



SUSTAINABILITY IN TRADITIONAL CAMBODIAN HOUSE

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**BY
Vichera HEANG**

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The thesis study titled "SUSTAINABILITY IN TRADITIONAL CAMBODIAN HOUSE" is submitted by Vichera HEANG in partial fulfillment of the requirements for the degree of Master of Science in the Department of Architecture, Gazi University by the following committee.

Supervisor: Prof. Dr. Cüneyt KURTAY

Architecture Department, Gazi University

I certify that this thesis is a graduate thesis in terms of quality and content

.....

Chairman: Prof. Dr. Figen BEYHAN

Architecture Department, Gazi University

I certify that this thesis is a graduate thesis in terms of quality and content

.....

Member: Prof. Dr. Cüneyt KURTAY

Architecture Department, Gazi University

I certify that this thesis is a graduate thesis in terms of quality and content

.....

Member: Assoc. Prof. Dr. Gülsu U. HARPUTLUGİL

Architecture Department, Çankaya University

I certify that this thesis is a graduate thesis in terms of quality and content

.....

Date: 24/05/2018

I certify that this thesis, accepted by the committee, meets the requirements for being a Master of Science Thesis.

.....

Prof. Dr. Sena YAŞYERLİ

Dean of Graduate School of Natural and Applied Sciences

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Vichera HEANG

24/05/2018

SUSTAINABILITY IN TRADITIONAL CAMBODIAN HOUSES

(M. Sc. Thesis)

Vichera HEANG

GAZI UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

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ABSTRACT

Lately, the contemporary architecture design has been promoted in cities without concerning depletion of natural resources such as water, energy, and material resulting in global warming, pollution, and climate change. Reducing the energy use in the building is one of the hot topics that many scholars are researching to sustain natural resources and protect the environment. Traditional architectures are well known for their adaptability to local climate conditions, topography, and available resources, resulting in a comfortable indoor environment without using excessive energy. Hence, this study aims to investigate the effect of sustainability in traditional houses in Cambodia by analysis energy, material, water, and quality and well-being to integrate the techniques of traditional Cambodian house, particularly sustainable techniques as an innovative step towards design for the future sustainable contemporary settlements.

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GELENEKSEL KAMBOÇYALI EVLERİNDE SÜRDÜRÜLEBİLİRLİK
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Vichera HEANG

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ÖZET

Son zamanlarda, çağdaş mimari tasarımı, küresel ısınmaya, kirliliğe ve iklim değişikliğine neden olan su, enerji ve malzeme gibi doğal kaynakların tüketilmesine ilişkin endişeleri olmayan şehirlerde tanıtıldı. Binadaki enerji kullanımını azaltmak, pek çok akademisyenin doğal kaynakları korumak ve çevreyi korumak için araştırmakta olduğu en önemli konulardan biridir. Geleneksel mimariler yerel iklim koşullarına, topoğraf ve mevcut kaynaklara adapte olabilirlikleriyle bilinirler, aşırı enerji kullanmaksızın konforlu bir iç mekan ortamını sağlarlar. Bu nedenle, bu çalışma, geleneksel Kamboçyalı ev tekniklerini, özellikle de sürdürülebilir teknikleri, tasarım için yenilikçi bir adım olarak entegre etmek için enerji, malzeme, su ve kalite ile refah analizini kullanarak Kamboçya'daki geleneksel evlerin sürdürülebilirliğinin etkisini araştırmayı amaçlamaktadır. gelecekteki sürdürülebilir çağdaş yerleşimler.

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1. INTRODUCTION

In recent years, facing the global warming, depletion of fossil fuels, and with pollution are majors concern around the world. Reduction energy consumption and using energy efficiency without compromise human comfort are popular solutions for many countries which can help to sustain natural resources and protect the environment.

Throughout the history, traditional architecture has played a crucial role in helping to define humanity's relation to its surroundings. It has not merely been a means for providing shelter but has operated to human's comfort and well-being. In this sense, the traditional architecture can play a pivotal role in the larger paradigmatic movement of sustainability. For instance, the designs of traditional Cambodian houses were built to respond to the nature, local climate, topography, and fulfill the needs of their local culture without using excessive energy. Material and construction techniques were taken from the local context. Well-being was reflected by fresh air, natural light, and spatial variety to accommodate individual needs.

However, the modern practice in architecture lacks conscious effort in using sustainable methods to control the environment. Excessive use of modern materials and poor design have often resulted in high energy consumption, leading to many environmental problems.

Moreover, within the development and influence of modern western architecture is seem diminishing the traditional elements in Cambodian house. Additionally, Cambodia was tragically disrupted by Khmer Rouge Regime and civil wars. Consequently, the infrastructure including the traditional Cambodian houses were demolished.

Due to the lack of awareness of the important of tradition, culture, sustainability and lack of human resources in architecture field in Cambodia, there are very few studies have been published on traditional Cambodian house, particularly concentrate on researching sustainable techniques that had been used in the traditional Cambodian house which are value sources to implement sustainability in the contemporary design.

1.1. Aim of the Study

Taking into this consideration the above matters, have brought to this study – the study is to investigate the sustainability in traditional Cambodian houses as objectives are: to define design elements in traditional Cambodian houses, in term of sustainability and define the contemporary Cambodian houses to find out the parallel and difference applications that have transferred from the traditional houses to the contemporary houses; finally, To address the effect of design elements on sustainability of traditional Cambodian houses to propose sustainable criteria to be used in the contemporary buildings.

1.2. Significance of the Study

There is an obvious lack of using sustainable development in the contemporary living. This study aims to define sustainable criteria in traditional Cambodian houses by examine building forms, opening, orientation, material, and water of the houses. This research attempts to fill the knowledge gap in contemporary design in term of the sustainability. Therefore, it is hoped that the study will enhance our understanding of sustainability and promote the awareness of sustainability in the contemporary architecture.

1.3. Research Methodology

This research is qualitative research by studying and gathering data of concepts, theories and relevant research from books, textbooks, journals, media and case studies to theorize sustainable criteria in architecture of traditional Cambodian houses to reveal the design techniques in term of sustainability.

1.4. Literature Reviews

To comprehend the study, various approaches are employed in the literature reviews.

One of the quotes from Frank Lloyd Wright who defined traditional architecture as (Oliver, 2003, P.13): "Folk buildings growing in response to actual needs, fitted into environment by people who knew no better than to fit them to it with native feeling. Wright expressed the opinion that traditional architecture was superior to self-conscious academic attempts to use a historical style in generating architecture".

Le Corbusier considered traditional architecture model in compromising physical and social needs by relating traditional architecture: “.... having attained perfection in serving human needs and harmonizing with the environment”.

Fatemeh B. M. B., Norhati I. & Dahlia M. S. (2015) have conducted a study of design features of traditional courtyard houses in the moderate climate of Iran. They studied of thirty-four courtyard houses in the moderate climate of Babul in terms of its adaptive potential to suit the users' comfort needs. The result of this research suggests those courtyard houses function ideally in humid and moderate climatic region through its adaptive behavior of the building owners. The houses are recognized as good environmental design.

Kader K. & Muteber E. (2016) have conducted a research on sustainable architectural characteristics of traditional Anatolian houses and current building design principles. In the study, traditional houses were chosen from different climate regions in Turkey, which is located in the middle of Asia and Europe, were inspected in terms of form, settlement, façade characteristics and material use, attempting to determine whether there are precepts for architecture. The result from this case shows that traditional Anatolian houses are built in harmony with the land structure, climate of the region, and the natural environment, minimizing damage to the natural environment by reducing energy need through the effective use of natural energy sources.

Abdulsamad A. (2012) has made a research on sustainable application of interior spaces in traditional houses of the United Arab Emirates. The result has shown that the architectural heritage in UAE can be described as being sustainable as it is of a high thermal performance, which provides thermal comfort while conserving energy.

Regarding these research studies, it is possible to assume that traditional architectural design methods are tangible resources in developing the sustainability. In this research, traditional Cambodian houses will be studied to define sustainable methods to implement the contemporary architecture.

2. SUSTAINABILITY

Sustainability is a complex concept and hard to define it specifically. However, the most common definition which is accepted, quoted by the UN Brundtland commission: “sustainability is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

According to Dictionary.com sustainability means the ability to be sustained, supported, upheld, or confirm. In term of the environment, sustainability refers to the quality of not being harmful to the environment or depleting natural resources and thereby supporting long-term ecological balance.

Sustainability is not only about building solutions, architectural strategies, and eco-friendly management systems. It is also about a quality of life, safety living, belonging to the living environment and self-dependent. Sustainable settlements offer people an opportunity to enjoy a high standard of living where they can indicate their own identity while having a minimal negative impact on the environment, economic and social structure (Barton, 2000).

The design criteria of the sustainability start with a series of questions: How is the building going to respond to the site’s orientation, wind exposure, and solar gain? How will it maximize natural light? How can the builders reduce construction waste?

In addition, the effort to maximize sustainability does not end even a building is completed. Occupants need to be environmentally conscious which is a huge part of sustainable development (Mola, 2013).

2.1. Sustainability Historical Review

The word "sustainability" has roots in Latin; “sustain” means, "to hold up" or "to support from below". Oxford Wordpower Dictionary defines “sustain” as to keep something alive or healthy, to cause something to continue for a long period of time (Oxford Wordpower, 2006, P.781); “ability” means “the quality of being able to perform” (Advance English Dictionary). If we apply the word meaning to the modern use of "sustainability" to keep the

earth, it is the duty of its inhabitants, present and, future, to support a community from below. (www.sustainablemeasures.com)

For centuries, people lived depending on available resources and natural energy sources to produce, built and cultivate. The turning point in human civilization was the Industrial Revolution that has been underway for two centuries. Its foundation was a shift in sources of energy from wood to fossil fuels, a shift that set the stage for a massive expansion in economic activity.

In spite of industrial revolution have made life easier and better for many people in ways that would have been unimaginable even a generation ago; it has also brought increasing damage to the physical systems and social fabric on which our well-being depends on (www.sustainable-development.gov.uk).

The modern concept of environmental sustainability goes back to the post- World War II period when a utopian view gave way to a perception that the quality of the environment was linked closely to economic development.

In the 1960s, as a response to the concern of environmental problem and poor resource management, the concept of the sustainability enhanced. As the environment became increasingly significant as a world issue, sustainability was adopted as a political goal.

Since the 1960s till date, several events, conferences, and summits have been held; this demonstrates “sustainability” as a prospective strategy to conserve environment and planets’ resources.

2.2. Criteria of Sustainability

The criteria of sustainability aim to address the environmental problems and lack of quality of life, to benefit a healthy environment in a long-term that provide quantitative, qualitative, physical, and psychological to building users.

There are many possibilities for achieving this seemingly difficult goal. The criteria of sustainability that are going to raise in this study are:

- Energy efficiency,
- Material usage,
- Water usage and,
- Quality of life and well-being.

The principles of sustainability below will provide a broad awareness of sustainable design in architecture.

2.2.1. Energy Efficiency

The purpose of sustainable building in energy criteria is to reduce the bad impact on natural environment and improve occupants' quality of life and well-being while using less artificial energy.

The energy associated with buildings is a power which can do work, such as providing light, heat, cold, and running equipment and appliances. The operational energy varies depending on building use, climate, and location. The climate has the biggest impact on the building's requirements for cooling and heating, but all factors have to be considered.

Sustainable energy can be addressed through but not limited to:

Climate Studies

Good design is the design that does not against to the climate. The designers need to ensure that the occupants remain thermally comfortable with minimal auxiliary heating and cooling in the climate where they built.

Building Orientation

Building Orientation refers to the way of placing a building on its site to take advantages of climatic features such as sun and natural cooling breezes. Good orientation reduces the need for auxiliary heating and cooling.

Natural Lighting

Building design that operates natural light will lead to conserving electrical lighting energy. At the same time, natural lighting enhances the psychological well-being and productivity of indoor occupants. To ensure perfect natural lighting, windows, doors, and skylights should produce a pleasant level of brightness and also allow an adequate visual contact between interior and exterior areas.

Natural Ventilation

Natural Ventilation is a bio-climate principal design strategy to improve comfort in- and outdoor space. The natural ventilation provides two major benefits, cooling, and hygienic effects. Natural ventilation can be achieved through openings such as windows, doors, louver, and etc. Orienting the building also a major of natural ventilation efficiency.

Shading

Shading of the building helps to reduce summer temperatures, improve comfort, reduce glaze from the sun and give pleasure to occupants. Shading can be addressed by planting trees and designing overhangs to prevent summer heat gain and accompany costs of fan and air-conditioning.

Water Cooling

Water cooling is another method in energy efficiency. It gives humidity and helps to cool down the building as well as give comfort to occupants. Water cooling can be addressed by having a pool, pond or lake nearby the building.

Building Envelope

Building envelope includes doors, window, shading devices, finishing materials and façades. Designing a building envelope is to moderate indoor temperatures. Selecting building envelope matters the sustainable design. For instance, building envelope can minimize

unwanted heat gains by using solar shading, insulation, low or medium-weight material, and reflective finishes.

Using Energy Efficiently

Zero-energy buildings are not realistic, but low energy building is. Although a building is designed providing a comfortable environment all year round through passive means, it will still require energy for lighting at night, operating appliances and equipment. In most cases, some energy will also be required to run hot water and ventilate the internal environment. Therefore, users need to aware of using energy efficiency. It can be achieved through but not limited to:

- *Zone Lighting*: Locate lighting only where required and optimize the distance between light sources and area to be lit. Install controls for small groups of lights rather than for large areas to maximize individual control and ensure banks of lights can be switched off when not required. Lighting zone should take into consideration when it is near to natural lighting source. The switch of the lights near opening should install separately.
- *Automatic Controls*: Detectors switch on and off lights can help to improve efficiencies. Light detector only when people are in a space. Daylight detectors switch on lights only when natural light levels are lower than a set level. Timed controls switch off lights after a set time of being switched on.
- *Educating Users*: Last but not least of energy efficiency is educating users. It is the most important strategy in term of sustainability is to educate the users to aware of the risk of high energy consumption and benefit of having a sustainable environment. Make individuals responsible for switching off lights and other appliances when it is not used or necessary (Sassi, 2006).

2.2.2. Material Usage

The material is one of the main resources required to construct the buildings. Materials are used throughout a building's life, firstly and mainly during the construction phase, and afterward for maintenance. Materials have a significant impact on buildings both the aesthetics and its build-ability. The materials can also affect the building users in terms of human comfort and health (Sassi, 2006).

In this part will address materials selection that helps to minimize the impact on the environment and human well-being.

