Investigation of the Bioclimatic Origins of the *Diaojiaolou* Form in Rural Chongqing, China

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By
Peter Kempson
(B.S.,Trinity College, 2011)

Thesis Committee
Shiqiao Li, Chair
Louis Nelson,
Bill Sherman.

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Introduction:

On the bank of the Yangtze River, in the Sichuan basin just downstream of the Tibetan Plateau and spreading out through the mountains, sits a house. The building sits half on the earth, using it as the floor, and half on timber columns and beams that reach down to the soil and rocks below. The walls, filled with panels of woven bamboo showing through chipped off limestone plaster, reach up and peak in the center of the home's long body. The panels rest on wood columns and beams that peek through the plaster coat. Sitting in the second floor attic the columns run into the purlins and support the terra cotta tiles that keep out the hot and humid climate rain through nothing more than their arrangement. The half sitting on the earth peels open its front wall, folding the wall panels into the side walls and inviting those passing by to approach. The kitchen sits on the transition to wood planks over hanging the drop to the river below, and a small balcony overlooks the river.

This home is known as a *diaojiaolou* (吊脚楼), a traditional housing form that rests on stilts and is found in southwestern China, spread throughout the mountains and cultures found there. The *diaojiaolou* is part of a larger family of stilt, timber frame homes known as *ganlanlou* (干栏楼),[1] or just *ganlan,* found in southern China, and tracing back 7000 years to the beginning of Chinese architectural history.[2] *Ganlan* buildings are found all across the mid-Yangtze River region[3] and are used by ethnic minority populations living in the mountain regions of Guizhou, Guangxi, Sichuan, and Hunan Provinces and the ethnic Han Chinese further north around Chongqing.[4] *Ganlan* structures vary greatly in size, location, and complexity of construction giving rise to many different sub-types. The *ganlan* sub-type *diaojiaolou*, a "scaffold structure,"[5] does not have a large English-language documentation base, but the sources that do exist make bold claims about the bioclimatic purpose of its peculiar form. This thesis will address both of these issues. The field work conducted for this thesis focuses on two historic town south of the city of Chongqing; three case studies from the Historic Town of Zhongshan, Jiangjin, southwest of Chongqing, and two from the relocated city of Gongtan to the southeast on the border of Guizhou Provence.

Once spread throughout the mountains of the Sichuan basin, the rapid growth of industry in Chongqing and Sichuan, coupled with the construction of the Three Gorges Dam, has destroyed many of the traditional *diaojiaolou* buildings. Fortunately, the

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[1] Literally translating to "dry column floor/building", Ronald Knapp. China's Old Dwellings. Honolulu: University of Hawai'i Press, 2000, 285
[2] "Survey: Chinese Traditional Architecture" by Xinian, Fu, translated by Virginia Weng, in Nancy Shatzman Steinhardt. Chinese Traditional Architecture. New York City: China Institute in America, China House Gallery, 1984, 16
[3] Ronald Knapp. China's Old Dwellings, 285
[4] Xinian Fu [et al.]. *Chinese Architecture*. Culture & Civilization of China. Edited by Nancy Shatzman Steinhardt. New Haven: Yale University Press, 2002, 316
[5] Ronald Knapp. China's Old Dwellings, 285

historic towns of Zhongshan, Jiangjin, southwest of Chongqing and Gongtan to the southeast on the boarder of Guizhou Provence maintain many examples of *diaojiaolou*. The three case studies sit on the Sunxi River in the Ancient Street of Zhongshan and two sit up the hill from the Wujian River in the displaced city of Gongtan. Each town's history has shaped the treatment of the *diaojiaolou* found within them.

Zhongshan is an ancient Chinese town just south of the city of Jiangjin in the Chongqing Municipal Province, 120 km Southwest of Chongqing City by bus. The historic Sanhe Street runs along the Sunxi River for just over one kilometer. Built more than 800 years ago in the Song Dynasty the 1586-meter street had over 453 shops along it in its heyday, though only 307 survive.[6] Many of the homes have been converted into shop fronts. Far from decrepit, the street is bustling with restaurants, inns, and souvenir shops up-stream near the main river crossing and a quieter downstream area where residences dominate.

The street is accessed by a step stone staircase that comes down to the center of the street, clearly noted in the map in Figure 2-1, or down the road that crosses a stone bridge at the top of the street. Across the river are other historic sites. The east bank of the river has temples along it and atop the hill sits the Lord's House surrounded by terraced fields left over from when Zhongshan was a favorite destination for those in court.[7] The fields are well tended by the inhabitants of Zhongshan but the Lord's Mansion lies empty and falling apart, with people living in the secondary sections, despite being designated a historic site in 2009. The buildings along Sanhe are in varied conditions. Some have recently been reworked replacing much of their old timber

[6] Official Information sign in Zhongshan Ancient town.
[7] Voodikon, Jane. "GoChengdoo: Zhongshan Old Town, Chongqing." http://www.gochengdoo.com/en/blog/item/2753/zhongshan_old_town_chongqing (accessed 1 March, 2015).

members and incorporating air conditioners and concrete structural elements, while others have slowly eroded and fallen apart.

Located 200 km Southeast of Chongqing on the Guizhou boarder, Gongtan was the first cultural town of Chongqing to be recognized as a historic site in the early 2000s.[8] This designation is what has saved the town from the flood caused by the Three Gorges Dam's instillation in 2007. Founded 1700 years ago, the town was originally called Gongtaun, but its name was changed during the Ming Dynasty when the nearby Phoenix Mountain collapsed and blocked up the Wujiang River that the city sits on.[9] With the river blocked Gongtan became a central trading hub and built trade halls as used men known as qianfu to tow boats through the treacherous waters. Gongtan is located inside the Youyang Tujia and Miao Autonomous Country in Chongqing and thus is home to members of the Tujia and Miao minorities. With the construction of the Three Gorges Dam the Wijiang River, a tributary of the Yangtze, was going to rise and flood the historic town. With much effort the town was able to get its historic buildings taken apart and moved 1.5 km downstream and uphill to a new site where it could be rebuilt in new "historic" district.[10]

New construction for the town is further up the mountainside. The historic town sits on a series of six different terraced levels that go from the riverbank to the main road. Because they have been moved to the new location and rebuilt, the buildings of Gongtan combine old timber members and wood screens with new concrete and CMU foundations, walls, and structural pillars. The streets use the original blue flagstone as they navigate

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[8] Jin Lu. *Dian Cang Gongtan: Gongtan to be Treasured*. Zhongguo Zui Mei Li De Jia Yuan China's most Beautiful Homes. Di 1 ban. ed. 4
[9] ibid. 25
[10] ibid. 4

the ground, and many buildings use the stilt foundation support to give themselves a firm foundation. Rebuilding efforts are still going on seven years after the town's relocation. Across the river and up the mountain is a 500-year-old ethnic Miao minority village[11] that has maintained many traditional stilt *diaojiaolou* buildings.

The five Case Studies have been documented through plan, occupant interview, and environmental analysis to try and understand the environmental question: how much of the *diaojiaolou*'s form is based in bioclimatic response? The two historic towns have distinctly different histories that have affected the treatment of their *diaojiaolou*. Zhongshan, an ancestral Chinese town, was used by members of the court, while Gongtan is home to many ethnic tujia Chinese people, with an ethnic Miao village across the river. It should be noted that throughout this thesis the discussion of "Chinese architectural history" will deal predominantly with the majority ethnic Han Chinese traditions, but will be talking broadly enough to include minority techniques and forms. When specifically dealing with differences between ethnic Han and ethnic minority Chinese, exact distinctions will be made.

By analyzing the structure, form, and materials of these case studies in terms of traditional Chinese architecture and bioclimatic design we will see that the *diaojiaolou* has been formed by the unique confluence of climate and topography in the larger context of traditional Chinese architecture. Chapter One presents a discussion about bioclimatic design theory, where it originated, and how it will direct our understanding of the *diaojiaolou* building typology's development. Grounding our understanding of bioclimatic design theory and how it has mixed with vernacular architectural history to

11ibid., 110

produce the idea of "environmental vernacular" will give insight into the interpretation of the building's climatic performance.

Next, Chapter Two will look at how the traditional building techniques, materials, and forms found in the *diaojiaolou* case studies relate to the broader traditions in Chinese architectural history. The form, framing system, and material choices are all reflective of larger traditions in the architectural practice used throughout the Han Chinese Dynasties. Finally, Chapter Three will illustrate how the expected bioclimatic qualities and techniques for this region are observed and quantified in the five case studies. It will be clear in the end that the *diaojiaolou* form transcends any single culture and its form is rooted in climate and topographic response.

Before we begin I must recognize the tremendous help I received from the members of Chongqing University's School of Architecture and Urban Planning, specifically Professors Yang Yuzhen and Li Hua, who helped me identify the case study towns, Zhang Fuxi who helped me organize groups of students to help me conduct my case study analysis, and the students Tian Jing, Wang "Jean" Jing, Li Wenting, and Shi "Steve" Linjun who accompanied me on my trip and helped record the case studies. I must also thank Professor Tianjie Zhang for helping put me in contact with Professor Yang and without whom my trip could never have happened. I also need to thank my thesis advisory committee of Shiqiao Li, Louis Nelson, and Bill Sherman for helping me compile this thesis. To all those that helped, you have my deepest thanks.

"The Desirable procedure would be to work with, not against, the forces of nature and to make use of their potentialities to create better living conditions. The structure which in a given environmental setting reduces undesirable stresses, and at the same time utilizes all natural resources favorable to human comfort, may be called "climate balanced."" – Victor Olgyay, from Design with Climate; Bioclimatic Approach to Architectural Regionalism, pg. 10

Chapter One: Understanding the Confluence of Architecture & Climate

In the world of architectural design the idea of "vernacular architecture" is rarely discussed without assumptions of innate sustainable design qualities. A popular idea for over the past fifty years, this idea of the "ecological vernacular" has had many proponents, as well as many who have quantitatively measured and qualitatively studied vernacular forms hoping to distill passive design qualities such as internal heat gain, natural lighting, and natural ventilation. The idea of ecological vernacular combines the study of vernacular architecture with the design methodology known as "bioclimatic design". The idea of bioclimatic architecture is very compelling, although at the same time theoretically problematic in its combination with studies of vernacular architecture. This chapter will cover the concept of bioclimatic design, the architectural design world's relationship with vernacular architecture, and their integration before turning an eye towards it application in the investigation.

