us analyze one of the key characteristics of the shophouse.

Literature on the Shophouse

Ideal literature would be those that analyze traditional Singapore shophouses from a sustainability angle, but what this author can find are books and papers that approach from two other perspectives. The first study the shophouses from a cultural perspective, like Li (2007). The other study them from an architectural historic perspective, like Lee (1988), and Davison and Tettoni (2010).

Li (2007) said that Singapore has long absorbed imported influences, localized and adapted them since before colonization, and the process has never stopped. The shophouse was a manifestation of this. The prototypes were brought over by the immigrants from south China, and absorbed Malay and European details, most clearly seen in the shophouse façades, which are outward expressions of a community's ideals and aspirations, and Li proceeded to analyze the façades of shophouses in the Telok Ayer area.

He divided them into three main styles – “Early” built between the 1820s and 1900, “Chinese Baroque” built between 1900 and 1940, and “Art Deco” built between 1940 and 1960. The political stability of Singapore together with the chaos of the collapsing Qing dynasty had attracted Chinese immigrants such that by 1900, 164,000 Chinese had settled in colonial Singapore, making up 80% of the population. The first generation shophouses constructed then were executed by Chinese builders, and the style, materials and methods were heavily Chinese, with Chinese elements making up 51.3% of the area of the façades in his sample. Over the years, these were reduced to 28.2% and then 10.3% at the end of stylistic periods. Other styles grew slightly, but the façades mostly became plainer.

Lee (1988), *The Singapore House*, is an architectural history of the main housing types of early Singapore built between the years 1819 and 1942. Lee described the basic principles on which the immigrants built their shophouses were dictated by tradition – a progression of spaces with courtyards or airwells. The houses ranged from one or two airwells within a long and narrow site to a more complex but symmetrical arrangement of living and working areas around airwells, or courtyards on wider lots. The roof spanned the depth of the building in sections rather than the narrower width. The elaborate beam-and-bracket roof support system of the Chinese prototypes was rarely used. Instead, five-inch diameter purlins of Bintangore (Calophyllum) were fixed at three feet intervals to support roofs which were covered with the cheaper Malacca clay tiles instead of the imported Chinese tiles. The maximum purlin size of about 20 feet consequently limited the width of the building and in turn influenced the floor plan arrangement.

Davison and Tettoni (2010), *Singapore Shophouse*, is an architectural history of the Singapore shophouse and descriptions of several well-preserved shophouses in Singapore. Describing the narrow and deep plan of the shophouse, Davison and Tettoni gave the dimensions for the typical frontage as between 16 to 18 feet, and listed the average depth as around 80 feet, although some of the older houses could extend back twice as far. They further elaborated on the building structure. Each shophouse unit shared a party wall with its neighbors which extended above the roof ridge by around 18 inches to reduce the risk of fire spreading from one unit to another. The interior was lit by airwells, or narrow courtyards, open to the sky, which helped with ventilation and cooling of the building. An enclosed yard at the back was used for meal preparation on a brick-built, charcoal-burning hearth, with a roof over it to keep off the rain. This was also where clothes were laundered and the occupants of the house bathed, with water drawn from a well. The privy was situated here too.

Most sources attribute the ultimate lineage of the shophouse to the courtyard houses of China (Davison & Tettoni, 2010, p. 18) but where and how did this transformation from the detached courtyard house to a row of multiple units of narrow fronts and deep plan happen? According to Lee (1988), it seemed to have happened in Singapore in response to the urban planning and regulations of the colonial government. According to Davison and Tettoni (2010) it seemed to have happened in the coastal cities of Guangdong and came to Singapore with the immigrants. Their accounts bear a close reading, so let us quote them at length. Here is Lee (1988):

> For the majority of the Chinese [in Singapore], however, life was lived in terraced houses often with businesses on the ground floor. The terraced form was due to the original subdivision of the land into narrow lots for reasons of economy as well as to Raffles' directive of November 22, 1822

> requiring that houses have uniform fronts with covered footways. Raffles stipulated that "for the sake of uniformity and gaining as much room as possible, a particular description of front for all brick and tiled houses should be attended to." He added that "a still further accommodation will be afforded to the public by requiring that each house should have verandah or a certain depth, open at all times as a continued and covered passage on each side of the street." (p. 79).

Lee (1988) was silent about the transformation of detached courtyard houses into a single row of shophouses, but we see him citing urban planning ("subdivision of the land into narrow lots"), municipal regulations ("continued and covered passage"), and material limits ("maximum purlin size") for the Singapore shophouse taking the form it had.

Here is Davison and Tettoni (2010):

> This characteristic [narrow and deep] ground plan has in origins in ancient China where house taxes were calculated according to a building's width or frontage on to the street. . . .
>
> The shophouse . . . was one that could be easily added to, simply by erecting a second building at the rear of the site, so that what was originally the backyard now became an internal courtyard, or airwell, separating the two built structures, with the cooking arrangements and so forth being transferred to the rear of the new construction. The process could be repeated a second, and even a third time, depending on how far back the site extended. In southern China, in the coastal regions of Guangdong province, from where many of Singapore's early immigrants hailed, this kind of dwelling is referred to as a "bamboo house", not because of its layout where rooms and courtyards are arranged sequentially like the nodular sections of a bamboo culm. There are instances of shophouses in Singapore with three or more airwells and a depth of more than 200 feet, although the great majority were less than half that length. (p. 16).
>
> Many of the features we usually associate with the Singapore shophouse – a long and narrow plan, airwells, firewalls and even Raffles' celebrated five-foot way – are to be found in southern China where one typically encounters rows or terraces of similarly built houses separated by narrow lanes. This type of settlement pattern encouraged the adoption of different construction methods to those of northern China, most notably load-bearing walls into which the floor joists and roof purlins are set. (p. 84).

Davison and Tettoni (2010) were also silent on when the detached courtyard house prototypes were transformed into a row but implied that the transformation, if any, was too far back into history to be in part of their purview, and showed that buildings in an urban context in south China had long been contiguous and shared party walls (Davison & Tettoni, 2010, pp. 84 – 85). Unlike Lee, they attribute the narrowness of the frontage to Chinese models "where house taxes were calculated according to a building's width or frontage on to the street." We can note here that narrowness being a consequence of taxation on frontages also indicates that if scarce resources are priced correctly, they are used optimally, whether the tax collectors intended it or not. In this case, the resource is the length of a pedestrian's stroll and it has led to high density and walkability. The practice of extending the house by building another section behind, whether in China or Singapore, could only have taken place in linear settlements around a single street. Once urban planning with back lanes arrived, the rearward extension of the plot was permanently blocked. In contrast to Lee giving emphasis to the shophouse taking its form in Singapore as a response to government urban planning and regulations and the limitations of purlin strength, Davison and Tettoni implicitly credit the Chinese prototypes as determinants for shaping the Singapore shophouse. They were, however, also careful to state only that "features we usually associate with the Singapore shophouse . . . are to be found in southern China", and not that a single building type like the Singapore shophouse which integrates all these features already existed in China.