Minimizing Material

Reduce the numbers of materials used in the construction is the first of sustainable strategies in term of material efficiency.

Choosing Available or Local Materials

Considering the available or local materials resources that can be found easily in nature such as timber, wood or stone. These materials require minimal process before use. The materials with such minimal manufacturing burn fewer fossil fuels and consequently produces almost no pollution or waste. Additionally, using local materials can reduce the distance of the transportation.

Design for Longevity

Minimizing requirement for maintenance by designing for durability and longevity helps to reduce the life impacts of materials (Sassi, 2006).

Waste as Resources

The building industry is one of the biggest consumers of materials. Therefore, the wastes from the building industry should be reconsidered and design to make it as resources for the future use. One way forward is to design buildings to be capable is to enable the waste to reuse, recycling, and down-cycling.

- *Reuse Material*: To reuse is to use an item again after it has been used without any reprocessing, Reuse help to save time, money, energy and resources. Materials that can be reused are the plastic bucket, wood, tin, enamel, glass, brick, slate tile, timber joist, precast concrete floor, ceramics ecologically, and aesthetically preferable.
- *Recycle Material* simply means reprocessing a material or component to form a useful material which can be used again.

- *Down-cycling Material*: reprocessing a material into a lower grade use material (e.g. concrete or brick into hardcore, timber into chipboard) (SolidWorks, 2010).

2.2.3. Water Usage

Water is essential for life on earth. Water is needed for plants to grow and the survival of animals, including human beings. Every year, the total amount of rainwater is about 110,300 cubic kilometers of water that can be used for renewable. However, there are only two-thirds is evaporated, it leaves 40,700 cubic kilometers per year of rainwater (Postel 1997; Mackenzie 1998).

Water efficiency is also one of the sustainable criteria which designers should consider. This part will discuss the use of water and the treatment of waste-water in relation to the buildings.

Minimizing Water Use

The first phase to address water-related environmental problems is to reduce the amount of water used, which will subsequently reduce the amount of waste-water produced.

To achieve the minimal water usage as well as environmental enhancements, educating the users is critical. In the respect of water use, water-efficient utilizations need to be operated and maintained correctly to achieve high water savings.

Maximizing Water Efficiency

There are two main approaches to maximize water efficiency relevant to building design. First of all, sources of water such as rainwater and grey-water should be reused where appropriate. For example, install greywater collection systems from basins, shower, and baths to flush WCs or water gardens. Secondly, recycle water by disposing of black-, grey- and rain-water.

2.2.4. Quality of life and well-being

Sustainable settlements are comprised more than just buildings, infrastructure, natural resources, and employment centers. People live in the community strive to improve the

quality of life by addressing the universal desire of people to have a decent, safe, enjoyable, place to live, work and visit. In addition, it extends into qualitative values such as having a sense of belonging to the community, feeling safe enough to play outdoors and having a close connection to the neighborhood.

Poor air and light quality, lack of views, and lack of the occupants' ability to control the temperature, lighting or humidity can significantly affect well-being that can be frustrating and stressful.

Therefore, to address the quality of life and well-being, the planners and designers need to provide both physical and mental comfort to occupants.

3. CAMBODIAN ARCHITECTURE

Cambodia architecture is famous and precise. There are over hundred major architectural sites to be visited in and around Cambodia especially in Siem Reap City. Traditional Cambodian house is also considered as one of the traditional architecture in Cambodia.

3.1. Overview of Cambodia

Cambodia (Khmer: Kampuchea, officially known as the Kingdom of Cambodia) is a country located in the southern portion of the Indochina Peninsula in Southeast Asia with a population of 15.33 million in 2014 (WorldBank, 2016a). Cambodian makes up 90% of the total population. The largest minority group, at about 5% is Vietnamese; Chinese makes up another 1%; and the rest are Cham and 30 various hill tribes. The country covers land area of 181,035 square kilometers with 2.5 percent covers with water. Cambodia is bordered by Thailand and Laos to the northwest, Vietnam to the east and the Gulf of Thailand to the southwest (Map. 3.1).

The capital city is Phnom Penh where the political, economic and cultural center of Cambodia take place. The official religion is Theravada Buddhism, which is practiced by around 95 percent of the Cambodian population, and the language is Khmer.



Map 3.1. Cambodia's location in South-east Asia (Sun, 2015)

3.1.1. Economic

Cambodia is known as an agriculture, natural resources, and a tourism country. Around 40 percent of Cambodia's economy is tourism. Most rural households depend on agriculture such as fishing, and farming; and partly in industrial sector such as garment factories. Chart 3.1. illustrates about the economic in Cambodia in percentage from 1999 to 2015.

The country has an abundance of natural resources such as bauxite, carbonate rock, natural gas, gold, iron, manganese, petroleum, phosphate, rock, salt, silica and etc. In addition, the country has great lake (Tonle Sap) which serve thousands of families to live by fishing, and has a beach length is more than 400 kilometers which is known as one of the most beautiful beaches in the world which attracts millions of tourists every year.

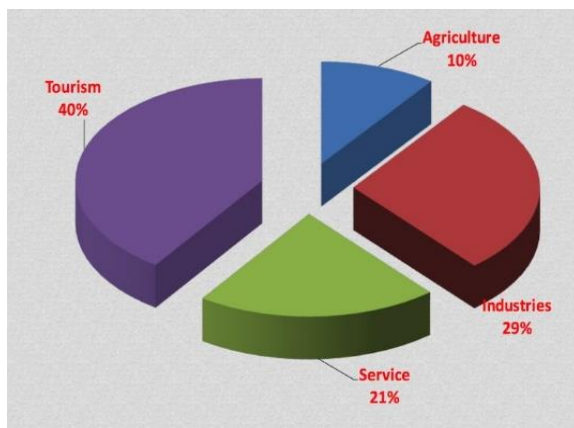


Chart 3.1. Cambodia's economic (Sun, 2015) Figure 3.1. Cambodian people at the rice field (Sun, 2015)

3.1.2. Climate

Cambodia has a warm (hot) weather throughout the country, throughout the year. The annual average temperature for the whole country is 26°C, except Phnom Penh, the capital city, the yearly average temperature of Phnom Penh is 28°C.

Cambodia is located in the tropical zone with two distinct monsoon seasons, rainy season (May to October) and dry season (November to April), which set the rhythm of rural life. From November to February, the northeastern monsoon brings little rain, whereas from May to October the southwestern monsoon carries strong winds, high humidity, and heavy rains. On average, the warmest month is April, the coolest month is January. September is the

wettest month, while February is the driest month. The chart below (Chart. 3.2) shows mean historical monthly temperature and rainfall in Cambodia during the time period 1900 – 2012. The dataset was produced by the Climate Research Unit (CRU) of University of East Anglia (UEA) (World Bank, 2016).

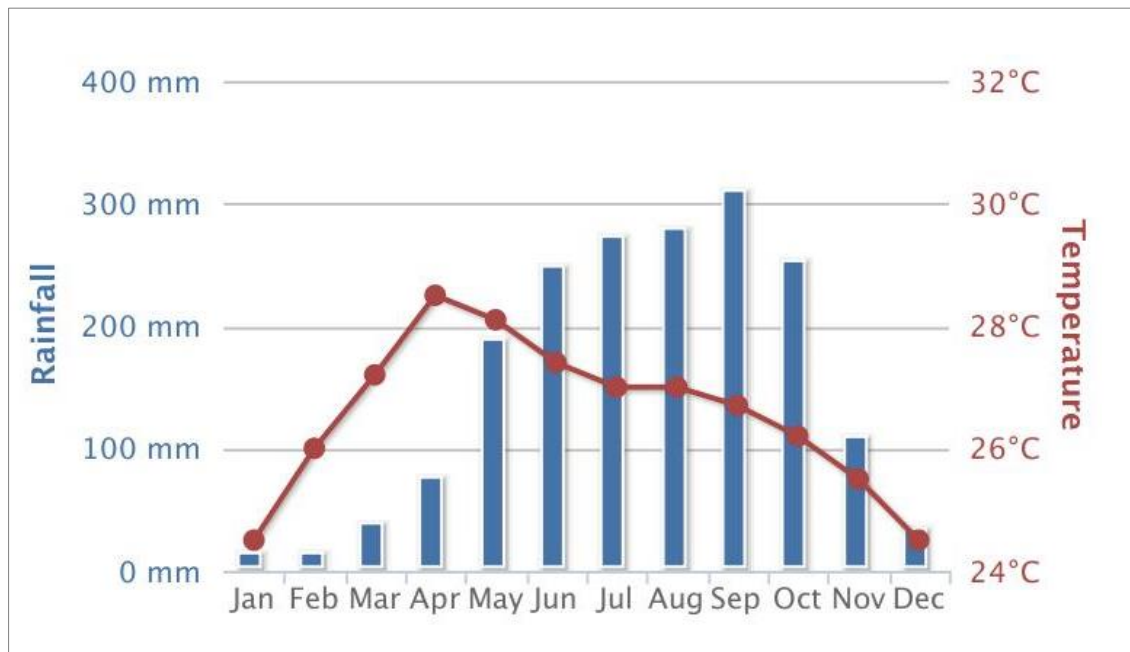


Chart 3.2. The average monthly temperature and rainfall. The bar chart represent rainfall. The line represent temperature. (The World Bank Group, 2016).

3.1.3. Cambodian Lifestyle

Most of the people in Cambodia live in villages. The houses are either clustered together, dispersed among rice fields, or strung out along a canal, river or hillside. Around the houses are trees, shrubs and kitchen gardens. Around the villages are rice fields.

More than 80% of Cambodian follow a traditional lifestyle in the country-side. The main occupants of a village are farmers and their families engage in traditional agriculture on small farm lots. The majority of farmers live in permanent villages known as sedentary villages. It may look idyllic, but subsistence farming is very hard.

Cambodia's people live in the city, normally are university students, office workers, and investors. They live independently, and more freedom compares to the country-side citizen. Some neighbors in the city may do not know each other, as normally they stay inside the

house rather than stay outside. Some citizen in the city spend their time after work at café or restaurant. They live in high-class, civilization. The city is full of residential buildings, offices, vehicles, shopping mall, factories and etc. Life in the city is more hurry while life in country-side is more relax and slow.

Youth and businessmen prefer to live in the city rather than country-side while elders prefer to live in country-side where they can breeze easily, relax, and stay calm and peaceful.



Figure 3.2. Local market at country-side (a)
(Sakal H.)



Figure 3.3. Local market at country-side
(b) (Sakal H.)



Figure 3.4. Cambodian's Lifestyle in a City (Dordain. D)

3.1.4. Periodization of Cambodian Architecture

Scholars have worked to develop a periodization of Cambodian Architecture. The followings are the names and periods of the Cambodian Architecture.

1. Angkor Borei and Phnom Da (1st to 6th Century)

2. The Pre-Angkorian Era (6th to 8th Century)
3. The Angkorian Era (9th-15th Century)
4. The Middle Period - the Dark Ages of Cambodia (15th – 19th Century)
5. French Colonial Architecture (1863 – 1953)
6. New Khmer Architecture (1950s to 1970s)
7. Contemporary Khmer Architecture (From 1970s)

Below are the pictures representing each style of Cambodian Architecture. For instance, figure 3.5. shows about Angkor Borei and Phnom Da style. Figure 3.6 is Sombo Preikuk Temple, it represents the Pre-Angkorian Era. In the picture of figure 3.7 is the Angkor Wat, it is one of the most famous temple in Cambodia. The Angkor Wat is found during 12th century. It represents the Angkorian Era's style. The Middle Period or Dark Ages of Cambodia refers to the year that Cambodia's economic is declined. Therefore, there is no new architecture have been found during that time. Figure 3.8 is UNESCO office, it is one of the French Colonial Architecture's style. Figure 3.9 represents New Khmer Architecture Style. Lastly, figure 3.10 represents Contemporary Khmer Architecture style.



Figure 3.5. Phnom Da
(Gollings)

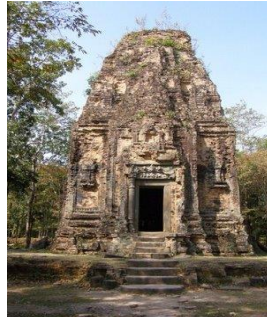


Figure 3.6. Preikuk
(Bora)



Figure 3.7. Angkor Wat Temple
(Bora)



Figure 3.8. UNESCO office
(UNESCO)



Figure 3.9. Library (Author)



Figure 3.10. Sleuk Rith
Institute

3.2. Traditional Cambodian House

Traditional Cambodian house is also known as Traditional Khmer house. The architecture of traditional Cambodian house is considered as one of the cultures and spirits of Cambodia. It plays an important role at the center of Cambodia culture which clearly views how Cambodian live and work. The lifespan of the wooden structure Cambodian houses is around 100 to 120 years depending on the maintenance. Currently, the traditional Cambodian houses still exist where mostly locate country-side. The increasing of number of houses were fewer compare to new couples. Normally, elders live with their daughter or the new couples live with their parents.

3.2.1. Types of Traditional Cambodian House

Similar to the traditional house in other countries of Austronesian origin, Cambodian house differed from one to another on less wealthy or wealthier by their size and presence of refined features (carving placed on door lintels, carve wood panel, roof design, etc.). The functions of the house are mostly similar from one to another.

Yet despite these similarities, traditional Cambodian house does offer a unique feature by classifying the house into different types. They are:

1. Khmer House,
2. Rong Daul House
3. Rong Doeung House,
4. Pet House, and
5. Kantaing House.

Each type has its own unique and identity, the following describe about characteristic of the five types of traditional Cambodian house.

1) Khmer House

Khmer house style started with erections of four lines of pillars, and crossbeams with two-tiered roof. It was popular in the year during 1840 to 1860 (Preah Ong DOUNG Period),

presented for high-ranking people (Nepote, 2013, 105). The house was build high, steeply sloped and big lower gable inspired by pagoda. The length of the house is twice the width and the height equivalent to the length (Fig.3.11 to 3.16).