The Development of Bioclimatic and Passive Design

Brothers Victor and Adalar Olgyay proposed the term “bioclimatic design” in their 1954 publication “Application of Climatic Data to House Design”.[12] This report to the House and Home Finance Agency of the United States Government was the first instance of the Olgyay’s method of design based in climatic understanding in relation to the human body as a measurement for occupation. The study bases itself on the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the American Society of Heating and Ventilation Engineers (ASHVE) data and studies connected to their understanding of a “comfort zone” of occupation based on temperature and humidity. The Hungarian architects spent the next 10 years publishing articles that worked to refine their theory and methodology to control the effect climate had on the occupants through use of form, envelope, and space.[13] A decade after the initial report Victor published Design with Climate in 1963 and firmly established their “bioclimatic approach to architectural regionalism”.[14] Victor Olgyay believed there were three main components that should drive the design: climate, biology, and technology.[15] He proposed a four-step progression that would produce informed design. First, (1) the designer must study climate, performing a broader environmental survey of the area; This

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[12] *Application of Climatic Data to House Design*. Washington, Housing and Home Finance Agency, Office of the Administrator, Division of Housing Research, 1954.
[13] Fraker, *Teaching Passive Design in Architecture*. Washington, D.C.: Association of Collegiate Schools of Architecture, 1981, 12
[14] Fuller Moore. *Environmental Control Systems: Heating, Cooling, Lighting*. New York: McGraw-Hill, 1993, 5
[15] Victor Olgyay, with Aladar Olgyay. Design With Climate; Bioclimatic Approach to Architectural Regionalism. Princeton, New Jersey. Princeton University Press. 1963. 11

collection of wind, temperature, humidity, and solar radiation data would then, (2) be evaluated in regards to the human body and its "comfort zone"; The biological understanding of the environment would, (3) identify the technological strategies the designer needed to (4) apply to their design.[16] Understanding the climate in terms of human biological needs is fundamental to bioclimatic design and is accomplished through what Olgyay called the "Bioclimatic Chart", seen in Figure 1-1. First introduced in 1954, the Bioclimatic Chart compares the relative humidity with dry bulb and wet bulb temperatures to construct a region of comfortable occupation. This comparison of climate and biological comfort is the basis for the new term "Bioclimatic." Victor Olgyay reiterates the Bioclimatic and the comfort zone's adjustment through the application of wind, and solar radiation from the original publication but expands on the methodology.

The Bioclimatic Chart's design and function rest on the scientific work being done by environmental engineers throughout the first half of the 20th century. Where the development of the separate L'Ecole Des Beaux Arts and L'Ecole Polytecnhique in France signaled the end of the reign of the architect as the "master builder" and growing divide of between the architect and engineer,[17] by the beginning of the 20th century developments in building technologies further separated the two. The engineering study of air and ventilation and the rise and development of Heating Ventilation and Air Conditioning (HVAC) technologies is the scientific half of the Olgyay's bioclimatic design theory. 1894 saw the founding of the American Society of Heating and Ventilation (ASHVE),[18] followed shortly by the invention of what came to be known as

[16] Olgyay, 4
[17] Harrison Fraker. *Teaching Passive Design in Architecture.* 9
[18] Which would go on to merge with the American Society of Refrigeration Engineering in 1959 to form the American Society or Heating, Refrigeration, and Air-Conditioning Engineers, known as ASHRAE. ASHRAE. "The Merger of

"The Psychrometric Chart" in 1904.[19] The field of Psychrometrics in physics is the study of moist air; a mixture of dry air and water vapor. Willis H. Carrier, who had two years earlier invented the world's first modern air conditioner in 1902,[20] developed a graphical visualization for calculating and understanding the relationship between humidity and temperature in 1904. The original Psychrometric Chart, seen in Figure 1-2 and then called Hygrometric Chart from Carrier's first paper introducing it, has not changed in its design, and will be used for the analysis later in this thesis.[21] The chart overlays many sets of measurements and can be difficult to read. The chart's vertical lines delineate the Dry Bulb temperature, or standard temperature, measured along a typical X-axis, and the moisture content or volume of water in the air is measured along the horizontal lines, moving up the Y-Axis. The chart measures percent saturation of the air, otherwise known as relative humidity, with the curved lines that travel across the chart. These values range from 0 to 100%, and above 100 percent humidity the water vapor in the air condenses into rain. The final set of lines on the chart is the diagonal "wet bulb" temperatures. This is the temperature reading from a thermometer covered in a wet surface that is evaporating liquid.[22] This development of HVAC science further helped separate a building's form from the environmental controls and aspects.[23]

As engineering developed the internal environmental control the design disciplines began to conduct their own studies of the effect the environment had on buildings. The effects of light and solar studies start in the 1930's, and were

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ASHVE/ASHAE and ASRE to Become ASHRAE (PDF)." ASHRAE. https://www.ashrae.org/File%20Library/docLib/Public/2003627113635_326.pdf (accessed 1 March, 2015).

[19]Donald P. Gatley P.E., "Psychrometric Chart Celebrates 100th Anniversary." ASHRAE Journal November, (2004): 1, March 2015-20, www.ashrae.org/File%20Library/docLib/Public/ASHRAE-D-22915-20041029.pdf.,16

[20] Carrier Corporation. "Willis Carrier - the Inventor of Modern Day Air-Conditioning." Carrier Corporation. http://www.carrier.com/carrier/en/us/about/willis-carrier/ (accessed 1 March, 2015).

[21] And will be used for the analysis and understanding of the temperature and humidity data taken in the Case Studies.

[22] Gately, *Psychrometric Chart Celebrates 100th Anniversary*, 16,

[23] Fraker, *Teaching Passive Design in Architecture*, 9,

predominantly conducted by the developing window and glazing industry, but the AIA began collecting climate data by the late 1940s and used it to release design suggestions and guidelines.[24] Designers lost an intuitive understanding of a building's energy performance, lighting, physical comfort, and the field of Architecture was also losing its institutional memory as HVAC systems became standard in new structures.[25]

Olgyay's four-step process made the best use of emerging climate science. The building site's yearly temperature, solar path and angle in incidence, humidity fluctuation, precipitation patterns, and winds were all to be recorded and analyzed through the growing scientific understanding of physical comfort. The resulting information could then inform the designer how to orient the building, what side to shade or reveal, where to block or use a breeze, and how to shape the building's form to balance the inside temperature.[26] Many designers began to adopt this new methodology, at least partially because of the growing focus on historical precedents of non-pedigreed, or vernacular, architecture.

The Architect's Vernacular[27]

The development of bioclimatic theory in the world of architectural design parallels the rising popularity of vernacular architecture as design precedent. The popular choice amongst architects to conflate the two is not surprising; this growth in the interest in bioclimatic design was happening at the same time as an increased interest in vernacular architecture.

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[24] Fuller Moore. *Environmental Control Systems: Heating, Cooling, Lighting*. 5.
[25] Fraker, *Teaching Passive Design in Architecture*, 12
[26] Olgyay, 12
[27] A further in depth paper investigating the Architectural Design community's ideas about ecological vernacular and the troubling orientalist implications they have may be obtained from the author by request.

Bernard Rudofsky's 1964 -1965 MoMA exhibit "Architecture without Architects" exhibition in New York City established vernacular architecture on the scene of popular architectural design.[28] Rudofsky, an engineer, architect, and designer had spent over 40 years, receiving two Guggenheim fellowships and a Ford Foundation Grant, collecting photographs and images of "non-pedigreed architecture" that were put on display for this exhibit.[29] Rudofsky personally thanked the architects Walter Gropius, Kenzo Tange, Gio Ponti, José Luis Sert, Pietro Belluschi, and Richard Neutra, had for endorsing his investigation. Not only is this a humble brag on Rudofsky's part but it serves to illustrate a wide interest in this previously unstudied form of architecture as these architects ranged from modernists to metabolists, industrial design to structuralism.

Rudofsky begins the exhibition booklet emphasizing the importance of non-pedigreed architecture in a critical rethinking of the entire history of architecture, but most important is his assumption of the inherent finality of vernacular architecture. His claim that "Vernacular architecture does not go through fashion cycles. It is nearly immutable, indeed, unimprovable, since it serves it purpose to perfection,"[30] imbues vernacular architecture with inherent design solutions. He goes on to propose that a wealth of design inspiration and technological information is to be discovered in the study of vernacular architecture, whether the inspiration is take from economic, technical, aesthetic, or social drivers.[31]

At the same time the architects Maxwell Fry and Jane Drew published Tropical Architecture in the Dry and Humid Zones in 1964 and reiterated that "we should learn to

[28] Bernard Rudofsky, Architecture without Architects, a Short Introduction to Non-Pedigreed Architecture. New York: Doubleday, 1964.
[29] Ada Louise Huxtable. "Anonymous Architecture." New York Times (1923-Current File), Nov 8, 1964, 1964, http://search.proquest.com/docview/115569877?accountid=14678.
[30] Bernard Rudofsky, *Architecture without Architects*, 1
[31] ibid., 4-6

draw sensible inferences from the past habits and styles of buildings … that will help us to solve our current problems."[32] Tropical Architecture in the Dry and Humid Zones established a procedure for building analysis coming out of the Olgyays' methodology. The discussion on the climatic characteristics of the tropics and basic ideas of ventilation and lighting illustrates how forms could interact with the climate and make a building more comfortable. Because of the books focus on modern architectural case studies it not only acted as a foundational piece for further study and investigation of tropical architecture but it also firmly established ventilation and lighting concerns while diagrammatically explaining how they could be accomplished with modern design sensibilities.