Regarding influences, both Lee, and Davison and Tettoni could be correct. Raffles was a well-traveled man, his work for the British East India Company taking him all over

Asia. He was intensely interested in all the indigenous cultures he encountered, so much so that he was able to write books like *A History of Java*. Quite possibly, he was aware of the Chinese prototypes, appreciated their quality, and borrowed elements for his new Singapore tropical architecture. The Chinese immigrants came, saw that the regulations were consistent with their traditions, adapted quickly and built well. The span of a single timber was mentioned by both, so there was no conflict there; indeed it was a natural technical optimization to avoid having any columns in the house.

To bring closure to this section, a reasonable hypothesis could be proposed that the row of narrow, deep units had first developed in south China. Various other shophouse features also existed there, but the full integration of everything into its final form with the five-foot way and the back lane took place in Singapore. Or, as another author Li (2007) simply said, “immigrant Chinese brought with them the ‘blueprints’ of the Southern Chinese shop dwellings that eventually evolved into a distinctive Singapore shophouse topology” (p. 1).

Literature on Learning from the Vernacular

Rudofsky first brought widespread attention to vernacular architecture via a series of Museum of Modern Art exhibitions and the book which resulted from it (Rudofsky, 1964). He criticized the state of architectural history and the attitudes of the time in treating the art of building as being too narrow, restricted in their purview to the late stages of European design thinking, and even then only to the grand buildings of the privileged. The rest of architecture did not even have a name. In his book title he used “non-pedigreed architecture”; elsewhere he also used “vernacular”, “anonymous”, “spontaneous”, “indigenous”, and “rural”. The body of the book is a series of photographs of buildings from all over the world, stunning in their variety and ingenuity

of solutions to problems, and most of all, for Rudofsky, in their humaneness. For instance, modern streets are deserts, while vernacular ones with pergola and awnings, or in the form of arcade, provide shelter from the elements, protection from traffic hazards, and even act as forums. While Rudofsky never surveyed Singapore, he would have appreciated the five-foot way of the shophouse.

The next surveyor of the vernacular was Paul Oliver. In the first edition of his book (Oliver, 1987), he said that there was as yet no discipline for the study of vernacular architecture, and such a discipline would probably combine elements of both architecture and anthropology, for the family and community life are powerfully integrated into the dwelling. By the second edition of his book (Oliver, 2003), there was still no discipline but at least the term “vernacular” was established and more architects were influenced by vernacular traditions. For instance, Oliver quoted the Egyptian architect Hassan Fathy after he studied the Nubian mud brick vault and designed the town of New Gourna near Luxor – “the vernacular architecture of the Arab World and neighbouring regions not only solved the climatic problems but did so with a combination of beauty and physical and social functionality” (Oliver, 2003, p. 11).

The message of these surveys is, as Rudofsky (1964) said, “There is much to learn from architecture before it became an expert’s art” (p. 4). For specifics, the field is much thinner, especially those concerned with sustainability aspects. Soflaee and Shokouhian (2005) showed that traditional building techniques are well adapted to the climate and we can use them with new technology. The techniques use sustainable forms of energy like wind together with the structure and form of the building. The paper studied the natural cooling systems used in the hot and arid regions of Iran, like

badgirs, central courtyards, showadans, and sabasters. Badgirs are wind catchers consisting of a tower and a head rising above the roof with vents facing the predominant wind direction. Showadans are rooms built 6 – 7 meters below ground and exhibit a constant comfortable temperature all year round. They are illuminated by vertical ducts to the surface of the courtyard. Sabasters are cellars with ceilings a meter above the courtyard with louvers to vent in fresh air and light. Exposure to direct solar radiation has always to be avoided, so there cannot be large or even any windows on external walls. Without the cross ventilation that windows enable, the traditional devices are able to adequate ventilate the house and avoid the heat. They concluded that in tight and dense clusters of courtyard houses where opportunities for cross ventilation are limited, such devices were the best key to facilitate natural ventilation. In a further pair of case studies (Soflaee & Shokouhian, 2007; Shokouhian, Soflaee & Nikkhah, 2007), they presented quantitative analyses of how the size, shape and direction of the courtyards regulate the temperatures of traditional Iranian dwellings. Soflaee and Shokouhian showed careful study of specific vernacular features for their functionality while being sustainable (not requiring electricity) within the context of a hot and arid climate.

Fathy (1986), *Natural Energy and Vernacular Architecture*, is a book looking at how vernacular architecture uses natural energy to keep cool in hot and arid climates; how climatic elements and the properties of local building materials are exploited to create a comfortable microclimate within the buildings. Bringing in modern tools of thermodynamics and aerodynamics, the sun, wind, and humidity factors were analyzed. In hot climates, the over-riding factors are to keep cool and control the light and

ventilation coming in and the various vernacular devices to achieve these were discussed. There are shading and orientation, various types of roofs, blinds, and openings. There is the mashrabiya, a cantilevered space with a lattice opening, where small water jars are placed to be cooled by the evaporation effect as air move through the opening. There is the claustrum, a multitude of small vents built instead of windows to create privacy, security, uniform distribution of air flow, and the blocking of direct solar rays. There is the wind-escape, a funnel using the suction caused by low air-pressure zones to generate steady air movement indoors. There is the malqaf or wind-catch, a shaft rising high above the building with an opening into the prevailing wind (Fathy regarded the badgir as a specific type of malqaf). It traps the wind from high above the building where it is cooler and stronger, and channels it down into the interior of the building. The malqaf thus dispenses with the need for ordinary windows to ensure ventilation and air movement. The malqaf is also useful in reducing the sand and dust commonly carried by the winds of hot arid regions. The wind it captures above the building contains less solid material than the wind at lower heights, and much of the sand which does enter is dumped at the bottom of the shaft. With special relevance for the tropics, Fathy noted that the value of the malqaf is even more obvious in dense cities in warm humid climates, where thermal comfort depends mostly on air movement. Fathy also discussed how courtyard designs and fountains affect the microclimate, and his study offers a valuable insight to vernacular architecture's utilization of free, natural energy for human comfort.

Schemes to Achieve Sustainability in Architecture

With growing environmental consciousness, building authorities and civic bodies in many parts of the world have developed schemes and rating systems for

sustainable/green buildings. The emphasis on buildings as a focus on a sustainability strategy was well justified. Deng, Li, and Quigley (2011) noted that buildings and their associated construction activities account for nearly a third of world green house emissions, and the construction and operation of buildings account for about forty percent of worldwide consumption of raw materials and energy, thus also explaining the priority on energy efficiency in all rating systems.

In a survey of six such schemes – Leadership in Energy and Environmental Design (LEED), BREEAM, SBTool, CASBEE, Building and Construction Authority of Singapore (BCA) Green Mark, and ESGB, Mao, Lu, and Li (2009) noted the provenance of Singapore's Green Mark from LEED and BREEAM. BREEAM, developed in U.K. in 1990 and considered the first real green building rating system in the world, is the foundation for all others systems. The Green Mark built on the experience of these other systems.