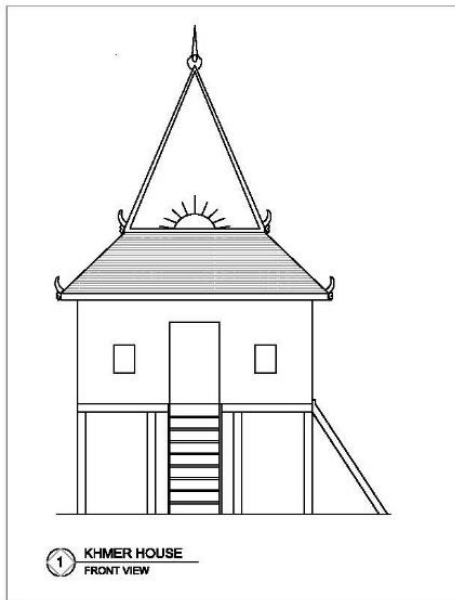


Figure 3.11. Front Elevation
(Author)

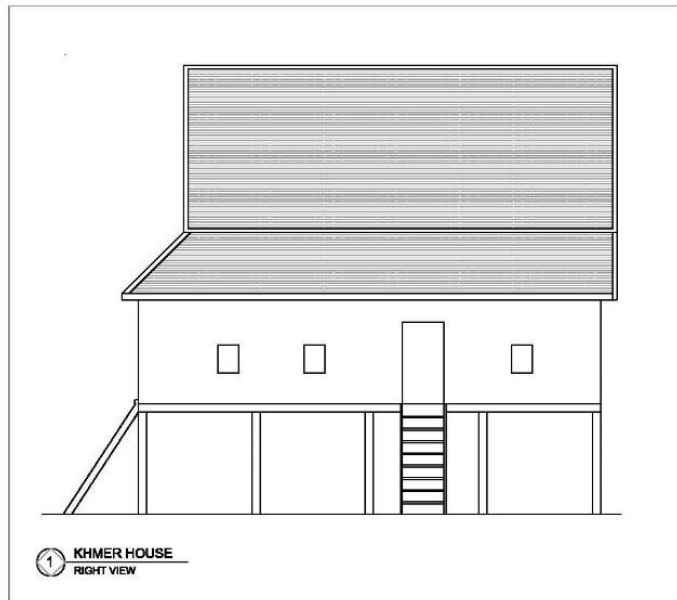


Figure 3.12. Right Elevation of Khmer House
(Author)



Figure 3.13. 3D Modelling Top-View
(Khmer Wooden Project)



Figure 3.14. 3D Modelling Perspective View
(Khmer Wooden Project, 2015)



Figure 3.15. Image of Khmer House (a)
(Unknown source)



Figure 3.16. Image of Khmer House (b)
(Unknown source)

2) Rong Daul House

Rong Daul house was popular in the year during Preah Norodom period. It is built with a gable roof with extended awning at the front of the house to reduce roof structure. The back of the house is left vacant, usually with loosely fixed wood paneling allowing for possible extensions. (Fig.3.17 to 3.22).

According to an interview conducted with descendants by Francois, most of the original Rong Daul house's owners were farmers who supplemented their income with activities like silkworm breeding or tobacco production or cotton and silk weaving. None of the original owners seen to have had any official title.

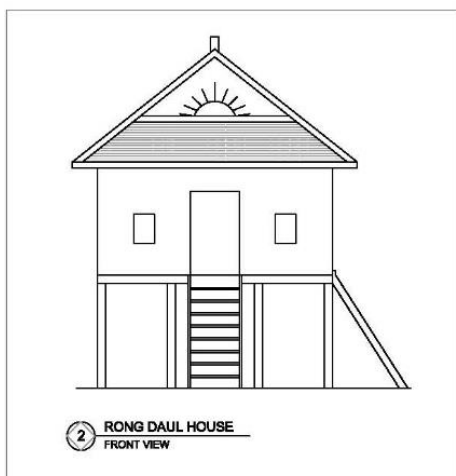


Figure 3.17. Front Elevation
(Author)

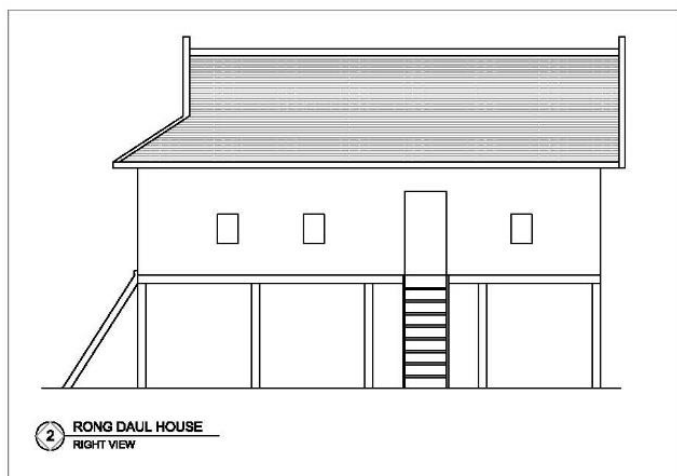


Figure 3.18. Right Elevation of Rong Daul House
(Author)



Figure 3.19. 3D Modelling Top-View (KWP)



Figure 3.20. 3D Modelling Perspective View (KWP)



Figure 3.21. Image of Rong Daul House (a) (Oung, 2001)



Figure 3.22. Image of Rong Daul House (b) (Oung, 2001)

3) Rong Doeung House

Rong Doeung house is found in Battambang province, popular in the year during 1904 to 1927. The house is built with a mansard roof with gables in front and back while it is shorter than Khmer house to make it easier for the construction and use fewer roof materials. The extension of the house is difficult, unlike Rong Dual house. Once completed, Rong Doeung house more or less took their final aspect. (Fig.3.23 to 3.28).

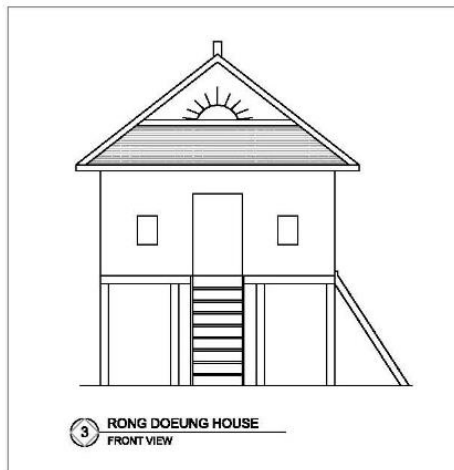


Figure 3.23. Front Elevation
(Author)

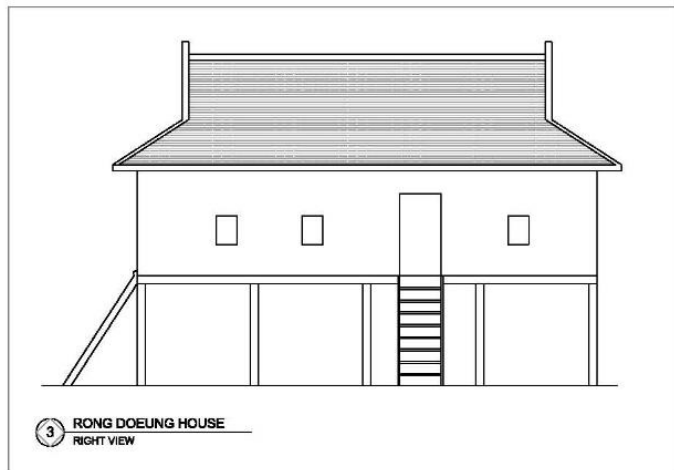


Figure 3.24. Right Elevation of Rong Doeung House
(Author)

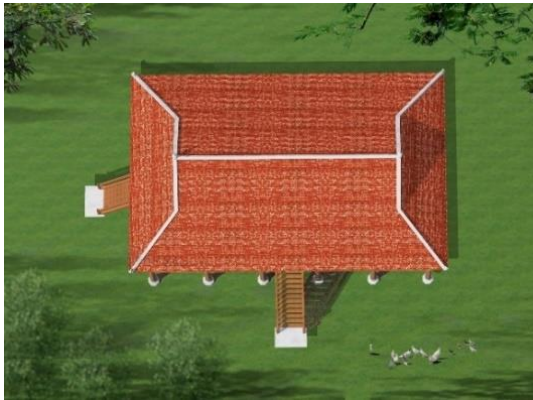


Figure 3.25. 3D Modelling House –
Top-View (KWP)



Figure 3.26. 3D Modelling Perspective View
(KWP)



Figure 3.27. Image of Rong Doeung House
Front View (Oung, 2001)



Figure 3.28. Image of Rong Doeung House
Back View (Oung, 2001)

4) Pet House

Pet house was popular in the year during 1927 to 1941. It appears with several innovations, the length is reduced, and the roof is sloped on four sides as in colonial houses. The kitchen is separated at the rear of the house, the fire being isolated for safety reasons. House ornamentation always kept to minimum, decorative posts on the end of roof ridge added which is almost the only decoration on the house. (Fig.3.29 to Fig. 3.34). Some houses have verandah or porch built in front to enhance the social status.

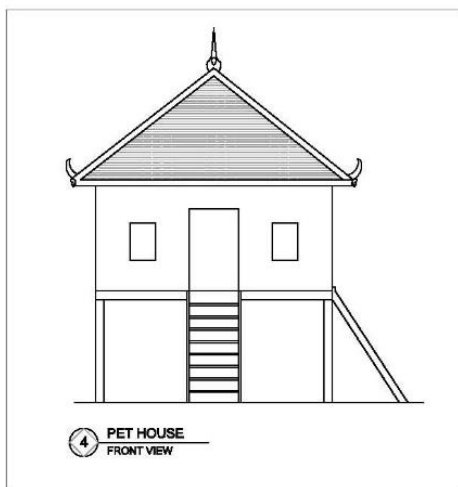


Figure 3.29. Front Elevation of Pet House (Author)

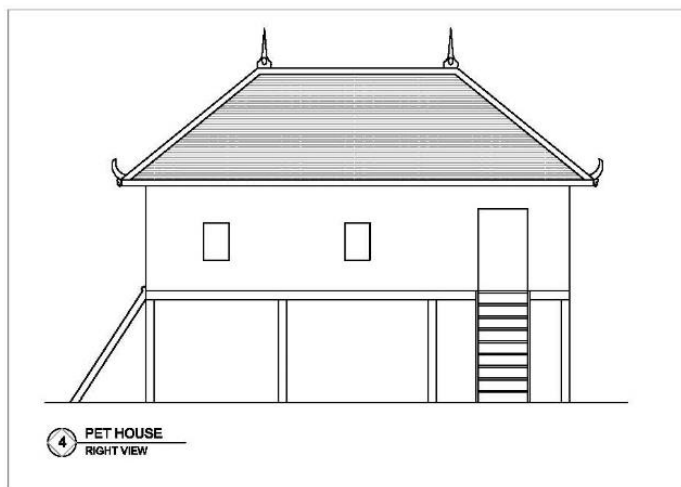


Figure 3.30. Right Elevation of Pet House (Author)



Figure 3.31. 3D Modelling Perspective View (KWP)

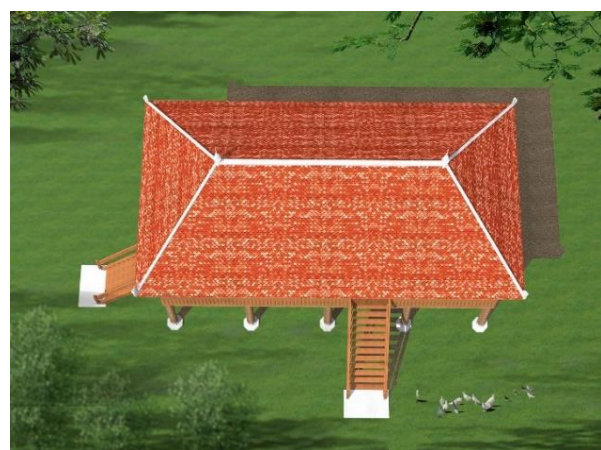


Figure 3.32. 3D Modelling of Pet House – Top View (KWP)



Figure 3.33. Pet House -Kratie province, 1800s (KWP) Figure 3.34. Photo of Pet House (unknown source)

5) Kantaing House

Kantaing House originally brought from Guangzhou province, China via Vietnam to Cambodia, with adaption to local climate. Usually, it is owned by Chinese families who migrated from China during 8th and 19th century. Their occupations mainly related to farming activities or timber trade.

The type of Kantaing house is easy to build. It is built in pitched roof, with two only rectangular slopes on each side running the length of the house, symmetrical and equal in size. The nature of building extensions to the house is becoming relatively flexible in design which mean the back of the house option for further extension (Fig.3.35 to 3.38).

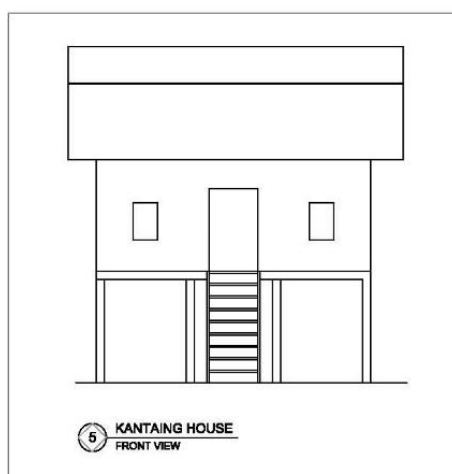


Figure 3.35. Front Elevation
(Author)

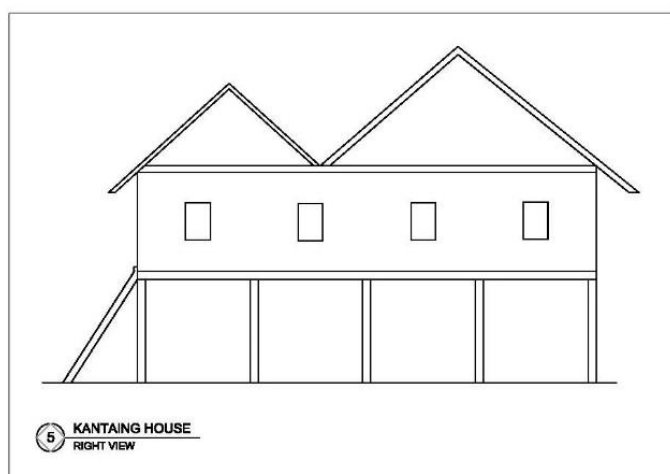


Figure 3.36. Right Elevation of Kantaing House
(Author)



Figure 3.37. Image of Kantaing House (a)
(unknown source)



Figure 3.38. Image of Kantaing House (b)
(unknown source)

3.2.2. The Typical Characteristics of Traditional Cambodian Houses

In this part, we would like to describe the common features that had been used in the traditional Cambodian houses including settlement patterns, exterior form, interior space, landscape and gardening, material, construction, and believes and Traditional Superstition of House Construction.

Settlement Patterns

The Cambodian rural landscape in the 19th Century was defined broadly in three types of settlements.