Rudofsky, Fry, and Drew, along with the Olgyays' publication, illustrate a clear interest in vernacular architecture and climatically responsive design. These, and other works like them established a connection between technical performance and construction, noting how the structures shifted and changed with climates and regions.[33]A growing desire to take back control, or at least account for internal climate control was bubbling to the front of architects' minds.[34] With the publication of vernacular architectural historian Amos Rapoport's House Form and Culture in 1969 architects were able to incorporate historical precedents into the basis of theory. Rapoport proposed cultural, economic, and material technology and was critical of physical determinism,[35] but many architects saw House Form and Culture as providing evidence in support of

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[32] Ubbelohde, Susan. 1991. "The Myth of the Ecological Vernacular". Design Book Review(20) (Spring 1991): 27-9. 27
[33] ibid., 28
[34] Fry and Drew have an entire chapter dedicated to "Air-conditioning and the architect" where they explain design techniques and consideration for incorporating air-conditioning into tropical projects. Fry, Maxwell and Jane Drew. *Tropical Architecture in the Dry and Humid Zones*. 2d ed. ed. Malabar, Florida: R.E. Krieger Pub. Co., 1982
[35] Amos Rapoport. *House Form and Culture*. Foundations of Cultural Geography Series. Englewood Cliffs, N.J.: Prentice-Hall, 1969. vii

climate being a main factor in the development of vernacular form, ignoring the evidence for cultural effects[36] as well as Rapoport's own desire for a nuanced understanding of these driving factors and his direct dismissal of pure climatic determinism.[37] By ignoring the broader scope and understanding of vernacular buildings architects rick simplifying their understanding of buildings and misunderstanding the theoretical basis they adapting to their work.

Incorporation of Bioclimatic Design into Studies of Vernacular Architecture

Interest and work to determine connection between climate and form has continued since. Studies by environmental and energy scientists are very common, but it is harder to find an architectural based work quantitatively looking into issues of design. One of the more common architectural forms studied by energy scientists and architects is the courtyard house.[38] Courtyards can be found in hot or cold, and wet or dry climates, across multiple cultural groups making the typology a polygenesis form.[39] Studies were quickly conducted on the courtyard house typology and modernist architects such as Alvar Aalto and Alvaro Size began incorporating courtyards into their designs.[40]

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[36] Susan Ubbelohde "The Myth of Ecological Vernacular". 29
[37] Rapoport, *House Form and Culture*, 83
[38]As it is found across five continents, in climates ranging from North Africa to the Himalayas and Swiss Mountains to Indian Palaces, the courtyard house provides many lenses and opportunities through which to understand and analyze them. 2006's Courtyard Housing: Past, Present and Future and Nasser Rabbat's, The Courtyard House; from Cultural Reference to Universal Relevance are good recent collections that provide examples of this breadth.
[39] Atillio Petruccioli. 2006. 1 The courtyard house: typological variations over space and time. In *Courtyard housing: Past, present and future*, eds. Brian Edwards, Magda Sibley, Mohamad Hakin and Peter Land, 3-20. Abingdon England; New York: Taylor & Francis. 4
[40] Nasser O Rabbat. Preface. *In The Courtyard House: From Cultural Reference to Universal Relevance*. ed. Nasser O. Rabbat, xxi-xxix. Farnham, Surrey, England; Burlington, VT: Ashgate. . xxiii

Scientific studies of courtyards houses investigated the form's environmental performance would find that it both cooled and warmed the interior. [41]

When the 1973 OPEC oil embargo revealed the general dependence on oil in the United States and the increasing energy consumption of building, designers began to press the importance of using work and methodology produced in the last two decades to as a foundation for the rediscovery of old climatic adaptation techniques.[42] "Passive Solar design" saw a resurgence of use in the 1970s, and by the beginning of the 1980s there were multiple handbooks and textbooks being published with the aim of teaching passive design. Textbooks like *Inside/Out: Design Procedures for Passive Environmental Techniques* worked to explain bioclimatic design as a necessary component for architectural practice and education, particular pushing bioclimatic design as methodology to address rising environmental degradation and rising sustainability concerns.[43] The growth of scientific knowledge and studies on vernacular buildings served only to bolster and reaffirm claims of climatic determinism, and was consistently called for in texts. A 1981 handbook *Teaching Passive Design in Architecture* noted: "Without knowledge of the technical principles which determine comfort, their spatial organizing parameters may never be recognized. The hidden thermal and luminous behavior of traditional architectural elements must be first rediscovered."[44]

This investigation was not limited to American designers, architects, or engineers, and is growing in its complexity in recent years. In the larger study of Chinese

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[41] Raydan, Dana, Carlo Ratti, and Koen Steemers. 2006. 12 "Courtyards: a bioclimatic form?". In *Courtyard housing: Past,Present and Future*., eds. Brian Edwards, Magda Sibley, Mohamad Hakin and Peter Land, 135-145. Abingdon England ;New York: Taylor & Francis. 135.
[42] Such as the work by Givoni in 1969 and Koenigsberger in 1974, Fuller Moore. *Environmental Control Systems: Heating, Cooling, Lighting*, 5
[43] Brown, G. Z., John Reynolds, and M. Susan Ubbelohde. *Inside/Out: Design Procedures for Passive Environmental Technologies*. New York: Wiley, 1982 1-2
[44] Fraker, *Teaching Passive Design in Architecture*, 12

architectural history a trend of growing scientific studies of traditional buildings can been seen in the juxtaposition of two bioclimatic investigations published a decade apart; Li Jingxia's The Bioclimatic Features of Vernacular Architecture in China[45] from 1996 and Jean Bouillot's Climatic Design of Vernacular Housing in Different Provinces of China from 2008.[46] Jingxia's piece looks at the capital city of Beijing and the historical city Suzhou and compares the cultural bases for the generation of courtyard house forms found in both cities without delving into scientific analysis.[47] Coming out of an analysis project from 2005, Bouillot's article looks at six case studies from across China through formal analysis and climate data. Using this combination to analyze a structure's environment has been growing in popularity and Bouillot's article is prime example of its increased use in the bioclimatic study of vernacular architecture.

Application to the *Diaojiaolou* Investigation

The *diaojiaolou* of this thesis' investigation are found in a region known as the Sichuan Basin. Located up the Yangtze River close to the geographic middle of China, the Sichuan Basin is full of subtropical hills and plains surrounded by mountains on all sides. The map in Figure 1-3 shows the entire topography of Asia and the recess east of the Himalayas, the Sichuan basin, is clearly visible inside a ring of mountainous topography. This topographic recess is bordered to the west by the Tibetan Plateau and to the South by the Yunnan Plateau and Mountains. The Yangtze River cuts through the

[45] Li Jingxia. 1996. "The Bioclimatic Features of Vernacular Architecture in China". Renewable Energy 8 (1–4) (0): 305-8.
[46] Bouillot, Jean. "Climatic Design of Vernacular Housing in Different Provinces of China." Journal of Environmental Management 87, no. 2 (4, 2008): 287-299.
[47] Jingxia,

basin, heading upstream into the Tibetan mountain, and downstream eastward, through mountains and hills.[48]

For the climate survey data needed for a bioclimatic analysis, this thesis uses Weather Data files provided by the United States Department of Energy's Energy Efficiency and Renewable Energy's EnergyPlus Energy Simulation Software site[49] and visualized using Climate Consultant.[50] The climate data is taken in the Shapingba District on the Western Edge of the main urbanized area of the City of Chongqing. This city lies close to the center of the Sichuan Basin, and is the closest available weather data to the case study locations. The dry bulb temperature ranges from an average low of 48 degrees Fahrenheit in January to 82 degrees in July while reaching highs of 100 degrees and lows of 37 degrees throughout the year. The region has an average relative humidity between 75 and 86 percent. These ranges can be best visualized using the psychometric chart of the data, as shown in Figure 1-4. Since the 1960s the exact size and range of the typical "comfort zone" has been altered, and this study will be using the California Energy Code's 2013 determination of what a "comfortable" range of temperature ranges inside; from 67 to 75 degrees Fahrenheit and from 20 up to 80 percent humidity.[51] This range is overlaid in the Psychrometric Chart seen in Figure 1-5. The majority of data points from the Chongqing region fall outside of this comfort area.

Next, the Wind Rose generated from wind and ventilation data in Figure 1-6, indicates no dominant wind direction. Winds come from all sides, and are on average 2 or 3 miles an hour, peaking in July, but can reach up to 10 to 15 miles an hour. The wind

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[48] "Eastern Asia: Southern China | Ecoregions | WWF." World Wildlife Fund. http://www.worldwildlife.org/ecoregions/pa0437 (accessed February 20, 2015).

[49]http://www.eere.energy.gov/buildings/energyplus/weatherdata/2_asia_wmo_region_2/CHN_Chongqing.Chongqing.Shapingba.575160_CSWD.zip (acessed 1 March, 2015)

[50] Climate Consultant was developed by the UCLA Energy Design Tools Group.

[51] Values that fall inline with the ASHRAE Standards Discussed earlier

never falls below 2 miles an hour. These constant breezes would suggest designs that would take advantage of the airflow, especially in context of the heat and humidity seen in figure 1-5. The sky cover illustrated in Figure 1-7, and the solar radiation measurements seen in figure 1-8 found out the final piece of the general climate survey. This region is constantly under some sort of cloud cover, with an average of 45% of the sky under cloud cover year round, blocking a large amount of direct sunlight.