We look then, at Singapore's Green Mark. When it started in January 2005, Green Mark certification was not mandatory, but sought instead to encourage developers to build to a more sustainable standard for their own long term cost savings and prestige. But since April 2008, it has been incorporated into the building code as the Code for Environmental Sustainability for Buildings (henceforth "the Code"), essentially requiring new buildings to attain at least the Green Mark "Certified" level. (The other levels rise through "Gold" and "Gold-plus" to "Platinum".) A tighter Code was effective from December 2010 (Building and Construction Authority, 2010). The Code applies to all new buildings or extensions or retrofits involving a gross floor area of 2,000 m^2 or more.

As the Code states, its intent is to “establish environmentally friendly practices for the planning, design and construction of buildings, which would help to mitigate the environmental impact of built structures.” The Code lays down its scoring criteria, separately for residential buildings and for non-residential buildings, and the five categories it measures buildings by are: energy efficiency, water efficiency, environmental protection, indoor environmental quality, and other green features (like innovative adoption of green practices and new technology). Energy efficiency is regarded as the prime category and on its own forms one of two Requirements – the Energy Related Requirements, with the rest combined into Other Green Requirements.

The first sentence of its Assessment Criteria section (Building and Construction Authority 2011c) states that “BCA Green Mark is a green building rating system to evaluate a building for its environmental impact and performance.” It does not address neighborhood development. The closest it comes is a minor category “Green transport” which measures a building’s access to the nearest Mass Rapid Transit, Light Rail Transit or bus stops, and provision of covered walkways, electric vehicle recharging points, and covered bicycle parks. It is otherwise strictly about the building itself. On its own, it will be insufficient for our purpose, as it does not address how buildings fit together to make a community that might, for instance, enhance walkability enough to make driving a car unnecessary.

As with the Green Mark, the United States’ LEED had not addressed neighborhood development, but, in collaboration with the Congress for the New Urbanism, and the Natural Resources Defense Council, it now has a pilot program called the Neighborhood Development Pilot, which “integrates the principles of smart

growth, urbanism and green building into the first national system for neighborhood design" (U. S. Green Building Council, 2009). With two-and-a-half years of market and user feedback, LEED has packaged its program into a Neighborhood Development Project Checklist.

Green Mark and LEED operate on the scale of an individual building. LEED now has a pilot extension for neighborhoods, but New Urbanism (New Urbanism, n.d.) can be applied on scales from a single building to an entire city or region. It aims to create walkable, mixed-use communities not necessarily through any new or alternative technologies but the same components as conventional development assembled in a more integrated fashion. These should contain housing, work places, shops, entertainment, schools, parks, and other essential civic facilities. New Urbanism promotes the increased use of trains and light rail, instead of having more highways and roads. It would complement the building-focused Green Mark quite well. It has ten principles for creating livable sustainable communities –

1. Walkability
2. Connectivity
3. Mixed-Use & Diversity
4. Mixed Housing
5. Quality Architecture & Urban Design
6. Traditional Neighborhood Structure
7. Increased Density
8. Smart Transportation
9. Sustainability

10. Quality of Life

While New Urbanism does not address the specifics of the required architecture, the Pattern Language of Alexander, Ishikawa, and Silverstein (1977) most certainly does, through a list of 253 patterns. Written before the present age of environmental narrative, it did not use the language of the current sustainability paradigm, but was prescient in its emphasis on environmental stewardship, treasuring of natural capital and the commons, and quality of life via personal freedom and development and living in harmony with nature. Starting from the scale of regions and cities and going down to that of rooms, they listed the design problems that are encountered time and again and prescribe the solutions. They did not believe that large scale structures can be designed by a central authority, but are best grown piecemeal by grassroots self-organizing. This emphasis on community has influenced the later New Urbanism movement (Alexander being one of the two inaugural recipients of the Athena Award given by the Congress for the New Urbanism). Presented in the form of a handbook of patterns, it was not explicit about its sources and influences but it would have drawn much inspiration from the vernacular, as vernacular evolve at the grassroots level through millennia of adaptation by generations of builders. The relevant patterns will be described as they are applied to analyze the shophouse in Chapter 5 below.

Literature on Density Aspects

In a series of studies launched by Leslie Martin and Lionel March in the late 1960s (Martin & March, 1972; Ratti, Raydan, & Steemers, 2003), it was found that the courtyard is the most efficient form of usage of land, and it was even calculated that the center of Manhattan could be replaced by large courts, creating large open spaces and

reducing the height of buildings from an average of 21 storeys to 7, as in figure 2-1 (Martin & March, 1972, p. 21).

The shophouse is a kind of courtyard house. From its southern Chinese courtyard house prototype, imagine squeezing both sides until it is deep and narrow, so narrow that rooms on the sides disappears into the party walls with the neighboring units, then the lost enclosed space is restituted to the front. Indeed, the squeezing is also applied to a row neighboring units, originally detached, until they are joined by party walls. The courtyard itself remains, for natural lighting and ventilation.

This squeezing results in a unit that can be as narrow as twelve feet, so that there can be twelve shop fronts in a 144 feet block. This is a form of density not often discussed – the number of shop fronts per straight line pedestrian stroll. Martin and March distinguished courtyard from terrace houses (which they called “street” or “parallel rows”), and showed that courtyard housing achieved half as much again accommodation as terraces while holding the height and the light angle constant. Where tower blocks (which they called “pavilions”) achieves a plot ratio of 1:1, terrace houses achieves 2:1 and courtyards 3:1. As they explained, with reference to figure 2-2:

> We might place on any given site parallel rows of 4-storey buildings spaced apart by a conventional light angle of 45°: in this case the plot ratio will be 2:1. If however the building remains at 4 storeys but is arranged as a solid block lit by courts, in which the prescribed light angle is still used, the plot ratio will increase from 2:1 to 3:1, that is by a factor of 50% (p. 35).

The Singapore shophouse is both courtyard and terrace, its shop front together with those of adjacent units forming a terrace, and this is a different kind of density that enables a high quality urban life. People will not willingly take detours, as the customer traffic differentials between ground floor shops and higher floor shops within any multi-

storied shopping mall, and main corridors and the side corridors within such corridors will attest. Johnson, Davies, and Shapiro (2000) gave the typical valuation of shops in town centers and shopping parades as – basement £20/m^2, ground floor £450/m^2, first floor £75/m^2, and second floor £20/m^2 (p. 383). The ground floor scores much more than all other floors in valuation for shops, and therefore having just a row of shop fronts on street level as the traditional Singapore shophouse already reaps most of the benefits of space allocation for shopping. Adding the upper floors for shops would add at most marginal returns. They are better used for residence or back offices for the shopkeepers to minimize commuting distances and achieve a different kind of optimum in density.