- 1) Located by river banks or flooded on water with a multi-ethnic population
- 2) Located near rice-growing village inhabited by Cambodian
- 3) In the remote village in the forest populated by ethnic minorities (Chandler, 1998, 102-103)

In term of population, the first type was the most significant (Delvert, 1961, 616). Riverbanks had always been considered ideal locations for village settlement for transport purpose and water supply sustaining both human needs and irrigation.

Yet, over time Cambodian built their houses along street and face to the road where they can easily reach to transportations and do business at home, and it is also for the safety reason (Fig. 3.43 & Fig.3.44).



Figure 3.39. The settlement of traditional Cambodian houses - on water (Sakal HOK)



Figure 3.40. The settlement of traditional Cambodian houses – Siem Reap 1795 (Unknown source)

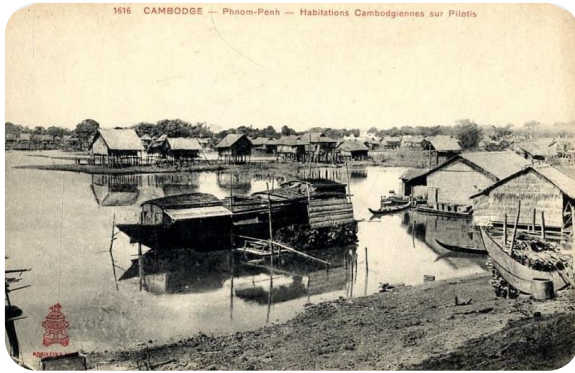


Figure 3.41. The settlement on water – Phnom Penh (Unknown source)



Figure 3.42. The settlement near riverbank (Unknown source)



Figure 3.43. The settlement along the road, Koh Dach (Author)



Figure 3.44. The settlement along the road, Bird View (Sakal HOK)

Exterior Form

The traditional Cambodian house was built in slope roof for better rain removal and heat reflection. The typical sizes of the house vary from four by six meters to six by ten meters, depending on family size and wealth of the family. The shape of the traditional Cambodian houses are typically rectangular two-story buildings with the open-ground floor and enclosed upper floor by elevated up to three meters build on stilt to resist flooding, prevent wild animals, get better ventilation, deter thieves coming in, keep animals and have work space during the day time. One to two wooden ladders or ramp for accessing to the houses-living level or sleeping area.

Interior Space

Typically, traditional Cambodian house contains three rooms separated by partitions of woven bamboo. The front room serves as a living room used to receive visitors, the next room is the parents' bedroom, and the last room is used for unmarried daughters. Sons sleep anywhere they can find space. The houses of poorer persons may contain only a single large room and sleep on the floor. Some houses may have straw mattresses.

Inside the house there is no much furniture. Basically, there are a TV set, a cabinet which are basically placed alongside the walls within the personal space of the inhabitants.

Typically, the kitchen is situated at the back of the house, often some steps lower and attached to the main building. Sometimes the kitchen is in a separate building near the house. Toilet facilities consist of simple pits in the ground, located away from the house, that are covered up when filled. Livestock is kept below the house [Source: Library of Congress, December 1987].



Figure 3.45. Bedroom (Wonyan)



Figure 3.46. Interior view (Author)



Figure 3.47. The Kitchen was attached to the main house (Wonyan)



Figure 3.48. Inside the kitchen (Author)

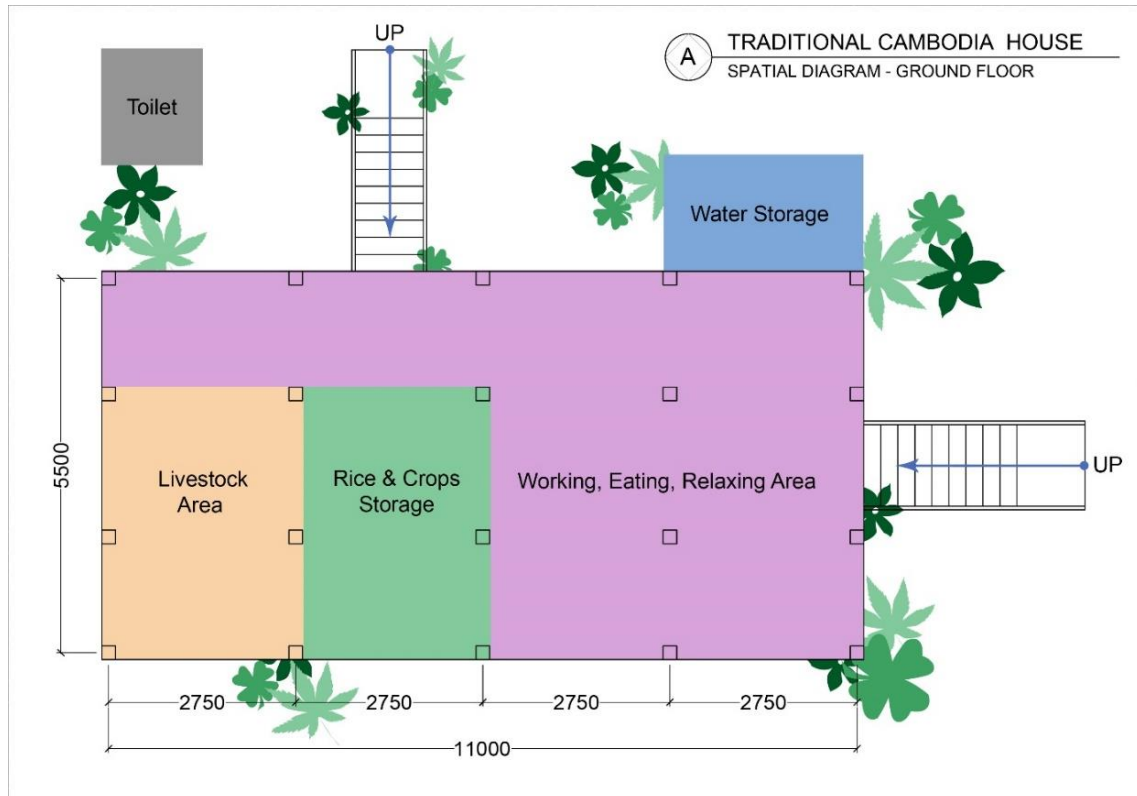


Figure 3.49. Spatial Diagram of Traditional Cambodian house – Ground Floor (Author)

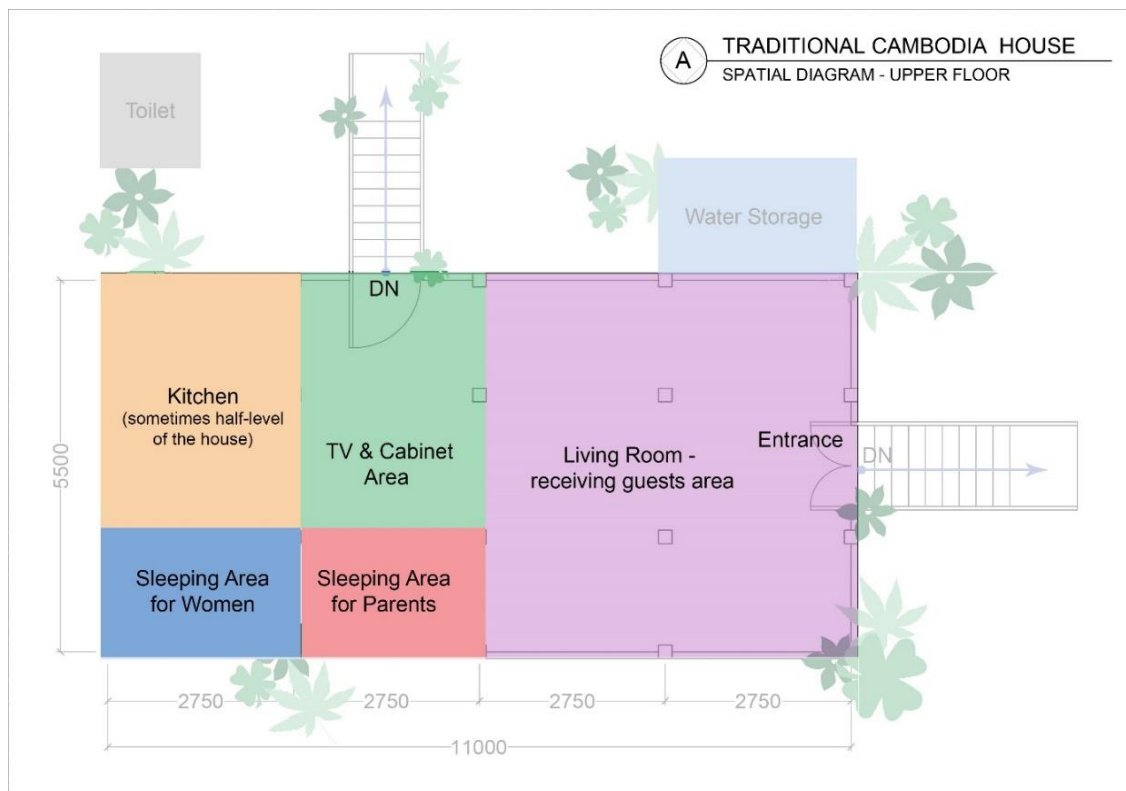


Figure 3.50. Spatial Diagram of Traditional Cambodian house – Upper Floor (Author)

Landscape & Gardening

Vegetables may also be cultivated in Cambodia. In this very common for Cambodian to grow trees surrounding their house. Some trees give as fruits such as banana, mango, papaya trees and etc.

The presence of a pool, pond or canal is also common in the enclosure of most of traditional Cambodian houses, or in the community with several houses. The relationship between water and human settlement is a central element in the organization of space in Cambodia ancient society, a feature described in the account of Cheou Ta Kouan, a Chinese emissary in the Angkor period¹.



Figure 3.51. Landscape of the Traditional House (Oung, 2001)



Figure 3.52. Front View of Traditional Cambodian House (Author)

Construction

The traditional Cambodian house are made entirely of wood. Wooden posts hold the upper floor, walls and roofs. One of the special construction features of the traditional Cambodian house is there is no bracing or shear walls to strengthen structure. Joints are made of square beams, usually passed through posts and locked in position with wedges (Fig. 3.53 – Fig. 3.55).

¹ PELLIoT Paul, Mémoires sur les coutumes du Cambodge, par Tcheou Ta Kouan.in BEFEO Paris 1902, pages 122 – 177.

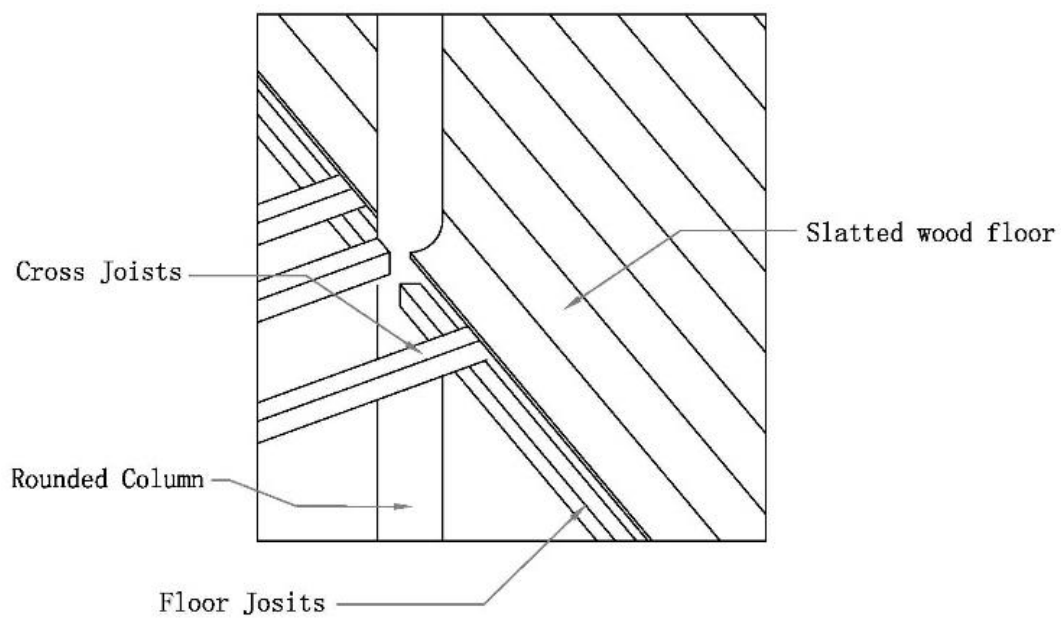


Figure 3.53. Joint Detail – Floor & Column (Author)



Figure 3.54. Roof & Column Joint Structure (Author)



Figure 3.55. Floor & Column Joint Structure (Author)

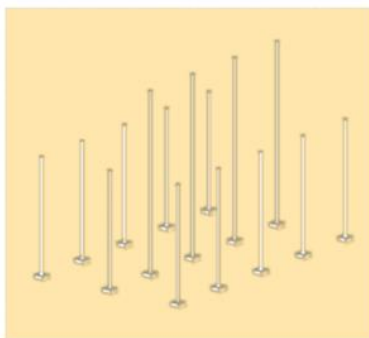
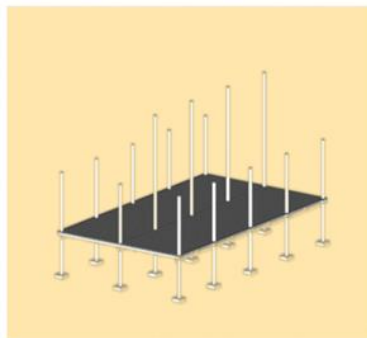


Figure 3.56. Column Structure (Author)



Base Structure



Figure 3.58. House Structure

Believes and Traditional Superstition of House Construction

In term of involving with belief related to Cambodian house construction, we believe that the door ought to build parallel or in the between of two rafters, and it must not build the house above a canal water, otherwise, prosperity would flow out of the house. Moreover, it is forbidden to start construction on full moon holy Buddhist days. In addition, the roof has to be ordered in different height – once roof the highest while the rests are lower, otherwise, it was believed to bring misfortune. During the construction, it is being warned that the female is avoided relating to the construction process.

There are some more traditional superstitions, for example: never grow tamarind trees and frangipani trees (Fig. 3.59 & 3.60) at the south of the house, it may bring bad luck. For a new house, it would never be rebuilt on the same foot-print as old one. Moreover, the house should not build close to neighbor property boundary and avoid digging a well in the south or west.