Bioclimatic theory would suggest using natural ventilation techniques in this climate to alleviate the high humidity and temperature. Open and operable apertures that could induce more ventilation would also be highly useful in this region to cool the interior of a home. Plant materials and other poor conductive materials would help absorb little heat throughout the day. Long over-hanging roofs or window sunshades that would help reduce direct sunlight and thus unwanted solar gain. An orientation of form and windows based on the sun's path would not be as important in this high overcast area because of the plethora of diffuse light. In terms of modern technology, some sort of forced ventilation with fans or an air conditioning unit would most likely be necessary to obtain the "comfort zone".[52] These are the methods and technology we should find in the case studies if vernacular buildings do have innate bioclimatic design principles.

[52] These design methods are collected with the help of Climate Consultant.

"[Chinese Buildings'] structure has retained it organic qualities, which are due to the ingenious and articulate construction of the timber skeleton where the size, shape, and position of every member is determined by structural necessity. Thus the study of the Chinese building is primarily the study of its anatomy."

-Liang Sicheng,[53] A Pictorial History of Chinese Architecture, Preface pg. 3

Chapter 2: Technics of Traditional Chinese Architecture

The ancient center of Gongtan straddles two worlds. The picturesque village looks like many of the remaining ancient towns in Chongqing province: as if plucked out of the past. The hills terrace back from the river, populated with timber buildings topped with clay tiles. Walking quickly through this town, treading on the blue stone pavers, one is overwhelmed with the decades-old wood screens, decorated with bats and traditional folk tales. The deep, worn color of the structural timber members holding the buildings high has been looked upon by generations; and yet this site was bare less than 10 years ago. Homes further up the hillside sit on poured-concrete raft foundations and those on the

[53] Written "Liang Ssu-ch'eng" using the Wade-Giles Romanization of Chinese.

river rest on cement piles that reach down to the riverbank. This rebuilt town has interwoven the old, surviving timbers and decorations with modern technology and managed to maintain the form and identity of the *diaojiaolou*.

All five Case Studies have the same basic structural system and formal layout. Timber posts that stretch from the floor to the roof are paced a meter or two apart along the length of each case study. The columns directly support the roof purlins and kept in line by beams that are notched through the columns. Joists run the span of each room at a height of 3 meters and range from four to five meters long. These joists directly support the upper floor and notch into each column and, in Case Studies Four and Five, notch just above a beam that supports a second set of columns running up to ceiling. This framework, seen stripped to the skeletal level in Figure 2-1, and each case study in Figures 2-2 through 2-6, is known as a *chuandou* frame and set on a system of three *jian*.

Architectural Technics: Measures and Walls

If we are to look at the forms that arose in Traditional Chinese Architecture we must first look at the mechanical systems and materials that comprise them. The common image of traditional Chinese construction is that of a timber frame with a pitched roof overhead, and rightly so. This was the basic form for Chinese construction, one that allowed for an open plan using a skeletal system that is more akin to the modern era of steel and concrete than its material and structural cousin of Elizabethan half-timber homes.[54] This image of a timber frame situated upon an earthen foundation while holding

[54] Sicheng Liang, and Wilma Fairbank. *A Pictorial History of Chinese Architecture: A Study of the Development of its Structural System and the Evolution of its Types*. Cambridge, Mass.: MIT Press, 1984, 9

up a decorative roof clearly identifies the three distinct parts of the Chinese home: the skeleton, the foundation, and the roof.

The basic modular unit of Chinese timber frame architecture is the *jian*, and originates from the Tang Dynasty.[55] The *jian* is the span between two structural columns in a building, or a bay. This module can refer to the two-dimensional space between a single set of columns, but it is more common to refer to the three-dimensional space between two sets of columns as *jian* and to use the term *kaijian* to designate a single two-dimensional component.[56] Figure 2-7 illustrates the difference between a *jian* and *kaijian*. The *jian* is the horizontal area in the diagram while three *kaijian* line the front and back of the bay. Rooms were usually more than a single *jian* wide but they do not have to be. The majority of Chinese dwellings are at least three *jian* wide along the transverse axis.[57] The depth of the building is referred as the *jia*, this is made up of group of *jian* that come together to form an enclosure.[58] The *jia* are specifically each set of columns that supports roof purlins and allows you to designate the depth of a *jian*.[59]

In 1103,[60] almost 30 years before the Southern Song Dynasty moved south to Lin'an, and kick-started growth and development in the southern Yangtze Basin[61] that would blend Han and minority styles, the Emperor's Superintendent of Construction, Li Chia, published the *Yingzhao Fashi*, setting the official standards for the module, sub-

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[55] Tang Dynasty reigned from 618 -907 AD, "Survey: Chinese Traditional Architecture" by Xinian, Fu translated by Virginia Weng, in Nancy Shatzman Steinhardt. *Chinese Traditional Architecture*. New York City: China Institute in America, China House Gallery, 1984., 13
[56] Ronald Knapp. *China's Old Dwellings*. Honolulu: University of Hawai'i Press, 2000.21
[57] Ronald Knapp *The Chinese House: Craft, Symbol, and the Folk Tradition*. Images of Asia. Hong Kong; New York: Oxford University Press, 1990. 27
[58]Ronald Knapp. *China's Old Dwellings*, 21 and Xinian Fu in *Chinese Traditional Architecture*, 14
[59]Ronald Knapp. *China's Old Dwellings*, 22
[60] Sicheng Liang, and Wilma Fairbank. *A Pictorial History of Chinese Architecture,* 14
[61] Chao-Kang Chang, Werner Blaser, and D. Q. Stephenson. *China: Tao in Architecture*. Basel: Birkhäuser Verlag, c1987. 9

module, and member sizes in the construction of new buildings.[62] The *Yingzao Fashi*[63] sets up building modules made up of eight distinct timber sizes that are subsequently divided into a certain ratio of width and depth depending on the rank or class of the structure being built.[64] The system of proportions helped develop a standardized appearance of member size as well as timber bracket and column arrangement.[65] In 1734 the Qing Dynasty's Ministry of Construction released a new set of Structural Regulations, known as the *Gongcheng Zuofa Zeli*,[66] adjusting the regulations set out in the *Yingzao Fashi*.[67] The rules limited the number of *jian* that could be used in a building based on the occupant's rank; a commoner's house was limited to three *jian*, a court official's seven, temples nine, and palaces eleven.[68] Because the permitted size of timbers also varied by social status, the actual size of a *jian* could range between three and five meters wide. The lack of drawing in the *Gongcheng Zuofa Zeli* is telling; the *jian* system and timber frame construction eliminated the need for plans of a home's interior because subdivisions did not need to be planned a head of time.[69] These standards would continue to evolve and be revised with little to no influence from outside powers up until the mid-19th century and the beginning of the Chinese Colonial Era.[70,71] Spanning ten thousand

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[62] Xinian Fu, *Chinese Architecture*, 2

[63] Also written Ying-tsao fashih in the Wade Giles Romanization. Sicheng Liang, and Wilma Fairbank. *A Pictorial History of Chinese Architecture*,14, and Xinian Fu in *Chinese Traditional Architecture*, 13

[64] Sicheng Liang, and Wilma Fairbank. *A Pictorial History of Chinese Architecture*, 14,15

[65] Xinian Fu, [et al.]. *Chinese Architecture*, 2

[66] Also Written Kung-ch'eng tso-fa tse-li in the Wade-Giles Romanization, Sicheng Liang, and Wilma Fairbank. *A Pictorial History of Chinese Architecture*, 18

[67] Where as the *Yingzao Fashi* has 34 Chapters total with 13 dedicated to resign rules, four comprised of drawings and the remainder for term definitions the *Gongcheng Zuofa Zeli* had 27 chapters alone on 27 different buildings and how to make them, with 13 more chapters on specific dimensions and assembly instructions, 7 chapters on apertures (such as windows, doors, and screens) and materials, and ended with 24 more chapters on how to estimate the cost of labor and materials. Sicheng Liang, and Wilma Fairbank. *A Pictorial History of Chinese Architecture*, 14, 18

[68] Ronald Knapp, *The Chinese House*, 27

[69] Sicheng Liang, and Wilma Fairbank. *A Pictorial History of Chinese Architecture*, 21 and Ronald Knapp. *China's Old Dwellings*, 27

[70] Xinian Fu in *Chinese Traditional Architecture*, 16,

[71] While the first official nominal "architects" in China were educated in the United States and Japan in the 1920s and 1930s this modern era of architecture and development is markedly different from the architecture that came before the

years of development[72] the iconic features of Chinese architecture developed in response to basic needs and royal decrees.[73] The "myth" of ahistorical architecture is China is truly a myth.[74]

The smallest dwellings, one *jian* big, were used by the poor and those who were starting to make a family as additional bays could, and would, be added on as the family expanded and could afford it. The most common arrangement for Han buildings was a single I shaped horizontal building of three *jian* wide.[75] Expansion would come in the form of many single story buildings being arranged in a courtyard form for Han dwellings while minority buildings would take on different forms more suited to them.[76] Figure 2-8 illustrates the different progression of housing expansion that can take place. The number of rooms in the expansion and the *jian* count would always come in odd multiples. This was to maintain the symmetry, luck, and balance of the forms. Four *jian* structures were especially avoided due to the Chinese word for "four" (四, pronounced "si") sounds like the word for dead (死, also pronounced "si").[77]

The central *jian* of a three-or-more bay structure acts as a larger ceremonial room, with bedrooms on either side of it.[78] The separate structures would be arranged around a central courtyard with the main building sitting in the top center facing south with at secondary building blocking it and creating the courtyard.[79] Sitting on this north/south

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Opium War in 1840, clearly separating the two eras of Chinese architecture into Modern and Traditional Xinian Fu, [et al.]. *Chinese Architecture*, 3

[72] Xinian Fu, [et al.]. *Chinese Architecture*, 1

[73] Sicheng Liang, and Wilma Fairbank. *A Pictorial History of Chinese Architecture*, xvii