In mathematically proving that low rise courtyards can be equivalent to or even beating high rise tower blocks, Martin and March held two parameters constant – people or units per unit ground area, and total surface area. The first is obvious. The second is there because it limits the amount of natural light and ventilation possible. Thus the importance of surface area, and it highlights a shortcoming of the shophouse – the party walls with adjacent units block off natural light and ventilation. But this is because the shophouse optimized for a different parameter, the density of shop fronts per unit length of pedestrian stroll. Glassie (1990) regarded vernacular architecture as insistently recording the history of a people. The shophouse had evolved in the ethnic Chinese urban conglomerations of Southeast Asia and needed to cater to their trades of trading, distribution, and home-scale crafts and manufacture, with the loss of surface area ameliorated by the jack roof and the vestigial courtyard. It was to cater to the business needs of this community that the shophouse had evolved, so the maximization

of this measure of density for business needs is the natural and correct one, rather than the more physical measures prioritized by Martin and March. The maximization of business encounters, people encounters, goods flow, people flow, gossip flow, and information flow rather than just residents per unit area need to take priority where these matter.

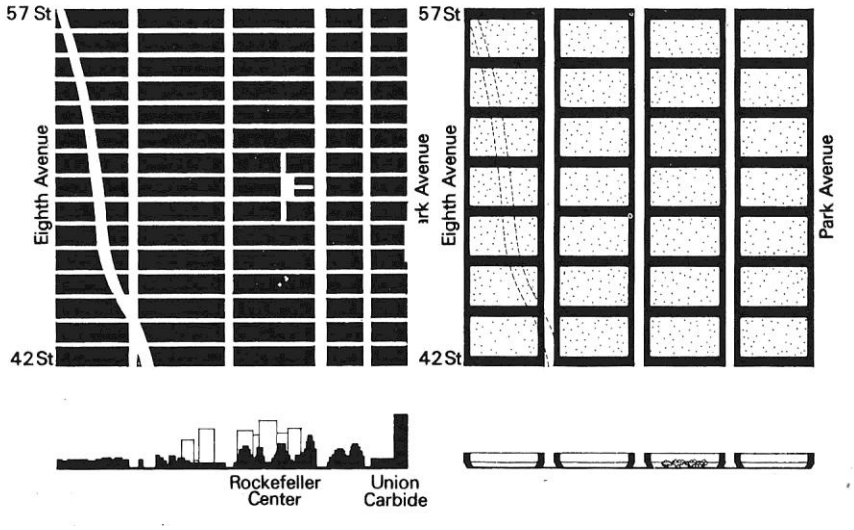

Figure 2-1. Replacing Manhattan by large courts. (Source: Martin & March, 1972, p. 21.)

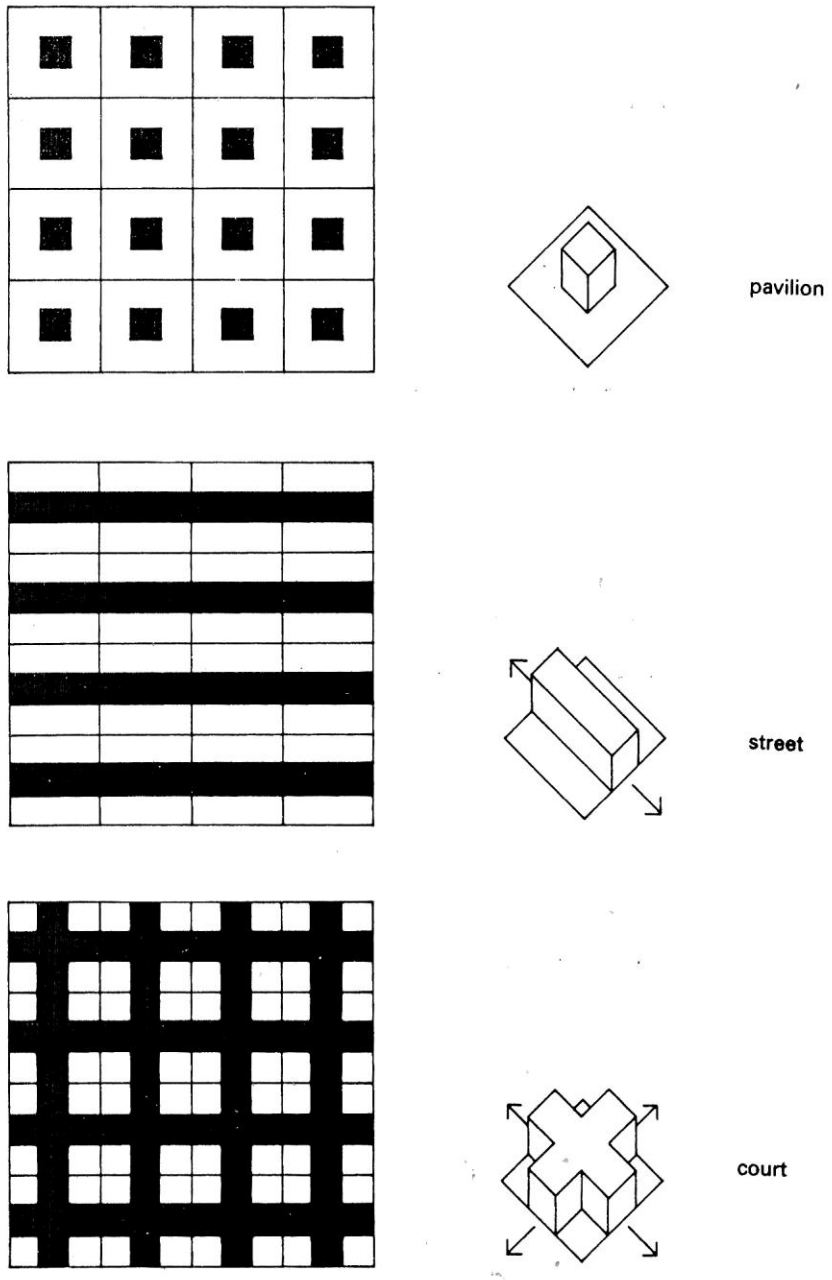

Figure 2-2. Comparing achievable density. (Source: Martin & March, 1972, p. 36.)

CHAPTER 3
METHODOLOGY

We want to find elements of the shophouse that can be borrowed for a sustainable tropical architecture. The methodology is

(a) Give a description of the shophouse sufficient for a sustainability analysis;

(b) List the sustainable features that could be used as they are; and

(c) Propose ways elements could be adapted for a modern context.

Part (a), which is Chapter 4, is to understand the essential characteristics of the shophouse, and what problems they are trying to solve.

From (a), we first derive (b), Chapter 5, where those shophouse features are still solving the problems satisfactorily and in a sustainable manner; and then derive (c), Chapter 6, where those features could be made to do so or in a more efficient way with modifications. Green Mark, New Urbanism, LEED Neighborhood Development Checklist, and Pattern Language would help decide the shophouse's strengths and weaknesses and determine what is sustainable. The factors chosen are necessarily selective. For example, the Pattern Language alone has 253 patterns and it would be impossible to run shophouse features by all of them. To guard against arbitrariness and selection bias, we will run through the entire Green Mark, New Urbanism and LEED Checklist categories.