Figure 3.59. Tamarind Tree



Figure 3.60. Frangipani Tree

There are also some concerns about the house construction materials which may be avoided – Posts which are very important to support the house, they are supposed to be straight smooth, no marks allowed which indicate the past event and avoid knot in the wood (Fig.3.61). It is believed that if the posts contain above items, it will contain any harmful bad luck potential such as disease or misfortune. Especially, a tree grows with three forks (Fig.3.62) at crown also forbidden, the reason is the vultures will build their nest over there which may also allow misfortune (Fig. 3.63).



Figure 3.61. Knot Wood



Figure. 3.62. Three Forks Tree



Figure. 3.63. Vultures Nest upon a Tree

It is believed that it is a duty to seek for a lucky time and place before starting to build the house. The reason is that the house is not only lived for one generation, but it is a legacy that got to be inheriting from one to another generation. Not only this, after picking up to right time and place, there are also two times of house ground-breaking ceremony, such as foundation ritual and house rising.

The foundation ritual, it appears to be a smaller scale, when every equipment and materials are already prepared for the build. The immolated objects are including a chicken, fruits, flowers and the incenses are being lighted in the middle of the house to ask for building permission from the god of the ground and the god of the water to start the construction of a new house (Fig. 3.64). After that, it is time to install the main column or start the construction, then that is the time for the second ceremony, house rising.



Figure 3.64. The Foundation Ritual Ceremony (Oung, 2001)



Figure 3.65. The House Rising Ceremony (Oung, 2001)

The house rising appears to be larger scale compared to the previous one. It can be told that the immolated objects are weight a lot more, such as Bai Sey, roast pig, flowers, chicken, Bai Spok Chveng Sdam, umbrella, sugar cane, banana (both still roots included) (Fig.3.65). Moreover, it is being noticed that the main beam of the roof and main columns are partially wrapped with glittering metal bands, typically the newly built house, which would invite good spirits to protect the house and prosperity after they move in.

3.2.3. Design Techniques Analysis in Traditional Cambodian Houses

The traditional architecture techniques are well-known for its energy saving, using available and local materials, and fully adapt to occupants' need. Below are some of the techniques that have been used in the traditional Cambodian houses in term of *energy efficiency*, *material usage*, *water usage*, and *well-being and quality of life*.

Energy Efficiency

Despite indoor and outdoor temperature of approximately 36°C and up to 80 percent relative humidity, and the absence of air conditioning or mechanical ventilation and lighting, the traditional Cambodian house still very comfortable both ground floor and upper floor by the means of natural ventilation, lighting, and cooling.

The followings are the main strategies and elements of traditional Cambodian house that have sustained the existing comfortable environment for the inhabitants. They are:

- Building Orientation
- Natural Light
- Natural Ventilation and
- Shading

Building Orientation

The wind classes at the position 11.25°N, 106.25°E in Cambodia. The annual wind speed of approximately 5-6 m/s, maximum wind speed in the area, are found in the northeast and southwest (Janjai, 2013). Normally, the longer and opening part of traditional Cambodian

houses were sited on the southwest and northeast orientation to get benefit from natural ventilation (Fig. 3.66).



Figure 3.66. Building Orientation – Ventilation Analysis (Author)

The sun path in Cambodia is from east direction to west direction which mean the sun rise from east orientation and set to west orientation daily. The time of the strongest heat is around 2 and 3 pm where the sun is located at the west direction. Therefore, the houses were constructed by avoiding big opening or important area such as bedroom, any room that occupants spend longer time at the west site to avoid strong glare from the sun during the daytime (Fig.3.67).

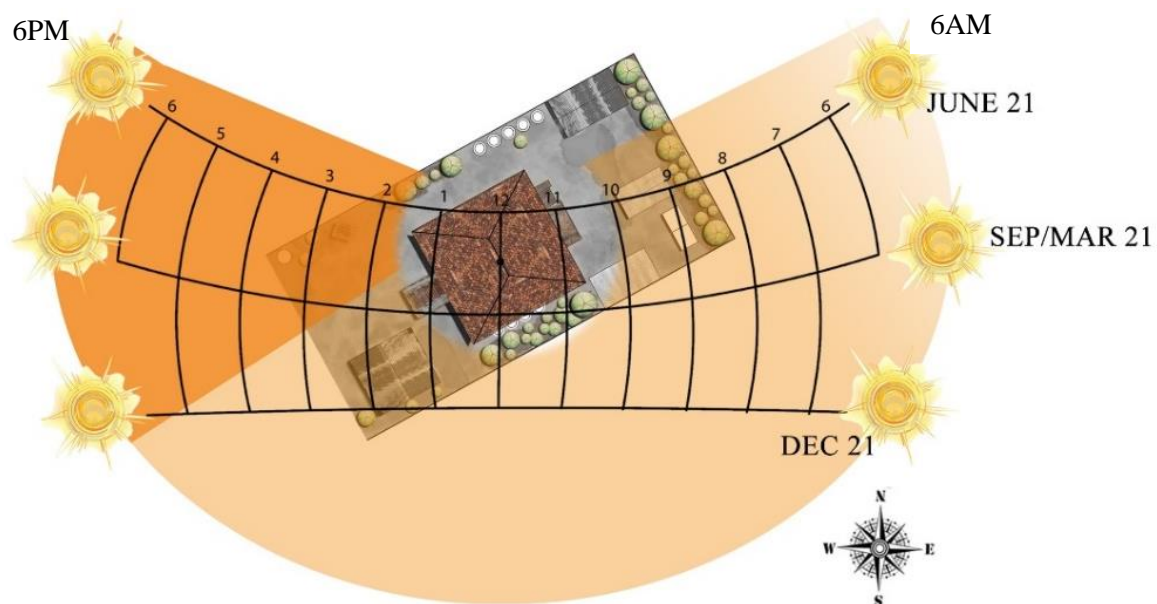


Figure 3.67. Sun-path diagram in Cambodia (Author)_

Natural Lighting

The traditional Cambodian houses had no problem with lack of natural light. The house was designed with big openings and fully open-ground-floor to benefit the natural lighting. In addition, Cambodia is a sunny country, lighting is not a problem, artificial light is not necessary during the daytime.



Figure 3.68. The open-ground floor (Sakol H.)



Figure 3.69. Interior view in the upper-floor (Sakol H.)

Natural Ventilation

One of the well-known sustainable techniques of traditional Cambodian house is a genius design in term of natural ventilation. For instance, the houses were designed with fully open-able windows to allow natural ventilation move to the interior at the body level and release heat from interior to exterior (Fig. 3.70 & Fig. 3.71). The houses were elevated up to three meters for better natural ventilation in ground floor where occupants spend most of their time during the day time. The floor is covered by spilt bamboo with a small gap between each strip bamboo to allows air move from ground floor to upper floor (living and sleeping area) (Fig. 3.72). In addition, the gap about 5 to 10 centimeters between the walls and roof help to remove hot air from interior to exterior (Fig. 3.73). Last but not least, room height is 3.9m – 4.2m and large opening without many partitions can improve ventilation inside the house.

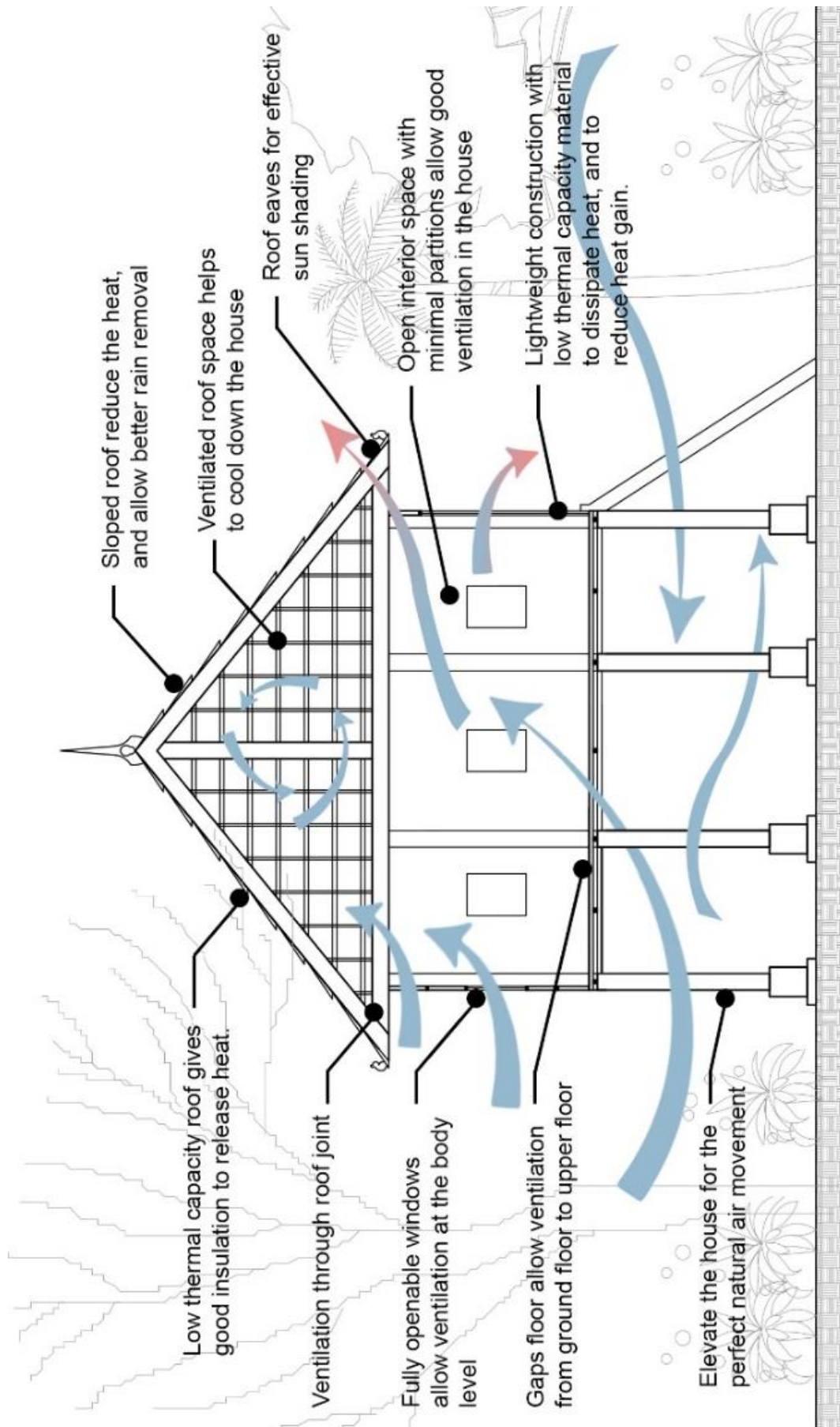


Figure 3.70. Natural Ventilation Diagram of Traditional Cambodian House Section (Author)

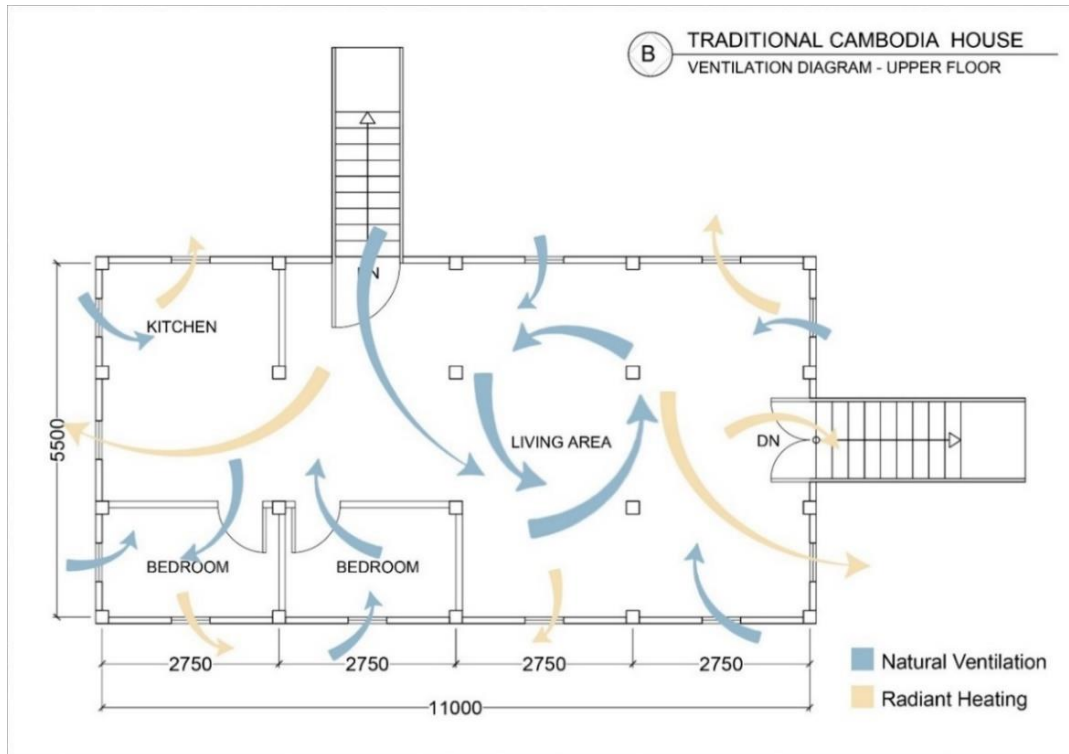


Figure 3.71. Natural Ventilation Diagram of the Traditional House – Floor Plan (Author)



Figure 3.72. The openable (Author)



Figure 3.73. Split bamboo floor (Author)

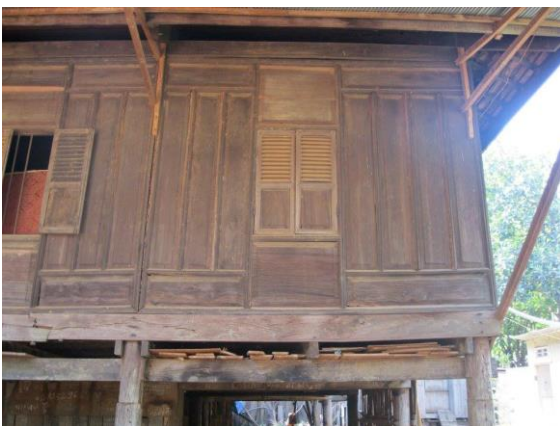


Figure 3.74. The gap between walls and roof (Author)



Figure 3.75. Interior roof view (Author)

Shading

Trees and plantation shade the house from the intensive sunshine and break down the strong wind and storms. Deep eaves provide shading for walls and occupants (Fig.5.51 & Fig. 5.52).