[74] Xinian Fu, [et al.]. *Chinese Architecture*, 4

[75] The width of these bays would range is size from region to region, Jian in the north averaged between 3.5 to 3.6 meters wide while southern jian were 3.6-3.9 meters wide. Ronald Knapp. *China's Old Dwellings*, 22

[76] Xinian Fu in *Chinese Traditional Architecture*, 14

[77] Ronald Knapp. *The Chinese House*, 27

[78] Ronald Knapp. *China's Old Dwellings* 24

[79] Xinian Fu, [et al.]. *Chinese Architecture*, 8

axis the main building would then be flanked by secondary side buildings[80] mirroring the internal arrangement. A timber frame structure allowed for an easy replacement of pieces or moving them to a new site, rather than tearing down a building or wall to allow for expansions. This base level of flexibility gave timber structures an advantage over masonry based ones.[81]

The split between skeletal and loadbearing wall construction runs back to the beginning of Chinese architectural history. The earliest architectural remains of Chinese architecture have been dated to 7000 years old[82] and are Neolithic era stilt homes in the southern Zhe*jian*g Province made of a timber frame held together by mortise and tenon joints with lashings.[83] These southern tree dwelling homes with balconies sit in stark comparison to northern homes that were carved and dug out of the ground.[84] The base forms of the Neolithic era of Chinese architecture would go on to set the tone for the two base forms of Traditional Chinese Architecture. The cave homes would move above ground and use masonry, while the timber frame would come to sit on a plinth made of rammed earth that supported its columns.[85] Load bearing walls made of tamped, or rammed, earth, sun dried bricks, stone, and even stacked logs are rare, but not uncommon in China.[86]

Load bearing walls made of tamped, or rammed, earth, sun dried bricks, stone, and even stacked logs are rare, but not uncommon in China.[87] Rammed earth homes are more common in the north and stacked timber masonry or log cabins like the jinggan

[80]Xinian Fu in *Chinese Traditional Architecture*, 14
[81] Xinian Fu, [et al.]. *Chinese Architecture*, 2
[82] Xinian, Fu, *Chinese Traditional Architecture*. 10
[83] ibid, 16
[84] ibid, 18
[85] ibid
[86] Ronald Knapp. *China's Old Dwellings*.101
[87] ibid

home seen in Figure 2-9 are found outside of the southeast.[88] These cases are however are not widely used and the majority of traditional Chinese structures are timber frame buildings.[89]

Particular to the study of rural vernacular Chinese buildings it is important to note that homes of the peasant class used materials that were readily available and did not require a great amount of sophisticated training to work.[90] This affected the framing choices made. The use of a consistent timber framing structure has allowed Chinese buildings to develop common spatial compositions and layout revolving around the *jian* unit.[91]

There are two standard forms of Chinese timber frames, seen in Figure 2-10, and each can be identified by its method of assembly and joints. In addition to these two, variations also exist which are more common in minority architecture that strays from the traditional Han Chinese style. The main timber frames are the *tailiang* and *chuandou* systems, compared in Figure 2-10 with a standard Western truss wall and immediately demonstrating the fundamental difference: the Chinese system uses an orthogonal joint structure with larger vertical timbers that distributes the load onto fewer points. In both of these systems the columns rest on stone pedestals above the tamped foundation to reduce moisture absorption, thus rot, as well as termites.[92]

The framing system that appears in the Case Studies is the *chuandou* frame. The *chuandou* system, illustrated on the bottom right of Figure 2-4, supports the roof purlins

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88 ibid 129, 131
89 Xinian Fu in *Chinese Traditional Architecture,* 10
90 Such materials would include wood timbers, rammed earth or adobe, or rough stone. Ronald Knapp. *China's Old Dwellings*. 71
91 Ronald Knapp. *China's Old Dwellings.* 21
92 Ronald Knapp. *China's Old Dwellings*, 79

directly on the structural columns.[93] Using horizontal tie beams known as chuan to connect the columns via mortise and tenon joints, the walls of a *chuandou* frame resist twisting and other torsional forces. The *chuandou* system is found in the eastern, southern, and southwestern regions of China.[94] Because it employs more vertical support the *chuandou* system uses smaller timbers for the columns than the other main system used throughout China: the *tailiang* system. By using columns that are usually only 20-30 cm in diameter, the *chuandou* frame allows younger trees to be used in its construction.[95] The increased use of smaller pillars in the *chuandou* system gives it the ability to create a greater curvature of the roof when desired than the tailiang system.[96]

The *tailiang*[97] frame on the bottom left of Figure 2-10 is defined by its system of pillars and beams. Similar to post and beam constriction of the west,[98] the *tailiang* frame runs major beams between the support columns and adds smaller beams as the structure ascends. In this case a *jian* is the space inside two adjacent purlins and columns.[99] Found in central, northern, northwestern and northeastern China the *tialiang* system can become very complex[100] and employs the complex system of known as *duogong* brackets to transfer the weight of the roof where the beams transfer their load to the column beneath them.[101] Because the *tailiang* system uses the bracket system to transfer the roof load outwards to the external columns of the system, a greater distance between columns is attained, thus allowing for larger interior spaces.

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[93] Xinian Fu in *Chinese Traditional Architecture*, 11 and Ronald Knapp. *China's Old Dwellings*, 83
[94] Xinian Fu in *Chinese Traditional Architecture*, 11
[95] Ronald Knapp. *China's Old Dwellings*, 86
[96] ibid., 83
[97] Also known as the *linangzhu* frame.
[98] Ronald Knapp. *China's Old Dwellings*, 79
[99] Xinian Fu in *Chinese Traditional Architecture*, 10, 11
[100] Ronald Knapp. *China's Old Dwellings*, 80
[101] Xinian Fu in *Chinese Traditional Architecture*, 13

The other two timber frame types are the *miliang pingding* and the *ganlan* forms. The *miliang pingding* or “flat roofed purlin and rafter system” is found in Tibet, Mongolia, and Xingjian.[102] Seen in Figure 2-11, this system uses a timber frame inside masonry exterior walls to support a flat roofing system. The *ganlan* frame is a stilt based structure that is commonly used dominantly by minority groups in the southern provinces of Yunnan, Guizhou, Hunan, and Sichuan, but has worked its way into Han use as well in this region. A *ganlan* style home, and variations thereof seen in Figure 2-12, has wood floors raised off the ground usually about two meters using bamboo stilts originally, but timber today, with sawn wood plank walls.[103]

The *diaojiaolou* found in the Miao village across from Gongtan again uses this *chuandou* framing system. Seen in figure 2-13, the exterior walls reveal the interior structure, specifically showing off the corner joint of the joist and beam notching into the columns that run from the ground to the roof system. This simple and easy to use frame ties the *diaojiaolou* to the broader structural traditions throughout China, regardless of the ethnic group employing them.

Being constructed with the same technology as traditional Chinese timber frames, and on the same *jian* modules, the *diaojiaolou* not surprisingly adopt common formal arrangements as well. There are “I”, or ribbon, “L” or “Head of the Key”, and “U” shaped forms of *diaojiaolou*.[104] The I form is most commonly three bays wide, but can be found with five or seven bays depending on the class of the occupants, with the center bay being used as the main living and ceremonial room flanked by bedrooms. The L and

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[102]Xinian Fu in *Chinese Traditional Architecture*, 11
[103]Ronald Knapp. *China's Old Dwellings*, 79
[104] Liu XiaoHui and Jiang Jialong, *Sustainable Development of Tujia’s People’s “Diaojiaolou” House in southwest of Chongqing*, 1261

U-forms expand off of the I-form by building one or two wings on either end. In *diaojiaolou* these additions are commonly the overhanging portion that makes the building a *diaojiaolou*. Courtyard *diaojiaolou* do exist, and are a product of high interaction between minority and Han Chinese.[105] Interestingly, the L and U forms of *diaojiaolou* expansion are more similar to the northern development progression shown in Figure 2-8 rather than the southern ones.

The Case Studies all maintained the I-form for growth, with only Case Study Five preparing to expand into an L-form with an addition. The forms of Case Studies One, Two and Three are fundamentally different from Case Studies Four and Five because of their orientations. The Zhongshan Case Studies are all arranged lengthwise along the street as row houses while the Gongtan Case Studies have the space to be arranged width-wise. The row houses organize themselves similarly to traditional shop houses found in southeastern China. The first room is an open public room and is immediately followed by a hallway that gives access to the private section of the home: the kitchen and bedrooms. The traditional I-form arrangement of rooms is seen in Case Studies Four and Five with their width-wise orientation. The center rooms are used a family and traditional ceremonial rooms, with bedrooms flanking on either side. The depth of Case Study Four allows an interior staircase to a second level whereas Case Study Five uses a more common external staircase.

House, Earth and Sky

The case study homes all use a similar system of flooring. The upper stories all consisted of wood planks laid on cross joists of the floor below. A single first floor room

[105] ibid., 1262

in Case Study Four used a drop ceiling to cover up this flooring system, proving an exception to the rule. This flooring system continued into the overhang section of Case Studies Two and Three. In each of these examples the basement ceiling is consistent in structure with the rest of the *diaojiaolou*'s flooring system. Additionally, every Case Study's ground floors, which make contact with the ground in all five Case Studies, are made with masonry materials. Case Studies One, Two, and Three have tamped earth floors in the front of their units under the first three *jian*. This tamped earth is pressed hard enough to be indistinguishable in Case Study One from the stones in its exterior, east addition, and the earthen floor inside. Case Studies four and five however use a concrete raft foundation for their floor. While unprecedented, this use of masonry materials for the floor stays in keeping with the traditional materials of floors.