CHAPTER 4
THE TRADITIONAL SINGAPORE SHOPHOUSE

We touched on history, style, and construction as part of the literature review. Here we look at the material used. Walls were made of locally fired bricks, brick-making being one of the first industries set up soon after the British settled in 1819. Wall plaster was made from river sand and lime. The walls were given a coat of lime wash, which forms a semi-permeable surface wicking moisture from the base of the wall and evaporate, which had a cooling effect. Piles, where necessary in uncertain soils, were staves of rot-resistant mangrove wood driven vertically into the ground. Sometimes short lengths of balau wood laid crossways and lengthwise were used instead. Foundations were made from masonry rubble set in lime mortar (Davison & Tettoni, 2010, p. 20). As noted earlier, roof purlins and beams were wood, and so were floor boards.

These were all traditional locally available material. No steel or concrete were used. The only material that would be environmentally taxing today is wood for beams, floor boards, and pilings. In the rest of this chapter, figures 4-1 to 4-7 illustrate the essential characteristics of the shophouse.

Figure 4-1. Shophouses by the Singapore River. The inner courtyards can be seen in the first few units of the riverside row, two thirds of the way inside each unit. These are full width courtyards, taking up the entire span between the party walls. Behind this row is the back lane, then another row of shophouses, a street, then a third row of shophouses, and another back lane. The third row units have their courtyards and rear sections covered by flat concrete roofs, a later accretion. Units are separated by party walls which rise above the roofs to act as firebreaks. (All photographs by the author.)

Figure 4-2. Shophouses at Sultan Gate. The upper floors are usually fronted by French windows which permit through ventilation even when closed. Splash from the rain is prevented by the overhanging eaves which also prevent direct sunlight. Behind the windows are waist level balustrades, as can be seen behind the panels on the left. The glass doors behind the balustrades are a later accretion to permit modern air-conditioning. The high ceilings can be discerned in the proportions of the upper floor.

Figure 4-3. Shophouses at Jalan Sultan. These three newly renovated shophouses would originally have half-width courtyards at the back, but the two outer units have theirs totally roofed over at the first level for small roof gardens. Vestiges of the original courtyards can be seen in the middle unit.

Figure 4-4. Shophouses at North Bridge Road. Each unit at the maroon block in the middle has two courtyards each, one in the middle and one at the back. Both are half-width. The design depth of the shophouse can be extended indefinitely by adding courtyards. Note also the jack roofs for natural light and ventilation. Traditionally, skylights are not used because of the unacceptable heat gain from direct equatorial sunlight, which has a strength of 1 kW/m^2.

Figure 4-5. Back lane in Ann Siang Hill. Every shophouse connects to a street in front and a back lane behind. In the days before sewage piping, the back lane provided a separate disposal route for buckets swapped out through a small hatch-door to the latrine just inside the back wall, and provided, and still provides today, a complete alternative access network free of motor traffic and forms a world unto its own.

Figure 4-6. Five-foot way at Seah Street. The five-foot way, so-called because of the original statutory minimum width, shelters the pedestrian from sun and rain, and allows him to view the goods and services on offer as he strolls past each shop front, and provides a neutral ground to initiate inquiries and bargains.

Figure 4-7. Restaurant at Purvis Street. The front section of the shophouse where the customer just steps off the five-foot way would be where business is conducted. Further inside would be preparation areas, kitchens, workshops, or stores. Interiors are usually free of any columns or walls, offering maximum flexibility of use. Ceilings are also high. This shop's does not look too high because it has a false ceiling, which would have been put up by a previous tenant for air-conditioning, two blower units of which can be seen here, and unused by the current tenant. The front door usually opens to the entire width of the unit, facilitating the maximum flow not just of customers, but fresh air which breezes through to the inner courtyard, which can be glimpsed via its outdoors light in alignment with the lady customer's hair.

CHAPTER 5
SUSTAINABILITY ANALYSIS OF THE SHOPHOUSE

Analysis through Green Mark

Let us run the shophouse through Green Mark's categories qualitatively. While this, together with the New Urbanism principles and the LEED Checklist run-through below might be repetitive, we will still do them for thoroughness as a check against any bias of selective omission. For residential buildings, Green Mark has two sections – Energy Related Requirements and Other Green Requirements. The first section has eight categories – Thermal Performance of Building Envelope (maximum points 15), Naturally Ventilated Design and Air-conditioning System (22), Daylighting (6), Artificial Lighting (10), Ventilation in Carparks (6), Lifts (1), Energy Efficient Features (7), and Renewable Energy (20). Keeping out the heat and otherwise keeping the interior cool is perhaps the most important requirement distinguishing tropical architecture from other architectures.

For the first category, by sharing party walls with neighboring units and having a narrow frontage, the exposed building envelop area is minimal and avoids heat gain by direct sunlight. The overhanging eaves further minimizes direct sunlight on exposed walls, and the traditional permeable lime wash wall coating further cools the walls via evaporation. For the second category, the inner courtyards, French windows, jack roofs promote some natural ventilation, though not as much as buildings with shallow floor plans, no party walls, and large windows. For the third category, daylight comes in through the jack roof and courtyard, though in the deep interior, this has to be complemented by artificial lighting. For the seventh category, the overhanging eaves

and jack roofs preventing direct sunlight entry can be considered energy efficient features. The other categories are not applicable.

The second section, Other Green Requirements, has four subsections. They are Water Efficiency, Environmental Protection, Indoor Environmental Quality, and Other Green Features. Water Efficiency, consisting of the three categories Water Efficient Fittings (10), Water Usage Monitoring (1), and Irrigation System and Landscaping (3), is not applicable to a building type.

Environmental Protection consists of Sustainable Construction (10), Sustainable Products (8), Greenery Provision (8), Environmental Management Practice (8), Green Transport (4), Stormwater Management (3). For the first two categories, the shophouse uses only traditional building materials and would score highly. For the last category, the shophouse has storm drains both front and back, and its efficiency would depend on the efficiency of the drainage infrastructure it is connected to. It does not implement any swales or any other buffering devices. The other categories are not applicable.

Indoor environmental quality consists of Noise level (1), Indoor air pollutants (2), Waste disposal (1), and Indoor air quality in wet areas (2). If windows are open, proximity at street side could let in some noise. With air flow through to the courtyard and jack roof, and being built with traditional materials, indoor air pollutants should be minimal. The other categories are not applicable. The fourth subsection Other Green Features, which consist of the single category Green Features and Innovations (7), is not specifically applicable.

To conclude, by Green Mark categories, the shophouse is energy efficient through avoiding direct sunlight and also through some evaporative cooling by its permeable

lime wash wall coating. It scores highly in the Naturally Ventilated Design and Air-conditioning System, and Daylighting categories due to its through ventilation and inner courtyards, though its natural lighting and ventilation may not be as high as other building types with large windows and without party walls. Finally, it has sustainable construction through the use of traditional locally available materials.

Analysis through New Urbanism

Let us run the shophouse through New Urbanism's principles. The first two principles are Walkability and Connectivity. The five-foot way shelters pedestrians from rain and sun and the narrow shop fronts allows a high density of units so that the pedestrian can cover lots of units in comfort per unit length stroll. The back lanes offer a motor traffic free path for walkers and cyclists, offering a complete access network totally independent of the main streets in front. The high density and dual-networks gives high connectivity.