Figure 3.76. Roof Eave (Phnom Penh Post)



Figure3.77. Plantation and shading (Jeffrey, 2014)

Material Usage

Cambodia located in the tropical area which make the country has a lot of trees. Therefore, the construction of the traditional Cambodian house was constructed with most suitable local and natural materials, such as wood, thatch, palm or bamboo.

The materials of traditional Cambodian house are light or medium weight materials for better insulation, dissipating heat, and reducing heat gain. For instance, thatch roof provides ideal insulation (U-value 0.25 – 0.35 W/m²K). Thatch roof absorbs moisture which reduces overheating by evaporative cooling effect.



Figure 3.78. Palm matting (Wonyang)



Figure 3.79. Palm matting wall (Wonyang)



Figure 3.80. Split Bamboo Floor (Author)



Figure 3.81. Wooden wall and structure (Author)



Figure 3.82. Trang leaves window (Author)



Figure 3.83. Wooden door (Author)

Water Usage

Cambodian people use water from rain-water and store it in the large jars for their everyday use. They design their house with slop roof and pile to allow rain-water to flow into their jars. Well, river or lake is also another source of water for Cambodian. They are used for washing, showering and cooking.



Figure 3.84. Large jars (peang) (Author)



Figure 3.85. The Well (Author)

Quality of life and well-being

Traditional Cambodian house is designed to fit with Cambodian's life-style which is considered as a perfect example of dwellings. Most residents live in a real attachment to their place where they can identify themselves, where they can feel belonging to their place.

The traditional Cambodian house provides both living and working area which is vital in the everyday life for Cambodian. During the day time, the house functions as a large umbrella. Work and life go on at ground level, where the most effective shade is provided. The area is used for eating, resting, keeping livestock and rice, and working area such as silkworm breeding, tobacco, cotton- or silk weaving. People do not stay upper floor area during the daytime. Generally, the upper floor is used for the sleeping area at night time, studying, giving advice, telling tales, and storing clothes, furniture, and valuables things.



Figure 3.86. The villagers are working at the ground floor (Dordain)



Figure 3.87. The Villagers' life-style (Dordain)

3.2.4. The Decline of Traditional Cambodian House

Cambodia is passing through a period of demographic and economic change with rapid urbanization. The population of the capital, Phnom Penh, and other urban areas are growing rapidly, and similar change are also occurring in the countryside. In Phnom Penh, high rise buildings have begun to appear, traffic congestion is increasing and lifestyles are changing which result traditional practices in house construction also subject to rapidly change.

According to studies by the Phnom Penh Municipality, the population growth rate is 2.5 percent per annum. That implies that about 40,000 people increase per year, or about 7,000 to 8,000 households are needed. This rapid expansion tends to weaken the traditional methods of construction in many ways:

- Influence from modernism and civilization especially during France Colonial in 19th century
- The high land prices have pushed people toward multi-story dwellings
- Higher urban density also leads to architectural choices and permit less initiative for ritual or symbolic references
- The ground floor of the house is enclosed by masonry walls. Inhabitants were interviewed in Siem Reap province explained these changes as an attempt to meet the needs arising from new activities more focused on trade or mixed activities that require a closed shelter. Some of them talked about the need for safety, better comfort and providing for the installation of equipment under the house.
- Family structure has decreased from extended to nuclear families. Changes in family structure also a subsequent change in housing form which has implications for new housing design (Cohen, 2005).

3.3. Contemporary Cambodian House

In the previous chapter, there were a discussion of the types and design elements of traditional Cambodian house. In this chapter, focuses on contemporary Cambodian houses to see how they are different and similar in term of types, design elements and its sustainability from the traditional.

3.3.1. Types of Contemporary Cambodian House

The contemporary Cambodian houses are designed to fulfil the need of the current living style which normally inspiring from western style, some were developed from the traditional architecture.

Here are the types of the contemporary Cambodian house:

1. Modern Khmer House
2. Flat house and Shop house
3. Villa
4. Apartment and Condo

Below are some of the examples of the contemporary Cambodian houses.

Modern Khmer Houses

100 Houses

The 100 houses are the good examples of modern Khmer house. The houses were designed by Mr. Vann Molyvann, a famous Cambodian architect. They were built in 1965, located in Phnom Penh, the capital city of Cambodia. The houses were built on 6.5 hector land. Initially, the houses were integrated modern reinterpretation of the traditional Cambodian houses.

Early in his study in France, Vann Molyvann recognized in Le Corbusier's Villa Savoye many similarities to the Khmer house, and the design fuses these traditional elements with Modernism. The frame of the house is concrete, rather than wood. Beam and column of the 100 houses were built from reinforced concrete; the wall was made of brick finish by paint plastering, and roof structure was made from wood cover by earthenware roof tile. Modern utilities and plumbing were included.

The arrangement of the houses was designed carefully by placing every house back and forth to allows wind flow to the houses (Fig. 3.88 & Fig.3.89). They are surrounded by greenery with soil and pond. The greenery factions as natural shading devices and as rainwater

harvesting to prevent flooding. Furthermore, greenery helps to clean the air and cool wind temperature and provide a comfort area underneath the house that is the location mostly people stay.



Figure 3.88. The top view of the 100 houses (Google Earth, 2017)



Figure 3.89. The arrangement of the 100 Houses, the graph shows the cross ventilation through houses (The Vann Molyvann project, 2015)

The 100 houses consist of two outdoor staircases, primary stair, and secondary stair. The main stair is used as the main entrance for welcoming visitors. As you see in figure 3.90, the stair is accessed directly to living without pass-through wet area (kitchen and toilet). Secondary staircase is used for workers and owners for access to the kitchen without passing through the living area, and without intercept welcoming way for visitors. Terrace area can be used for dinner, sitting, relaxing, drinking which is next to the kitchen where we can access easily to get food and drink. The kitchen is enclosed; air or smoke can flow out through the opening and chimney at the top of it.



Figure 3.90. Floor Plan of the 100 House
(Vann, 2015)



Figure 3.91. The Modeling of the 100 House
(Vann, 2015)

The 100 houses draw on elements of the traditional Cambodian house such as the house consists of two stories building, opened-ground floor, and enclosed upper floor. They are elevated above the ground to allow cross ventilation, prevent the flood, it creates a shaded outdoor living space. The hipped roof slopes pass the walls of the house around 1300mm long to protect from rain and sunlight. The roof is designed to allow air to enter under the eaves and exit from a vent at the peak (Fig.3.92).

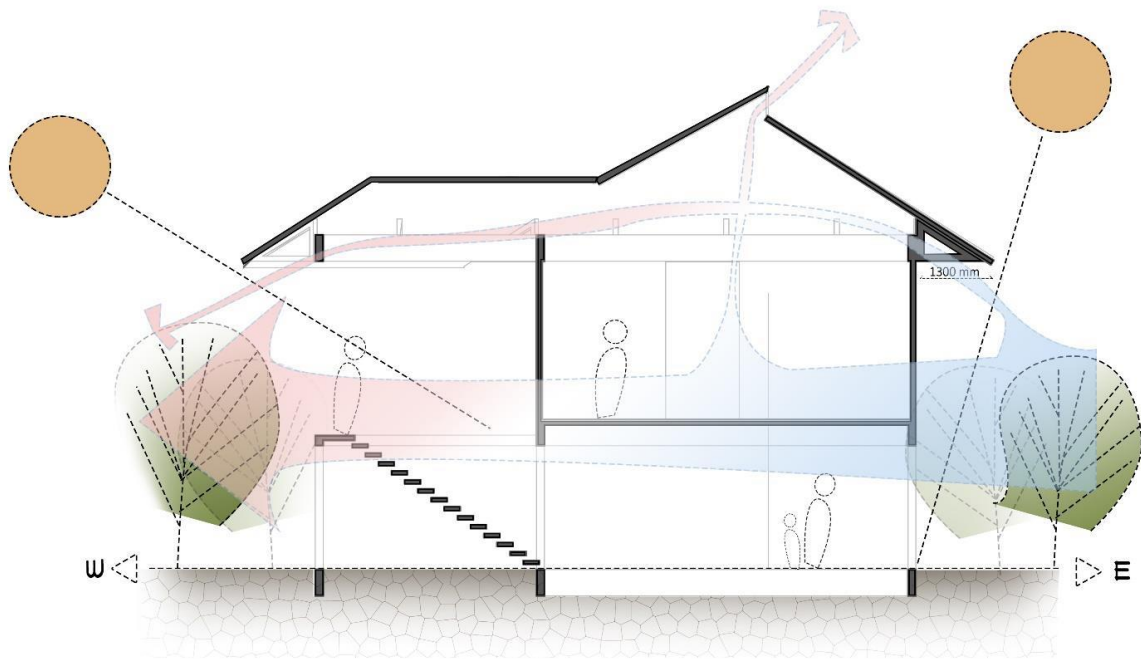


Figure 3.92. Sun & Wind Diagram of the 100 House (The Vann Molyvann project, 2015)

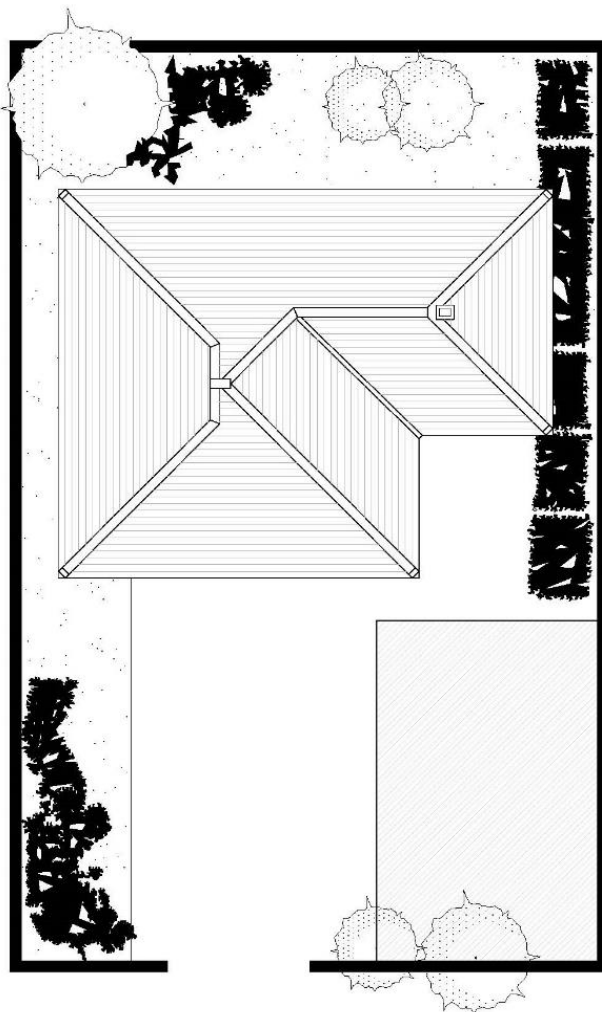


Figure 3.93. Master Plan of the 100 House (The Vann Molyvann project, 2015)

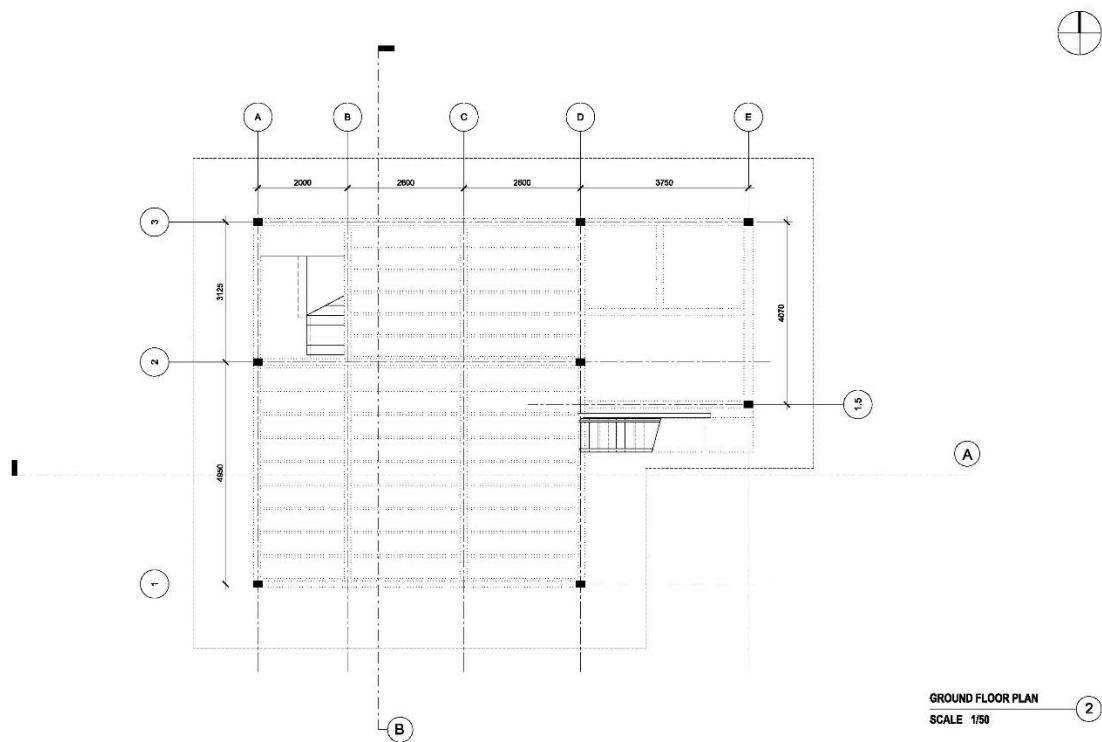


Figure 3.94. Ground Floor Plan (The Vann Molyvann project, 2015)