Subterranean foundations in traditional Chinese buildings are rare, if not almost non-existent. Traditional Han Chinese homes do not have a basement and the building sits on flat earth that has been tamped down to a hard floor.[106] Foundation platforms, such as the base seen in Figure 2-7, sitting above or on grade with the height of the ground reflecting status of the occupant, date back to the Shang Dynasty.[107] The raised foundations extend outward beyond the walls of the structure, and often beyond any roof overhang as well.[108] Homes in the south were known to often use stone foundations or wall footings for the columns, as this would reduce the soil moisture and rot caused by the region's excessive humidity.[109] Another sort of foundation that forms an area similar to a basement and is found in traditional dwellings is a pile foundation of *ganlan*

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[106]Ronald Knapp. *China's Old Dwellings,* 72
[107] The Shang Dynasty Reigned from 1600-1100 BC, Ronald Knapp *The Chinese House*, 28
[108]Ronald Knapp. *China's Old Dwellings*, 74
[109]ibid., 29

buildings where the structural timber frame is used as a foundation footing. This structure are rarely seen in ethnic Han Chinese homes and is more common in minority homes found in hilly and mountainous areas of southern China where the pillars are used to stabilize the structure.[110] The “basement” area is the area under the elevated floor and is often used for storage of animals and equipment, and seen in Figure 2-13, or as a covered work area. The use of the lover levels as storage areas is consistent with Case Studies One, Two, Three, and Five. The structures in Zhongshan all used the lower areas for storage, providing themselves with an internal staircase down to a recessed level that rested on the mountainside. Case Study Five should be read as a structure that has enclosed this traditionally open area underneath the first floor with wood clad walls. Not only does Case Study Five use this area primarily for storage, but also it has a lower ceiling height, closer to the traditional two-meter clearance of *ganlan*.

An alternating pattern of simple terra cotta tiles lay along a simple purlin and joist system is used in each of the Case Study houses. The tiles are able to easily move rainwater off the building while still ventilating the structure. By using clay the *diaojiaolou* employ one of the two main roofing materials in Chinese building tradition. Traditional Chinese roofs are made of plant materials (or thatch) or mud and clay tiles, as well as a mixture of the two. The longest-used roofing style is the thatch roof. The material used for the Chinese thatch varies by region and vegetation but can include a combination of straw, bamboo, sorghum, and mud. Mud and mud-lime roofs are found in the northern regions of China where multiple layers of different materials are tamped under a final layer of mud that helps insulate and protect the dwelling inside.[111]

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[110]Ronald Knapp. *China's Old Dwellings*, 72,73 and Ronald Knapp *The Chinese House*, 29
[111]Ronald Knapp. *China's Old Dwellings*, 148-150

Tiled roofs are younger, and only date back to the Xia Dynasty in the mid-16th century BC. While mortar and clay nails are sometimes used to tie down the roofing tiles, most southern homes rely only on the weight of the tiles to hold them in place. Different from the curved tiles, roofing shingles can be made up of flat clay tiles, wood, or stone. The latter two are most commonly found in the northeast and southwest regions of China and are used dominantly in shingle style roof. Clay tiles are arranged in a combination of orientations and layers, using varying amounts of mortar. These arrangements of curved clay tiles developed the six common tile layout patterns shown in Figure 2-14.[112] Style 5, the overlapping concave and convex patter of tiles, was employed in each of the case studies. This reduced the need for extra materials to solidify the roof.

The roofs of the Case Studies are all simple linear systems at an angle of about 30 degrees, as illustrated in Figure A-3 in the appendix. The roof extends a least a meter on each side of the Case Studies, and covers the external stairs and balcony in Case Studies Four and Five. Integrated with the *chuandou* frame this roofing system mimics the traditional *xuanshanding*, or overhanging gables, roof system.

The emblematic concave, double-sloped roof of traditional Chinese buildings traces back to the 17th century B.C. and can be divided into four distinct types differentiated by their gables.[113] The *yingshangding* roof type is common in the northern and southern coast. The roof is divided into two sections, peaking in the middle with gables that lie flush with the walls in the transverse axis, and eves that extend very little if at all over the longitudinal walls. Developed in the Ming Dynasty, this roof type works very well in areas of little rain and the short eves allow large amount of sunlight that

[112]Ronald Knapp. China's Old Dwellings, 153-154, 162
[113]Ronald Knapp. China's Old Dwellings, 133

needed inside in the northern winters, as illustrated in Figure 2-15, while also resisting the coastal winds of the south.

The *xuanshanding* roof is also a two-part roof peaking in the center. It is known by its gables, its purlins that extend beyond the transverse walls, and its overhanging eves. The extension of the roof works to protect the walls of the structure from direct sunlight and is found all over the country except in areas of heavy rain. The *sizhuding* roof is a structurally complex hipped system that divides the roof into four sections. The structural complexity comes from the bracket and support system required to hold up the diagonal seams. Similarly, the final roof type of the *xieshanding* is a combined gable and hipped-roof that also uses the complex radial roof carpentry to support a four-slope roof. This *xieshanding* style was most commonly seen in Ming and Qing Era buildings, but has been dated back to the Shang Dynasty.[114] The ridgelines of all these roof forms vary greatly in levels of ornamentation based on the owners' economic and social status, but always are clearly designated with some form of ornamentation.[115] The simple mechanical system of the *chuandou* frame easily connects into the *xuanshanding* roof system. Returning to Figure 2-1, the purlins clearly notch into the tops of the columns. The purlins support the rafter system and ridge board that in turn support the tiles.

These Case Studies are all clearly connected into a part of the larger building tradition of Chinese architecture. The use of the *chuandou* timber frame, three *jian* module, masonry floors, and clay tiles in a *xuanshanding* roof connects the base technical and material aspects of the *diaojiaolou* out to the traditional Chinese construction methods used across dynastic Chinese history.

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[114] ibid., 133-140
[115] ibid., 141

"The substantial variations that are observable from one area to another in the south reflect more than dissimilarities in climate, topography, and economy, however they also exhibit the extent to which migrating Han pioneers adopted local building forms and practices and the degree of receptivity by indigenous groups to Han Chinese norm"- Ronald Knapp. China's Old Dwellings

Chapter 3: Five Points of Bioclimatic Analysis and Understanding of the *Diaojiaolou* Case Studies in Sichuan Province

Lanterns line the far south end of the street. The roofs on either side extend out and meet in the middle, connecting the row houses across from each other up the street and blocking out the night sky. The lanterns provide light at all times, the light from each home alternates between sunlight and electric bulbs that only last until bed. Walking north along the stone street: the houses to the west become sporadic, revealing the hill side for short, ten-meter stretches, pulling back the overhang and letting the sound of the Sanhe River to the east come through. Halfway up the road, and more lights are on now and the homes stand up a little bit straighter. Restaurants and inns are mixed in with shop houses selling local apple wine and other goods to tourists who travel for hours by bus out to this historic town. The row houses disappear on the east side of the road and a stone sitting area runs up to the back end of the houses on either side, and stops as abruptly as they do, supported on timber posts that dive down the sheer drop to the stone along the river bed below. This is the town of Zhongshan, its ancient Sanhe Street, one of the few historic towns that still have *diaojiaolou*.

Light over Lanterns

Despite being row houses and not using electrical lighting during the day, daylight was able to pierce the row house of Zhongshan. Sitting amongst these clay tiles is a wonderful innovation that helps bring light into the Case Studies but keeps the water out better than a traditional Chinese courtyard or light well; glass ceiling tiles. Case Studies One, Two, and Three all have well-lit interiors thanks to the use of these glass roofing-tiles. Integrated in to the ceiling of Case Study One and Two in Figures 3-1 and 3-2, these tiles provide all the light into the center rooms that would otherwise be dark, only receiving light through doorways and small internal windows.

Case Study Four is very well lit by the glass tiles as well. Figure A-42 shows the expansive network of glass tiles used in the ceiling. The clay roof tiles are interspersed with glass tiles that act as small skylights letting a large amount light into the second floor. The well-lit nature on the first floor of Case Study Four, and throughout all of Case Study Five, is accomplished by having windows in every room, save the rear bathrooms. These windows are open, only using a wood-lattice, jali-type screen to keep out direct light and provide privacy. The open windows provide another benefit to all the case studies through ventilation but first a review of the local environment and regional climate is in order.

Climate and Form

Combining the understanding of bioclimatic architectural response and traditional Chinese building technology, and its deviations, will focus this investigation on the home region of the *diaojiaolou* form: the Sichuan Basin and surrounding mountains. Despite the similarities and connections spreading throughout Chinese architectural history seen in Chapter Two, the variation of forms, materials, and building techniques cannot be ignored.

China is divided between four distinct biomes, or weather regions, as the map in Figure 3-3 shows. This map shows the north as a cold biome and the western region of China divided between dry desert and polar tundra, both desert type environments with little rainfall. The Sichuan Basin sits in the temperate region that covers all of southeastern China. It is not surprising that we will later see that these three biome regions parallel the architectural regions Chinese architectural historian Ronald Knapp uses to delineate traditional Chinese architectural styles, as seen in Figure 3-4. Knapp's map comes from the geographer Jin Qiming's Three Regions of Architectural Heritage. An overlay of these two maps, seen in Figure 3-5, reveals a correlation between climate and architectural styles. Overlaid, we see the Western China region of traditional architectural sits mostly in the Desert Biome and Tundra Biome, Northern China falls onto the Cold Biome, and the northern most section of the Temperate Biome, and Southern China sits entirely inside the Temperate Biome.