The third and fourth principles are Mixed-Use & Diversity and Mixed Housing. With its column-free interiors and usually wall-free interiors – certainly free of all load bearing walls – shop houses can be and have been used for all purposes. Traditionally, the family running the shop on the ground floor lives upstairs.

The fifth principle is Quality Architecture & Urban Design. This is subjective, and shophouses can be simple and bare with only boards for walls; or large and luxurious, especially those constructed as purely residential units with brick walls to partition the interior into rooms. Works like Davison and Tettoni (2010) contain many examples of well-planned and lovingly decorated units. On objective criteria like the amount of cool air and natural light, it certainly scores less than other forms, but it has to be noted that

those forms, say bungalows or attap houses, could not achieve the density of shophouses; while modern buildings could only achieve them via heavy air-conditioning.

The sixth principle is Traditional Neighborhood Structure. Being a vernacular form, the shophouse by definition forms a traditional neighborhood. The seventh and eighth principles are Increased Density and Smart Transportation. The issue of density has been discussed in connection with the literature review on Martin and March above. The shophouse does not address transportation directly but its density, mixed use, and walkability reduce the need for cars.

The ninth principle is Sustainability. As a vernacular form developed before the spread of modern air-conditioning, the shophouse used in the traditional way is nearly carbon-free. It can be built with traditional materials, and does not require any steel in its construction as reinforced concrete would. As a low rise, the level of expertise and cost of construction and maintenance required are low.

The tenth and last principle is Quality of Life. The shophouse facilitates a traditional neighborhood and all the quality of life that that implies. In terms of physical comfort, operating in a Singapore climate with a mean temperature of 27.0°C (81°F) and mean relative humidity of 80.4% (Climate and Temperature, n.d.), it does not compare to some modern buildings, which are able to achieve the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommended temperatures of between 67°F and 82°F and relative humidity of less than 65% (ASHRAE, 2010a). However, it has to be noted that these modern buildings achieve their superiority at an environmental cost, in particular its need for air-conditioning to achieve the necessary temperature and humidity.

To conclude, the shophouse scores highly in almost all principles of New Urbanism. It is walkable, of mixed use, traditional, dense, and sustainable. Only in the subjective principle of Quality Architecture & Urban Design would it, as noted also in the Green Mark section for natural light and ventilation, score less than some other building types.

Analysis through Leadership in Energy and Environmental Design Neighborhood Development Checklist

Let us take the shophouse through the LEED Neighborhood Development Checklist. The Checklist has three sections – Smart Location and Linkage, Neighborhood Pattern and Design, and Green Construction and Technology. There is an open format fourth section, Innovation and Design process, and a fifth Regional Credits section, which are not applicable to us. The Checklist is for a particular development and not a type, and we will apply it to a typical shophouse neighborhood where it makes sense.

The first section, Smart Location and Linkage, has five prerequisites. These are Smart Location, Imperiled Species and Ecological Communities, Wetland and Water Body Conservation, Agricultural Land Conservation, and Floodplain Avoidance. They are all not applicable, but the shophouse's dense, compact design would help conserve agricultural land by minimizing land use.

The nine credits are (maximum points awardable in brackets) – Preferred Locations (10), Brownfield Redevelopment (2), Locations with Reduced Automobile Dependence (7), Bicycle Network and Storage (1), Housing and Jobs Proximity (3), Steep Slope Protection (1), Site Design for Habitat or Wetland and Water Body Conservation (1), Restoration of Habitat or Wetlands and Water Bodies (1), and Long-

Term Conservation Management of Habitat or Wetlands and Water Bodies (1). The back lanes could be used for bicycles, and traditionally, the family who run the business on the ground floor lived upstairs, so enabling housing and jobs proximity. The rest are not applicable.

The next section is Neighborhood Pattern and Design. Its three prerequisites are Walkable Streets, Compact Development, and Connected and Open Community. Its fifteen credits are Walkable Streets (12), Compact Development (6), Mixed-Use Neighborhood Centers (4), Mixed-Income Diverse Communities (7), Reduced Parking Footprint (1), Street Network (2), Transit Facilities (1), Transportation Demand Management (2), Access to Civic and Public Spaces (1), Access to Recreation Facilities (1), Visitability and Universal Design (1), Community Outreach and Involvement (2), Local Food Production (1), Tree-Lined and Shaded Streets (2), and Neighborhood Schools (1).

The shophouse comfortably and fully fulfill all three prerequisites via its five-foot ways and its back lanes free from motor traffic. The five-foot way, though legally having each section the property of the respective unit owner, allows public access and invites the public to browse each shop front in neutral territory making every row connected and open. The narrow shop fronts contribute to compactness in frontage, and the lack of any lawns or gardens contribute to areal compactness. For the mixed use credit, the flexibility of the shophouse has always allowed it to house a diversity businesses and residences wherever it appears. The rest are not applicable.

The third section is Green Infrastructure and Buildings. It has four prerequisites – Certified Green Building, Minimum Building Energy Efficiency, Minimum Building Water

Efficiency, and Construction Activity Pollution Prevention. There are also seventeen credits – Certified Green Buildings (5), Building Energy Efficiency (2), Building Water Efficiency (1), Water-Efficient Landscaping (1), Existing Building Reuse (1), Historic Resource Preservation and Adaptive Use (1), Minimized Site Disturbance in Design and Construction (1), Stormwater Management (4), Heat Island Reduction (1), Solar Orientation (1), On-Site Renewable Energy Sources (3), District Heating and Cooling (2), Infrastructure Energy Efficiency (1), Wastewater Management (2), Recycled Content in Infrastructure (1), Solid Waste Management Infrastructure (1), and Light Pollution Reduction (1).

The first prerequisite of certification is not applicable, as it applies to a building and not to a type. For the next two, minimum energy and water efficiencies, as a pre-modern vernacular, the shophouse would fulfill. For the fourth prerequisite of preventing construction pollution, it would depend on particular development, but as a low rise building using traditional and local materials, it is unlikely to cause much pollution. For the credits, if the shophouses are preserved, they certainly get full credits for reuse and historic preservation and adaptive use. For stormwater management, all shophouses have a storm drain in front and another behind, so it will depend on how these are connected. For infrastructure energy efficiency, party walls with adjacent units not providing extra surfaces for heat gain could be regarded as contributing to it. The others are not applicable.

To conclude, the shophouse measure well in most of the applicable categories of LEED Neighborhood Development. Whether it is Smart Location and Linkage, or Neighborhood Pattern and Design, its compact design and walkability allows it to score

highly. For Green Construction and Technology, its use of traditional and local materials is also an asset.

Analysis through Pattern Language

Alexander et al. (1977) advocated piece-meal development, for organic growth that precisely caters to the needs of the community. The shophouse can be built a row at a time, or even have units added to the side of the row a unit a time where the sides have not been fixed by urban planning. Each unit can be modified independently of its neighbors as long as the integrity of the party walls is respected. In a linear settlement with no fixed back lanes, the back can even be extended simply by adding courtyards. Because each unit is small and flexible, it can be bought or rented by a single family or small enterprise and operated for practically any purpose. Change and growth is cheap and easy. The modern mall or large building would require active tenant selection and operational management. The shophouse, because of its flexibility and smallness of unit, self-organizes. This allows an easy and autonomous clustering of related businesses into the Mosaic of Subcultures pattern (pp. 42 – 50).