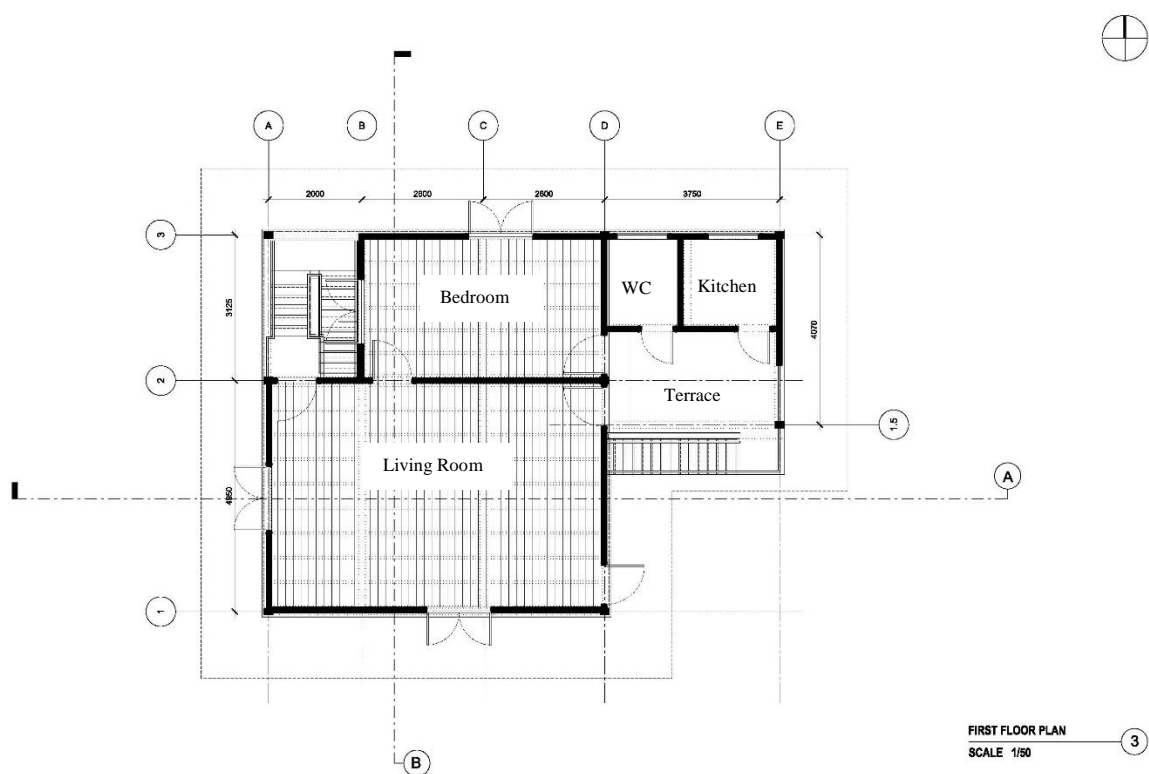


Figure 3.95. First Floor Plan (The Vann Molyvann project, 2015)



Figure 3.96. North Elevation (The Vann Molyvann project, 2015)



Figure 3.97. East Elevation (The Vann Molyvann project, 2015)



Figure 3.98. East Elevation (The Vann Molyvann project, 2015)



Figure 3.99. West Elevation (The Vann Molyvann project, 2015)

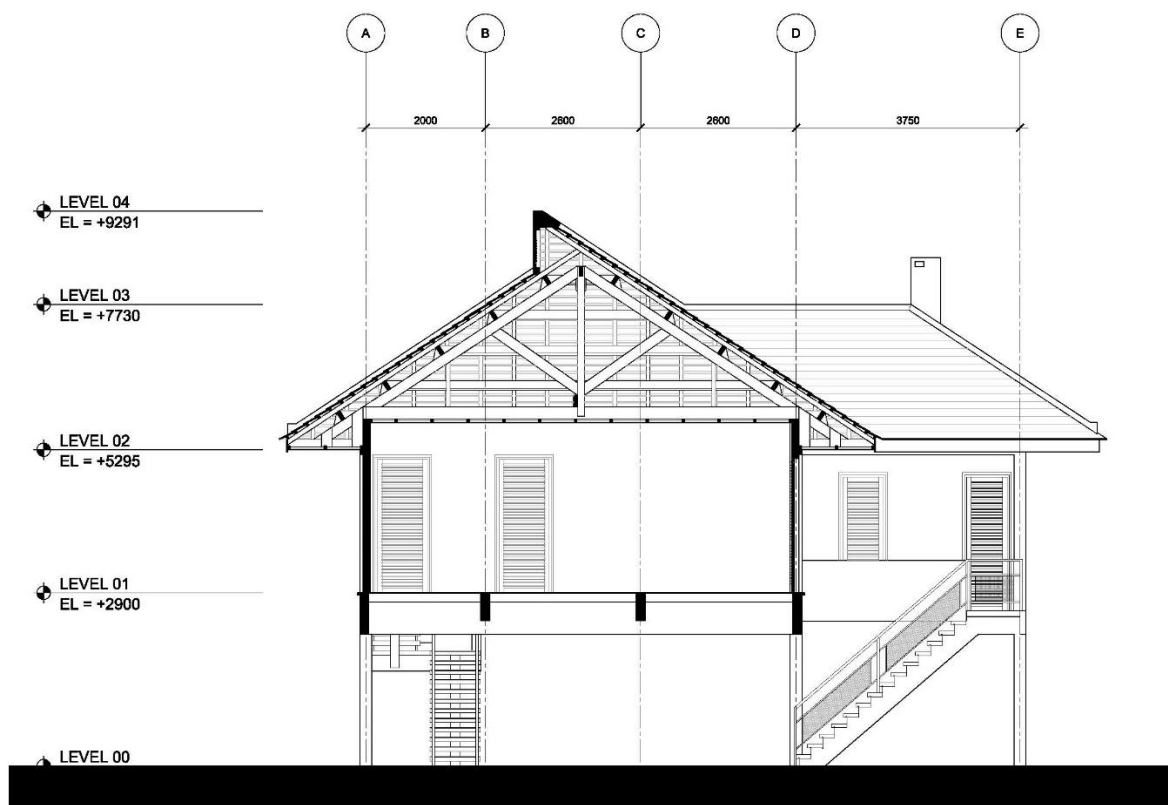


Figure 3.100. Section AA (The Vann Molyvann project, 2015)

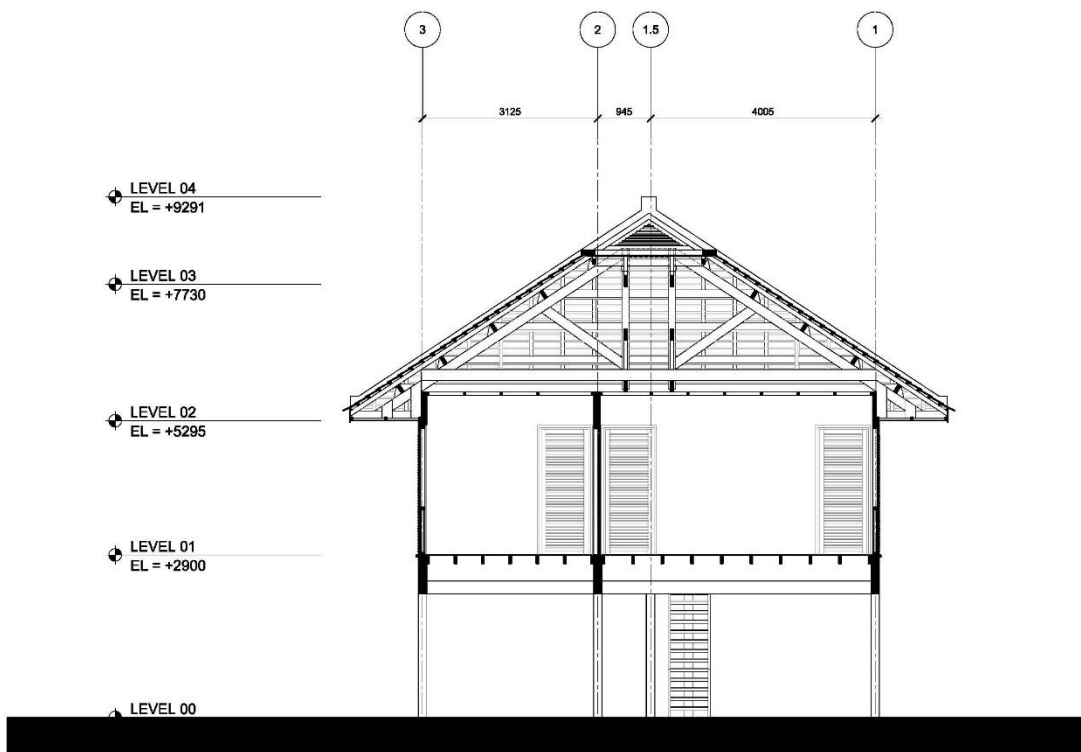


Figure 3.101. Section BB (The Vann Molyvann project, 2015)



Figure 3.102. The 100 Houses (Vann)



Figure 3.103. Roof Overhang (Vann)



Figure 3.104. Upper-floor View (Vann)



Figure 3.105. Ground floor (Vann)



Figure. 3.106. Ceiling (Vann)



Figure 3.107. Roof structure



Figure 3.108. Beam structure

Courtyard House

Courtyard house is designed by respect vernacular Cambodian dwelling, located in Kandal Province, Cambodia. Its aim to combine elements of the traditional Cambodian dwelling with a number of contemporary elements that make the idea of a comfortable, attractive, healthy, and sustainable house, for a medium-sized family.

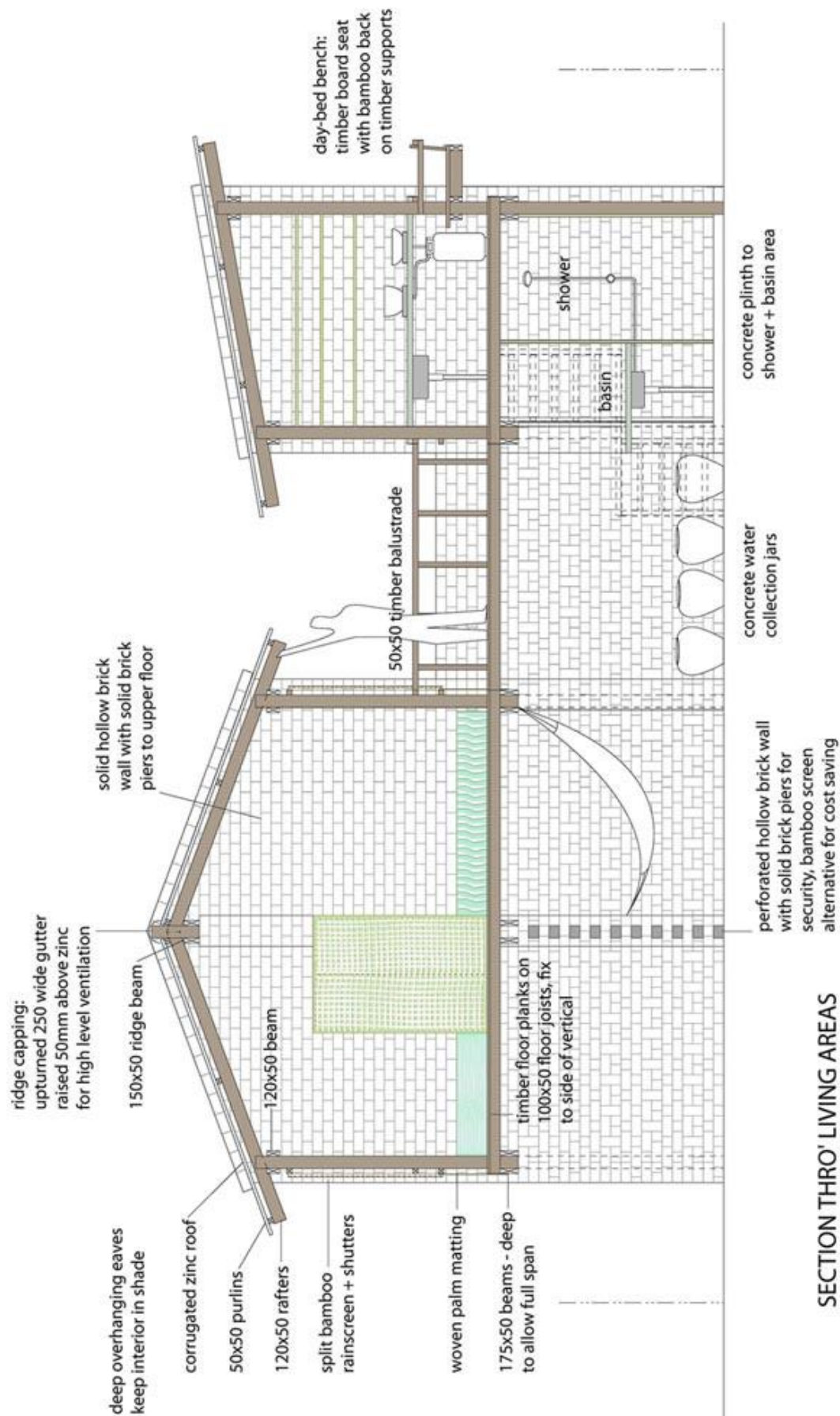


Figure 3.111. Section through Living Area (Fatemeh, 2015)

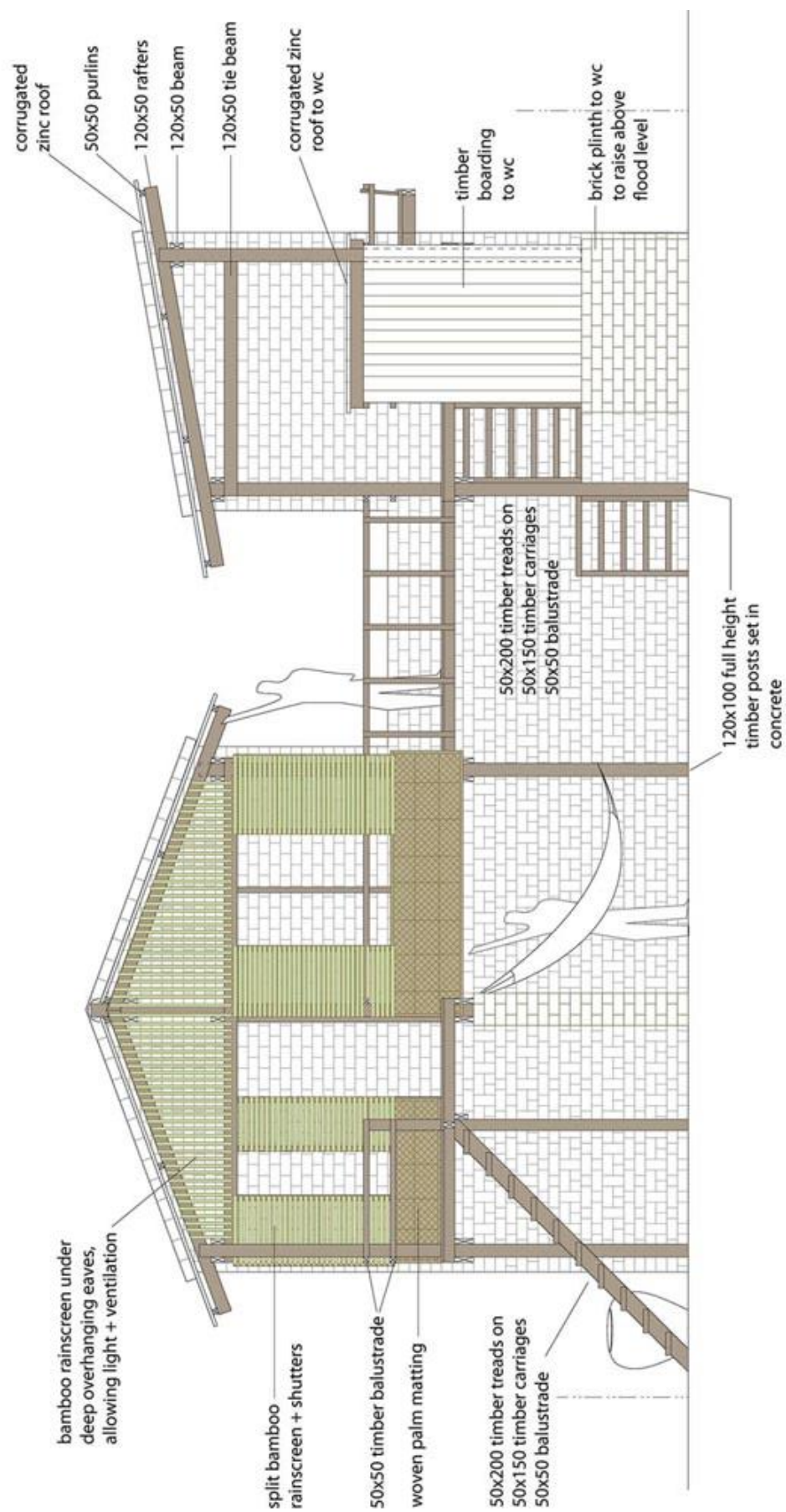


Figure 3.112. Section through Stair (Fatemeh, 2015)