That architectural variation in China follows very closely the climatic variation across China is not surprising. Qiming divided the country into Northern China, Southern China, and Western China based on the common architectural forms, details, and materials used in each one. These three regions, Northern China, Western China, and Southern China line up with the three Climate Zones seen in Figure 3-4 and the specific Biomes in Figure 3-6. The Southern China Region encompasses the temperate south climate region and the Subtropical Biome, Northern China is the Cold north and Temperate Biome, and Western China is the dry desert regions, both tundra and hot. Other historians of traditional Chinese architecture have divided Eastern China into 5 formal representative regions. These divisions take cultural regions into account and identify the areas of the Loess Plateau and outlying area, Beijing and Surrounding Area, Lower Yangtze Basin, Sichuan and the Surrounding Plateau, and the Southern Coast.[116]

These divisions help reiterate the idea that the various architectural forms in China developed have environmental and social responses to each region's specific characteristics.[117] The unifying mechanics of Chinese forms have undergone regional adaptations based on topography, material, culture, and climate. Forms moved to new locations by migration over China's history, mixing with the indigenous styles and adapting themselves to the area.[118]

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[116] Chang, Chao-Kang, Werner Blaser, and D. Q. Stephenson. *China: Tao in Architecture*. Basel: Birkhäuser Verlag, 1987. 11

[117] Ronald Knapp. *China's Old Dwellings*, 1

[118]Ronald Knapp *The Chinese House*, pg 2, But it should also be noted that specifics of cultural migration's effect of the development of Chinese architectural forms is very much still a developing field of study, ala Ronald Knapp. *China's Old Dwellings*

The Province of Sichuan and its surrounding region have always been heavily populated by ethnic Chinese minority cultures.[119] Presently, it is one of the densest minority areas in all of China.[120] The region saw a sudden incursion of ethnic Han Chinese with the Qin Empire's 316 BC expansion that brought more than ten thousand families to the region and sparked development in this region.[121] The Sichuan Basin's history of development that continues to this day and has helped make it the densest agricultural-land region in the world[122] with a density of 380 people per square kilometer One can easily see the Sichuan Basin delineated on the population density map of Asia in Figure 3-7.

The *ganlanlou*[123] stilt homes were a standard of the Yangtze River area when the Qin Dynasty arrived. The *ganlan* buildings developed across the mid-Yangtze River region and are a very well documented minority structure today, with the most developed sub-form being the zhulou buildings in south Yunan Province. These structures would be adapted into the Han Chinese architecture that was built in this region because they realized the value of the techniques it employed.

Major adaptations for the south include dealing with the increased amount of rain in southern China; three times what the north is used to.[124] Imported Han buildings often had improper roofs that didn't allow for ventilation or moisture control.[125] Eventually buildings in the south adopted 30-degree pitched roofs made of tiles and extending

[119] 56 different Minority Groups live the in the Southwest region of China, Ronald G Knapp. *China's Old Dwellings* 285

[120] Ronald Knapp *The Chinese House*, 17

[121] *China: Tao in Architecture,* 136

[122] Eastern Asia: Southern China | Ecoregions | WWF

[123] Literally translating to "dry column floor/building", Ronald Knapp. *China's Old Dwellings*, 285

[124] Ronald Knapp *The Chinese House*, 19

[125] Ronald Knapp. *China's Old Dwellings*, 227

beyond the buildings walls and foundation to deal with heavy rains.[126] Built forms were also adapted, the L and U shaped courtyards of the north shrank in size in the south, helping to reduce the surface area that could be heated up by the sun.[127] Another way the home was protected from the sun was elongating the bay depth; *Jian* in southern China are twice as deep as those in northern China measuring between 5 and 6.6 meters deep.[128] Heat was also mitigated with the application of white limestone plasters that would reflect sunlight and the removal of kitchens to a detached location to reduce the heat gain of the dwelling.[129]

Wind and Ventilation

In the hot and humid temperatures of this region, discussed in Chapter One, one would expect old buildings to be unbearable to live in. The open lattice windows provide a clue to how these buildings stay enjoyable: through natural ventilation. A breeze is constantly moving through the homes in the Case Studies. Each of them kept their doors wide open, and Case Studies One, Two, and Three all had windows on the internal wall dividing the front and center *jian*. This aperture helps increase the ventilation that is already flowing through the buildings.

The Zhongshan Case Studies all take advantage of the cool air coming off the river. The open walls and breathable flooring allows the cool air to enter the home. Temperature readings of all basement levels confirm that these areas consistently stayed the coolest throughout each Case Study. Even in Case Studies Four and Five the lower

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[126] Ronald Knapp *The Chinese House*, 20
[127] Ronald Knapp. *China's Old Dwellings* 227, Ronald Knapp *The Chinese House*, 19
[128] Ronald Knapp. *China's Old Dwellings* 22, Ronald Knapp *The Chinese House*, 18
[129] Ronald Knapp *The Chinese House*, 19

levels stayed cool, simply by using a heavy thermal mass that was hidden from the sun and connected into the lower levels of the ground. By these Case Studies' digging into the ground, the concrete floors are able to take advantage of the lower ground temperatures three meters below the surface. This cooler temperature on the lower levels generates natural ventilation through the stack effect. The "stack effect" is a particular type of ventilation that results from internal heat gain and specifically places inlets and outlets. Body heat, cooking, or other activities that generate an internal heat gain warms the air. Because air expands as it heats, and thus less dense, it rises in the space and is exhausted through a higher opening. The exiting air creates a pressure differential in the space that pulls in cool air from a lower inlet area. This cycle is repeated and the resulting ventilation is known as "the stack effect".[130]

Ventilation in the case studies is also aided by the porous nature of the walls clearly seen in Case Studies One, Two, Three, and Five. These case studies all used a woven bamboo panel to infill the spaces between the timber columns, seen uncovered in Figure 3-8. These panels are not only easy to replace but also porous; they easily let the air seep into the buildings. The panels can be sealed with a limestone plaster in areas where ventilation is to be blocked. The tile roof also allows easy air escape.

Studies of the large trends of *ganlan* structure reaffirm all these observations from the field. The minority populations of Guizhou, Guangxi, Sichuan, and Hunan living in the mountain regions use the stilt *ganlan* forms to avoid building on arable lands, but they also used the space gained below the living area for storage of animals and livestock and as a shaded working area. The traditionally thatched roofs have been mostly replaced

[130] Baker, Nick. "Natural Ventilation - Stack Effect." The Royal Institute of British Architects. http://www.architecture.com/RIBA/Aboutus/SustainabilityHub/Designstrategies/Air/1-2-1-2-Naturalventilation-stackventilation.aspx (accessed April/30, 2015).

with mud or clay tile in surviving buildings.[131] When not using wood plank walls, woven split bamboo wall panels were put up between the timber frame to provide much needed ventilation and breathability while retaining privacy. [132] These panels are sealed against rain with mud or limestone plaster when needed. The plastered whitewashed panels are common across Sichuan *ganlan*.[133] The timber frame could be totally enclosed but was most often left exposed.[134]

Building ventilation also becomes a major concern with the high humidity for all buildings in southern China, not just the *ganlan*. Throughout the region window size was reduced and they were moved higher on the wall than in the north. Wood lattice-pattern windows replaced the paper window-covers seen further north. They also avoid or even prevent direct sunlight from entering the interior of buildings. Air passes easily through these apertures without an overload of direct solar heat gain.[135] Doors were also left open in southern China and the home structure was reoriented along water sources to pull in the natural convection currents and eschew cosmic orientations.[136]

Ganlan structures vary greatly in size, location, and complexity of construction giving rise to many different sub-types and great difficulty in finitely determining the "form-generating forces" that guided the formation of the *ganlan* form.[137] While it is clear that material, form, and structure, for instance, provide ventilation it cannot be said that the materials, form, and structural system were chosen because it would increase ventilation.

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[131] Ronald Knapp. *China's Old Dwellings*, 89
[132] Sorghum and corn stalks have been used instead of bamboo in many cases, ibid., 96
[133] ibid., 94,96
[134] ibid., 99
[135] ibid., 230
[136] Ronald Knapp *The Chinese House*, 21
[137] Ronald Knapp. *China's Old Dwellings*, 285

Materials and Topography in Sichuan Province

The Sichuan Basin is home to a temperate broadleaf forest with mixed flora and has a subtropical moist broadleaf forest to the south, as seen in Biome Map in Figure 3-6. With Chongqing on the southern border of the temperate zone, Yangtze River and the mountains generate an interesting condition where the alluvial, or sediment, river plains surrounding the Yangtze River and its tributaries quickly give way to rock filled mountains filled with red sandstone and purple shale. The Yangtze River carries sediment down from the Tibetan Plateau, which combines with these rock types to create an incredibly fertile soil layer throughout the region.[138] The region has been historically a center for agricultural development, but the less developed land still has the originally dominant pine trees and Japanese cypress trees growing throughout.[139] With this material abundance it is not surprising that the structural material of choice was timber.

Climate and material availability also contributed to the Han adaptation of stilt houses. With increased availability of bamboo and timber for construction in southern China[140] the *chunadou* frame began to proliferate, particularly set upon a stilt foundation.[141] The stilt homes' unique foundation helped air move underneath the structures and reduced overall dampness by making use of natural airflow.[142] The stilt timber frames also provide for easier navigation of the topographic conditions as we have can see in Figure 3-11, and this may have been more important than the climatic

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[138] Eastern Asia: Southern China | Ecoregions | WWF
[139] ibid.
[140] Ronald Knapp *The Chinese House*, 22
[141] Ronald Knapp. *China's Old Dwellings*, 230
[142] Xinian Fu, [et al.]. *Chinese Architecture*, 5

adaptations.[143] The wooden joinery used in the *chuandou* frame responds wonderfully to the region as well. The wood easily adjusts with the temperature, expanding in the humidity, and also performs incredibly well in seismic events, having been shown to be able to survive earthquakes rating level seven and eight on the Richter Scale,[144] as well as allowing easy replacement of damaged members from either of these.

The *diaojiaolou*, shown in Figure 3-10, stilt home traditionally is used to deal with rough topography in mountain and riverbed areas and can be traced back to the Han Dynasty.[145] We have seen that the *diaojiaolou* uses *chuandou* timber frame skeleton for the upper wall and roof portions, but it is the foundation that makes the *diaojiaolou* as distinctive type.[146] Unlike the *ganlan* form that sits entirely on stilts, a *diaojiaolou* has one section sitting on a traditional rammed-earth or stone slab foundation. The building then extends over a change in topography where the foundation shifts to a timber pile foundation on the ground below,[147] hence the literal translation of *diaojiaolou* being "hanging foot floor" or "suspended base building". The *diaojiaolou* is an economic as well as environmental response, allowing the owners to live on previously uninhabitable land and spare farmland.[148] The three bottom *ganlan* examples in Figure 2-12 give good example as to the section employed by the *diaojiaolou* form.