The pattern Lace of Country Roads (pp. 29 – 31) recommended having country roads at least a mile apart and enclosing countryside and farmland at least a square mile in area, with homesteads one lot deep along these roads. The compact, narrow and deep floor plan of the shophouse would fit in perfectly, having sufficient density to give self-contained community life while minimizing encroachment into farmland. The pattern Scattered Work (pp. 51 – 57) put a case for having people working within minutes of where they live. The shophouse, where the family running the business at the ground floor lives in the floors above it, takes this principle to its logical conclusion.

Summary of Analysis

To conclude this chapter, here are some examples of shophouse features with strong sustainability aspects that can be used as they are. The first is that the traditional Singapore shop house has details that help cool the house and ensure ventilation, like overhanging eaves, jack roofs and courtyards. The second is that it has a narrow shop front. This enables the shopping browser to walk just a few steps to the shop next door. It achieves a high degree of density and allows a walkable community.

The third is that its covered five-foot-ways make walking and browsing pleasant in the sun and rain, again contributing to walkability and efficiency in all weathers. The fourth is that its compact and flexible design allows it to be used for many sorts of settlements, giving sufficient density to allow a critical mass of community life and minimizing sprawl, and offering self-organization and easy adaptation for changing community needs.

CHAPTER 6
TOWARDS A NEW TROPICAL ARCHITECTURE

Adaptations

Here are some examples of the sustainability features of the shophouse that could be adapted for the modern world. The first is that the walls of many traditional Singapore shop houses were coated with a lime wash which was semi-permeable. It wicked moisture from the ground, evaporated, and cooled the walls, but could also encourage mildew and mold, deteriorating air quality. Neo-shophouses could try a more systematic solution involving collected rainwater and semi-permeable cladding using all that modern technology and materials make available. The fact that many modern occupants of the shophouse put in air conditioning points to the fact that modern expectations have gone beyond what the original shophouse could offer. Figure 4-2 shows gutters leading rainwater off the roofs. Singapore has 2.4 meters of rain a year and most of the tropics are equally blessed, and there is ample opportunity to collect this for both this cooling effect and other non-potable uses.

The second is that every shop house is connected at its back by the back lane. The original purpose was to provide access to swap in an empty bucket for the full bucket and cart it away, in the days before piped sewers. The relevant characteristic here is that this is a second parallel network offering complete (every shophouse being connected to a back lane) and alternative (being separate from the main road in front) access, simply because it interferes with clients and customers moving along the five-foot way. For neo-shophouses, we could connect all the back lanes into an alternative network for bicycles, separate from the motor road network.

The third considers the problem that the jack roofs of shop houses were trying to solve – how to bring in natural light and ventilation while not letting in direct sunlight and rain – can be solved more effectively. Neo-shophouse jack roofs can be enlarged or incorporate a badgir or malqaf to funnel in more wind or have light shelves added to bring in more light. With new LED lighting both extremely energy efficient and non-toxic, lighting is perhaps of less important so priority should be given to adapting the badgir that can be used in conjunction with the evaporation cooling mentioned above, assisted by some fan draught if necessary. Earlier, ASHRAE recommended levels of temperature and relative humidity were quoted to compare against Singapore's climate. But as ASHRAE themselves would point out, thermal comfort is a function of temperature, humidity, airflow, and clothing acting in combination (ASHRAE 2010b), so improving airflow could minimize if not eliminate the need for air conditioning.

There is much scope here. 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, as mentioned above; groundwater, reprising the earliest shophouses's 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 or insufficient or leaky. Even in an efficient city, on-site sufficiency will always help as distribution systems always have losses.

Borrowing of Elements

In addition to neo-shophouses, elements can be adapted for other building types. For instance, in a study for a podium with tower block done by the author, the five-foot way goes all around the podium block at street level offering pedestrians the same

shelter from sun and rain while they browse the shop fronts at street level. For each floor, as illustrated in figure 6-1, eaves as used in the shophouse extend out boldly 2 meters. In combination with a ceiling height of 4 meters, and exploiting the free space around the tower block, these eaves go all round each floor and implement an adapted jack roof idea of bringing in natural and ventilation at a high ceiling level while blocking out rain and direct sunlight. While a jack roof extends above the ceiling, this adaptation extends as a continuation of the mid-level fixed windows, with the eaves extended out 2 meters to prevent direct sunlight coming in. It exploits the multiple levels of the tower block to reflect sunlight from the upper surface of each lower eave upwards to the lower surface of each upper eave to then come inside the building. Figure 6-1 explains it better. The angle of the slope of the eaves are optimized for this effect.

Limitations of Shophouses

Flexible as the shophouse is, it cannot fulfill all purposes. For instance, it offers nothing to the requirement of wide and open spans for food markets or a cooked food center. We had noted that the strength of a single timber beam puts a limit of the width of the shophouse if it still wants to remain column free. With reinforced concrete, this restriction no longer exists today, but using such modern methods to broaden the width would remove its essence of being a shophouse, leaving perhaps just a façade. That may be desired to fit into a particular neighborhood, but for most such applications, conventional modern architecture will usually have better answers.

Limitations of this Study

Firstly, the analysis was not quantitative, as that would be a highly technical work beyond the scope of this study, and this author did not uncover prior studies of this type on the shophouse that could be cited. There is also the difficulty of defining a baseline

platform. For instance, on what do we measure energy efficiency? Lived in the traditional way, the shophouse is essentially carbon free. The earliest shophouses used only kerosene lamps for lighting, and when electricity first arrived, only for lighting at night. On the other hand, many modern occupants have added air-conditioners.

Secondly, the adaptations proposed could have been provided with more details and drawings. The enormous arsenal of modern technology and materials has also not been brought to bear for adaptations. These should not just enable higher functional specifications but allow lower costs. For instance, beams and floor boards made from laminated bamboo could be used in place of the traditional timber to refurbish old shophouses or construct new ones. New possibilities of design offered by such new materials and techniques were not explored.

Thirdly, there is a lack in historical thoroughness in tracing each feature back to its earliest source and seeing how they were used. Many features of the shophouse, like overhanging eaves, narrow fronts, courtyards, jack roofs, have long appeared elsewhere. The shophouse, after all, is less than two hundred years old. This study has used the shophouse to channel these features because it has brought them together in such a compact package optimized for doing business in an urban setting. A better history would also shed more light on how the shophouse adapted to changing needs as it morphed from a possibly rural agrarian courtyard house to urban trading south China row house to metropolitan international commerce Singapore shophouse.

Future Study

The shophouse does not offer solutions to everything, in recognition of which the research question has been “What elements of traditional Singapore shophouse can we borrow to support the development of a new sustainable tropical architecture?” It needs

complementation from modern architecture and other vernacular traditions. In Singapore itself, other vernacular forms on offer include the attap house and the kelong. While attap houses are unlikely to appear in high density urban developments, its solutions on keeping out rain and sun and out of the way of damp ground and floods could be studied. Kelongs are structurally attap houses on stilts over shallow seas and serve as fish traps and accommodation for the fisherfolk. Clusters of them (without the fish traps) linked by walkways form villages elsewhere in Southeast Asia. They may offer solutions, not just on building forms, but neighborhood organization, to the disappearing of land under rising sea levels. What remains to be done is to show comprehensively how shophouse elements can be combined with these other elements and implemented with all that modern technology can offer.