Figure 3.113. The Courtyard House (Fatemeh)



Figure 3.114. Wall Material (Fatemeh)



Figure 3.115. Floor Material (Fatemeh)

1. Flat house and Shop House

Flat house and shop house are very common and popular houses in Cambodia nowadays because they are easy to build, save space and cost less. The houses are built in a rectangle shape with typical dimension 4 meters by 20 meters. They are constructed in one or more

stories building depend on the occupants' need and wealthy. The flat house and shop house are built enclosed ground and upper floors by masonry for safety and business reason. The roof shape is inspired from Kantaing house, one type of traditional Cambodian house, two rectangular slopes on each side running the length of the house, symmetry and equal in size.

The flat house and shop house are built link with each other up to 20 houses without any gap to allow natural light go through and natural ventilation flow in. Consequently, the house needs to use electricity and artificial cooling day and night time.

The shophouse is functioned for both living and working. Occupants use ground floor as a grocery store, café, small restaurant, office and etc.

The interior of the houses is separated by masonry to rooms in different functions such as public space (living room, kitchen, and dining room), private space (bedroom and home office). The ceiling is built low to save construction materials; however, this could create uncomfortable to the occupants. The wealthy people may prefer live in a villa rather than flat house and shop house.



Figure 3.116. Flat houses (a) (Author)



Figure 3.117. Flat houses (b) (Author)



Figure 3.118. Shop houses (a) (Author)



Figure 3.119. Shop houses (b) (Author)

2. Villa

Villa is used for living, owned by rich and high range people. It consists of one, two or more stories depend on the need of the occupants. The shape is undefinable, some are cubie, some are zigzag. Besides the building, there is a small garden near the house where the owners can spend time sitting outdoor, and a parking area where they can park one or two cars. Some villas are also included a pool in their property. The villa is much more special than flat- and shop-house, it has its own gate and is arranged with a gap from one to another villa which can benefit from natural lighting and ventilation. Unfortunately, some owners choose to close windows and use artificial cooling such as air-conditioner and fan, instead of opening windows for the natural ventilation.

Similar to the flat-house and shophouse the roof shape is inspired from traditional Cambodian house, but it looks more modern. The interior is divided into different function rooms by masonry.



Figure 3.120. Villas in Phnom Penh (a)



Figure 3.121. Villas in Phnom Penh (b)

3. Apartment and Condominium

Apartment and condo are other types of residential building in Cambodia, particularly in Phnom Penh Capital. They are rapidly grow during these last five years. However, they are not yet very popular among Cambodian. Cambodian people still prefer to live in separate house. They are for foreigners like Chinese and Korea who come to live and work temporarily in Cambodia.

Apartment and condo are built in many stories. These types of buildings have used quite a lot of energy for its facilities, but the good is that it can save the footprint of the land. Typically, the material used for construction in apartment and condo are masonry, steel, glass, reinforced concrete, and other modern materials.



Figure 3.122. The Condominiums locate in Phnom Penh (Author)

3.3.2. Typical Characteristics of Contemporary Cambodian House

Similarly, to the traditional Cambodian House, contemporary Cambodian houses also have some common features. This part will describe the typical characteristics of the contemporary house in Cambodia such as settlement patterns, exterior form, interior space, access, landscape and gardening, material, water, and quality of life and well-being.

Settlement Patterns

Due to pricey land, most of the contemporary houses in Cambodia commonly build close to each other, without any gap from one house to another. Without the gap means, the house cannot have windows with at the sides. Thus, the view, light, and air are blocked which lead to discomfort both physical and mental to the occupants.

Exterior Form

There is no clearly defined form or shape in contemporary Cambodian house. Some houses are rectangle, square, and round, depend on occupants' preference. However, we can see a typical shape of the house is a rectangle with a sloped roof, and enclosed ground and upper floors.

Interior Space

Unlike the traditional Cambodian house, the contemporary Cambodian house is divided into rooms, each room has its own functionality such as bedroom, living-room, kitchen and dining room, and storeroom. The house is filled with many types of furniture such as television cabinet, decoration cabinet, sofa, dining table, cupboard, chairs, and etc.



Figure 3.123. Livingroom (Author)



Figure 3.124. Kitchen (Author)



Figure 3.125. Bedroom (Author)



Figure 3.126. Bathroom (Author)

Access

Unlike to traditional Cambodian house which contain two staircases attach outside the house, the contemporary house integrates the stairs inside the house. The owner can enter the house directly through door. Most of houses that own by wealthy people integrate with gate for the security and privacy.

Landscape and Gardening

Most of the flat-house and shophouse do not integrate garden in their property, except some villas which have a small personal garden and pool in their property.



Figure 3.129. Mini garden (Author)



Figure 3.130. Pool in Villa (Author)

Material

The contemporary Cambodian house is built with the masonry wall, steel structure, clay and concrete tile roof, glass with steel frame window, wooden door and other modern material.

Water

Unlike the traditional Cambodian house, the contemporary house uses water that supply by utilities.

Quality of life and well-being

The development of technology and civilization have made human isolate from real attachment from the community. People prefer to live in the house, children prefer to stay inside bedrooms. The contemporary house is designed to fulfill the need of occupants by enclosing ground- and upper- floors for security and privacy reason; the interior space is divided into rooms for different functions. Houses are linked with each other due to the pricy land. Artificial lighting and cooling are used day and night for extra comfort.

4. DISCUSSION

The evolution of the building keeps changing base on the need and people's lifestyle. Therefore, the Cambodian houses also have some criteria have been developed to adapt to the modern style of living. For instance, the buildings are built high-rise to fulfill the need of the growing population; the houses are built enclose to guaranty the security. They build with strong and modern materials for the long-term use and protection from natural disaster. However, some modern development is lack of awareness of sustainability which occurs the high of energy consumption.

To see the development of the building, this chapter will define the parallels and differences of the traditional Cambodian house and contemporary Cambodian houses. Three houses are chosen to make the comparison. They are traditional Cambodian house, modern Khmer house (100 house) and flat house. The modern Khmer are chosen to make comparison with traditional Cambodian house because it is one of the good example dwellings that have been designed by inspire design techniques from the traditional Cambodian house. Flat house also is selected for comparison due to it is one of the most popular settlements that seem to appear everywhere in Cambodia nowadays.

Table 4.1. The comparison between traditional Cambodian house and contemporary Cambodian house:

The Comparison of Traditional & Contemporary Cambodian Houses	Traditional Cambodian House	Contemporary Cambodian House	
			
Style	<u>Traditional Khmer House</u>	<u>Modern Khmer House</u>	<u>Flat House</u>
NATURAL LIGHT			
Natural Light	More windows	Wide windows	Less windows but wide windows

Table 4.1. The comparison between traditional Cambodian house and contemporary Cambodian house (Cont.)

Exclude direct sunlight	- Avoid the house face to west direction - Louver Design	Inspired by the traditional house	x
Sun Shading	Deep overhang, shading devices and plantation	Inspired by the traditional house	Short shading devices Less greenery
Preventing excessive absorption of heat	Sloped roof	Inspired by the traditional house	Inspired by the traditional house
	Use low and medium thermal capacity	Medium and heavy weight material	Medium and heavy weight material
NATURAL VENTILATION			
Cooling the building and air	Located nearby the river	Located near main road, school, market, or hospital	Located near main road, school, market, hospital and community zoon
Enhancement of air turbulence	Built along the natural breeze (northeast and southwest)	Inspired by the traditional house	x
	High ceiling and wide windows	Inspired by the traditional house	Low ceiling
	One big open living space with less partition	Inspired by the traditional house	Living area partitioned
	Using stake-ventilation (A gap between wall and roof)	Inspired by the traditional house	x
	Raise up the house	Inspired by the traditional house	Multi stories building with enclosed both ground floor and upper floors

Table 4.1. The comparison between traditional Cambodian house and contemporary Cambodian house (Cont.)

Enhance air-movement	The house had a gap from one to another	Inspired by the traditional house	The houses are linked with each other without any gap
Temporary provision for air movement	Use a lot of opening	Inspired by the traditional house	Only front and back opening, no side windows
MATERIAL			
Construction Material	Wood	Concrete	Concrete
Finishing Material	Use low and medium thermal material	Painting in Bright color finishing	Painting Multi-color finishing & Glass
WATER			
Water usage	Rain water, well, pond or lake	<ul style="list-style-type: none"> - Water from water authority - Rain water is used for secondary source 	Water from water authority
OTHER			
Disposal of rainwater	Gentle sloped roofs	Inspired by the traditional house	Inspired by the traditional house
To break-down the strong wind	Planting trees	Planting trees	Less Plantation

According to the analysis and comparison of sustainable techniques in term of *energy efficiently, material usage, water usage, and quality of life and well-being* in traditional and contemporary Cambodian houses, the outcome of the study is indicated that the traditional Cambodian house is creatively design adapted to the local climate conditions without using

excessive energy; minimized damage to the natural environment by reducing energy need through the effective use of natural resources. It provides comfortable and healthy living environment fulfill the need of occupants' living style.

Below are the sustainable criteria that have been inspired from traditional Cambodian houses. They are summarized as below:

Energy Efficiency

- *Orientation*: The opening of the house should face to northeast or southwest direction for the benefit of natural ventilation due to the maximum airflow in Cambodia found in these two orientations. Moreover, designers should avoid the building and opening face to west direction to avoid the strong heat during the daytime.
- *Arrangement*: The building should have a good arrangement. For instance, from one to another building, it should have a gap to promote airflow and remove the heat.
- *Elevated house / open ground floor* could improve a better ventilation.
- *Cross Ventilation*: Open-able windows allow air flow to the interior at the body level.
- *Stack Ventilation*: A gap between roof and wall can remove hot air from interior to exterior.
- *High ceiling with less interior partition* to have a better air movement inside the building
- *Opening*: A lot of big openings can benefit from both natural light and ventilation.
- *Deep eaves or Shading devices* provide shading to the house as well as the owners
- *Water cooling*: the presence of the water encloses to the house help to cool down the building and air, as well as mentality comfort to the occupants
- *Plantation*: The greenery factions as natural shading devices, and as rainwater harvesting to prevent flooding. Plantations and trees can break down the strong wind and storms. Furthermore, greenery helps to clean the air and cool wind temperature and provide a comfort area underneath the house.

Material Usage

- Minimize the use of material
- Use local and available material could reduce the transportation and increase country economic

- Use light and medium weight material, the heat can dispatch faster; and it is convenient for construction.

Water Usage

Cambodia is known as rainy country. If the citizen collects rainwater during the raining season, they can use it for gardening and toilet disposal.

Quality of life and well-being

Traditional Cambodian house is designed to fit with Cambodian's lifestyle which is considered as a perfect example of dwellings. Most residents live in a real attachment to their place where they can identify themselves, where they can feel belonging to their place.

5. CONCLUSION

The design of traditional Cambodian house is constructed in harmony with the climate of the region, land structure and natural environment, minimizing damage to natural environment by reducing energy need through effective use of natural energy sources. It was resulted to the fulfil need of the local culture, provide comfortable, healthy and sustainable living space. Material and construction techniques are taken from the local context. The importance of well-being is reflected in the emphasis on fresh air, natural light and spatial variety to accommodate individual needs. Some of the traditional techniques have been influence to the new designs which is interpreted that the architects and new developers are also interested of the traditional techniques. It is a positive sign to show that in the future, the design techniques of the traditional architecture will be integrated more to the contemporary architecture.

The contemporary houses are designed to adjust the living style nowadays. The houses are enclosed both ground- and upper-floor for security and business purpose. The materials are changed to make the construction stronger. The population are increasing, the single house has to change to multi-storeys building such as apartment and condominium to save footprint land. Therefore, it leads to inefficiently in term of using natural resource which lead to environmental problem.

For the further research will research the local material, recycle material and renewable energy that can be use in building. In construction sector, material and energy are the main criteria that have been used in a large amount. To make those materials for construction and produce energy of everyday operation, lead to lot of waste that create to pollution to the environment. Therefore, the next study analyzes the material that have less effect to environment, for instance, bamboo. Bamboo is one the plants that is easy to grow, and fast-growing tree; and it can be used for construction material.

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RESUME

Personal Information

Surname, Name : HEANG, Vichera
 Nationality : Cambodian
 Date of Birth, and Place : 15. May.1992, Kompong Cham, Cambodia
 Marital Status : Married
 Telephone : +855 70 328 351
 E-mail : vichera09@gmail.com



Academic Background

Level	School	Graduation Year
Master Degree	Gazi University /Architecture	Present
Bachelor	Limkokwing University of Creative Technology / Architecture	2013
	University of Puthisastra / English	2013
High School	Preah Sisowath High School	2009

Work Experience

Year	Place	JD
2012-2014	SOMA Construction & Development Co., Ltd	Architect

Foreign Languages	Mother Tongue
English & Turkish	Khmer

Habit

Swimming, reading and exploring new places



GAZİ GELECEKTİR..