The shophouse, like all vernacular constructions, may have limitations, but the study of the vernacular does not rely on the premise that it was some kind of perfection that only needed to be resurrected for the world to return to a golden age. For a start, conditions of society and economy have changed and we now have technology and materials unavailable to the vernacular builders, so any criteria for perfection would have shifted. Rather, it is that – with the realization that the carefree use of electricity and natural resources would have to end and that it would be a good time anyway for a retrospection on the entire modern paradigm – an appropriate way to proceed would be to mine our heritage for solutions and insights because they have evolved in a low-carbon era. For instance, we should reconsider the use of air-conditioning as a panacea to every heat and ventilation problem. Furthermore, vernacular architecture are often more attractive than modern. In Paris, young suburbanites congregate in the

ancient vernacular “twisting, narrow streets that were supposed to be rationalized out of existence . . . in the evening for relief from dull [modern] housing projects.” (Hohenburg and Lees, 1995, p. 346).

Modern technology need not be avoided. Glassie (1990) explained that modern technology is simply a greatly exaggerated form of certain tendencies of western vernacular, and indeed, it and all other sources have to be tapped for solutions. For example, Alexander et al. (1977) strongly championed ultra-lightweight structural concrete as “one of the most fundamental bulk materials of the future” (p. 958).

A program for future work could look like the following. Firstly, we note that the performance or efficiency of a building or neighborhood is derived from two separate concepts – functional specifications, and costs. We encountered a dilemma earlier in assessing the carbon efficiency of shophouses when we saw that early shophouses are essentially carbon free in use while modern occupants have added air-conditioners which of course require electricity. Ideally, scales for both functional specifications and costs can be calibrated so that they can be normalized to each other to make comparisons meaningful between different building types or different neighborhood designs.

Next, the functional specifications have to be well understood. This is not just the number of appropriately built up square feet or specifications for light, ventilation, and temperature levels. It has to include how buildings can fit together at what appropriate measures of density to enable what types of residential, social, and economic activity.

Thirdly, what are the costs? This has to include whole life costs and externalized costs, including those to the environment, and whether they are low enough to be

sustainable. Do the builders have the necessary skills to build and maintain the buildings, or will they need extra training? Will the materials have to travel a long distance or otherwise damage the environment? In use, what are the operating costs? Does it facilitate a low carbon lifestyle and less need for travel? Does it require constant maintenance and repair work? Will that curved glass canopy or intricate computer-controlled integral sunlight angling mechanism ever need to be repaired or adjusted? What if the manufacturer goes bankrupt? We should not look just ten or twenty years ahead but fifty or a hundred, as demolition and reconstruction or even just refurbishment is costlier financially and ecologically than continued occupation. A standardized and comprehensive framework for evaluating the two dimensions of functional specifications and costs would be ideal.

An inventory of vernacular forms could then be collected within this framework. The context for which they were optimized must be fully documented, so that their appropriateness to any particular problem will be clear. In future, elements could be borrowed as appropriate or re-interpreted in modern materials as necessary.

But all that is for the future. For now, 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 livelihood, and existing copies are still highly coveted and lovingly restored and used. Architecture, after all is 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.

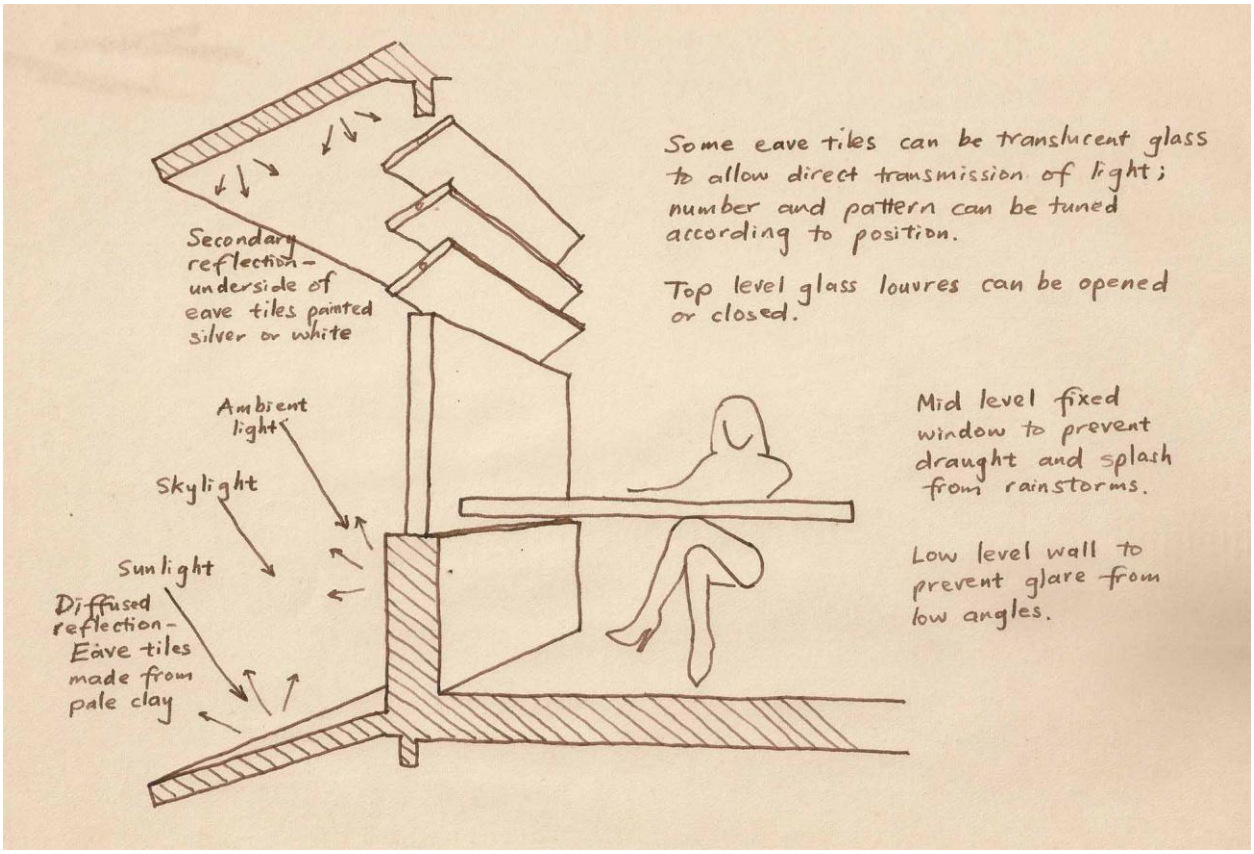

Figure 6-1. Study for a podium with tower block – interior. (Drawing by the author.)

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