"*Diaojiaolou*" is used to describe buildings that are used by many different minority ethnicities, and no one single minority has claim to the form. The Dong minority on the boarders of Hunan, Guizhou, and Guanxi provinces uses *diaojiaolou* for their

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[143] Jean Bouillot. "*Climatic Design of Vernacular Housing in Different Provinces of China*." 297
[144] Xinian Fu, [et al.]. *Chinese Architecture*, 1
145 "Chongqing Culture: Bayo Culture, Diaojiaolou, Traditional Art..." Chinatour.com. http://www.chinatour.com/chongqing/chongqing-culture.htm (accessed 14 April, 2014).
[146] Ronald Knapp. *China's Old Dwellings*, 90
[147] Liu XiaoHui and Jiang Jialong. 2011.
[148] Ibid., 1263

buildings that kick out from its entrance level over sharp topographic drops, supported on piles that rest on top of the ground below.[149] The Tuijia minority in southwest Chongqing also uses *diaojiaolou* to name their overhang buildings as well.[150] The Miao people in Guizhou province also make use of the *diaojiaolou*.[151] The *diaojiaolou* form is scattered across the mountains and throughout these cultures on the southern end of the Sichuan basin in areas of high topographic change.

Understanding Comfort

The final analytical piece looks at the western developed "comfort zone" as it applies to the Case Studies. As shown in Figure 3-9, the yearly temperature and humidity readings for Chongqing are mostly outside of the comfort zone as is understood by American HVAC engineers. With this in mind it is not surprising that the temperature data gathered on site reflects a similar displacement. Figures A-14 through A-21 in the appendix chart the individual "comfort" of the rooms throughout all five Case Studies, and they are entirely outside of the comfort zone, falling in fact towards the extreme of the yearly measurements. When considered with the potential mitigation strategies offered by the Climate Consultant program, every room but Case Study One's front room would only be potentially cooled through "Adaptive Comfort Ventilation,"[152] itself a strategy not guaranteed to work.

Material choices greatly changed the temperature and humidity of the interior rooms. There is a correlation with the rooms in Case Study Four and Five that use cement

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[149] Ronald Knapp. *China's Old Dwellings*, 90
[150] Liu XiaoHui and Jiang Jialong
[151] "Langde Miao Ethnic Minority Village." http://www.travelchinaguide.com/attraction/guizhou/kaili/langde.htm (accessed 1 March, 2015).
[152] Case Study One's front room, the chart finds, could also be made comfortable through "Fan Forced Ventilation."

wall also raise the humidity, even though masonry materials in all the Case Studies were consistently cooler than the ambient temperature by 10 degrees Fahrenheit, thus helping to cool in the interior rooms. Clearly, the temperature and humidity readings are not the entire explanation for the fact that, while none of the rooms fell into the “comfort zone,” each of the buildings were quite comfortable, and the exterior was as active as the interior.

The answer to the comfort of the *diaojiaolou* form is in the ventilation of the structure. The Case Studies show case uses of interior apertures (Case Studies One, Two, three, and Four), double height ventilation areas (Case Studies, One, Two, Three, and Four), long forms to accentuate ventilation (Case Studies One, Two, and Three), open exterior apertures and easily ventilated walls (Case Studies One, Three, Four, and Five), use of exterior site temperature variance due to water (Case Studies One, Two, and Three) or geothermal (Case Studies Four and Five), and easily ventilated roofs (All Case Studies). Allowing the constant light breezes of the region to circulate freely into, through, and out of the buildings in the Case Studies, the *diaojiaolou* architecture maximizes is potential bioclimatic design solutions.

Conclusion

By applying the Bioclimatic Analytical steps to five Case Study examples of the traditional rural Chinese vernacular form of the *diaojiaolou*, this investigation has both increased the data available for studying this typology, and also shown the inherent bioclimatic nature of the *diaojiaolou*. The major aspects of the *diaojiaolou* form brought to light by the Case Studies used in this investigation are readily divided into the Technological and Environmentally Adaptive.

First, the *diaojiaolou* form uses the structural framework of the traditional Chinese *chuandou* timber frame skeleton. This permits for the use of easily ventilated wall panels and also allows the building to navigate the uneven topography of the Sichuan Mountains. The *xuanshanding* roof system used to support the tiled roof helps protect walls and the building's interior while also generating a roofing system that can both ventilate and let light through without subjecting the inhabitants to the precipitation. Finally the three *jian* home module situated the *diaojiaolou* form in both the tradition of Han Chinese home forms, and the ethnic minorities such as the Tujia and Miao structures that were visited.

The forces of tradition and culture are just as visible in the formal layout and construction of *diaojiaolou* as are the bioclimatic considerations, and it is doubtful that any single one of these factors solely drove the form's development. The history of the *ganlan* and *diaojiaolou* is one of constant cultural mixing and dispersion however, so no single ethnic tradition or culture can lay claim to the *diaojiaolou* form. Incorporation of widely used traditional Chinese building technology points to the *diaojiaolou* being part of a larger national building tradition.

Environmentally, the *diaojiaolou* form inherently takes advantage of the region's climate. Bioclimatic theory indicates that the region's vernaculars would use open apertures for ventilation, over hangs to block the sun, plant material to avoid heat absorption, orientation to make use of diffuse light, and some sort of mechanical system to induce ventilation. The Case Study Buildings did take advantage of constant breezes for internal ventilation, as well as breathable envelopes. The extended gables did help reduce direct sunlight, and plant material such as the timber structure, wood panel flooring, and woven bamboo wall panels helped reduce the ambient heat absorption during the day. To maximize the use of diffuse light, however, the *diaojiaolou* used high window placement, lattice designs, and skylights instead of building orientation. The orientation of each Case Study was based more on the site and topography than potential solar issues. General bioclimatic design expectations did not anticipate the impact of siting and immediate context upon the Case Studies.

Other patterns emerge to help support the idea of bioclimatic responses in the *diaojiaolou* form. The consistent appearance of glass tiles in the traditional terracotta roofs provided skylights that allowed in natural light, a critical feature for a region of sparse infrastructure and low income. The kitchen space in each case study is also important to note as they all had double height spaces that allowed the heat to dissipate. Case Studies Two and Four had enclosed double height spaces but had systems of direct ventilation and natural lighting for the kitchen. Case Studies One and Three were open to the outside, Case Study One more so than Case Study Three. Even Case Study Five, which placed the kitchen in the basement, adjusted by having the cooking area close to the entrance where it could be moved if needed. These spaces took advantage of the natural ventilation created by cooking and also provided an easy way to shunt the heat created to the exterior without disrupting the whole interior. The fireplace on the interior wall of Case Study Three suggests that when heating was desired it was obtained through a system other than the natural heat gain of a kitchen.

Environmental response cannot be ignored as a major factor in the form's development. The *diaojiaolou* at its most basic is defined by its topographic mitigation through a pile based skeleton frame. Beyond this, adjustments are made. The *diaojiaolou* of the Miao minority are not that of the Tujia, which are not that of the Dong, which are not that of the Han; but all are still identifiable as *diaojiaolou*. While the materials used in current projects are evolving to match that of contemporary construction, a climate-based mindset is inherent in the *diaojiaolou* form. Although the sample size for this investigation was too small to definitively make any claims, the evidence correlating the *diaojiaolou* to environmental factors cannot be ignored.

Sample size is not the only factor to consider in moving forward from this investigation. The challenge that the buildings in Gongtan present to the stilt-form definition for *diaojiaolou*[153] requires a separate investigation into the modernization and adaptation of these buildings. The *diaojiaolou* in Gongtan sit on a flat, raised concrete plinth, only jumping topographic levels on the second floor that was inaccessible from the first. Despite this, the homeowners were adamant the Case Study Four and Five being *diaojiaolou*. The owner of Case Study Four conceded that the building's main failure as a *diaojiaolou* was in its lack of a wrap around porch or veranda on the second floor. This illustrates a fundamental shift in the understanding of the *diaojiaolou* typology from what is academically accepted, as well as the citizens' view of their rebuilt town. In the homeowner's mind this was the same *diaojiaolou* that his grandparents had built over 30 years ago, even though they were relocated from 2006 to 2008 to the current site. Case Study Five also presents problems by incorporating an enclosed basement and concrete addition. The basement area encloses the area that would have been open to the elements in a traditional *diaojiaolou*, and materially shifts to concrete and plaster from the traditional timber structure above. Not only is the home not about the specific material pieces of the dwelling, but also the material nature of the dwelling can change. A pile foundation system unifies all these buildings and pushes for a heavier reliance on the frame and structural mechanics to assert the name of *diaojiaolou*. Most of the buildings on the lowest terrace in Gongtan used concrete piles to support them and create new

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[153] A timber frame structure that used its framing system to mitigate topographic changes, giving itself an overhanging base that shows a shift in flooring, and left the lowest levels under the piles uninhabited by the occupants.

foundations, as seem in Figure C-1. This updated structural material is clad in wood or painted and uses the traditional wood infill walls where it can but opens up a new avenue of investigation to understand exactly how the *diaojiaolou* form is being updated with modern technology. It is regrettable we were not able to document the addition to Case Study Five as it would greatly inform how the *diaojiaolou* form is evolving.

Amos Rapoport was correct when he identified the forces of society, economics, technology, and climate as factors in the development of housing forms in his 1964 book House, Form and Culture. We have seen that all these play a role in the vernacular form called *diaojiaolou*. Nevertheless, the conclusion to be drawn from this investigation and the five Case Studies, that the *diaojiaolou* form is predominantly based in its topographic and climatic context, cannot be denied.

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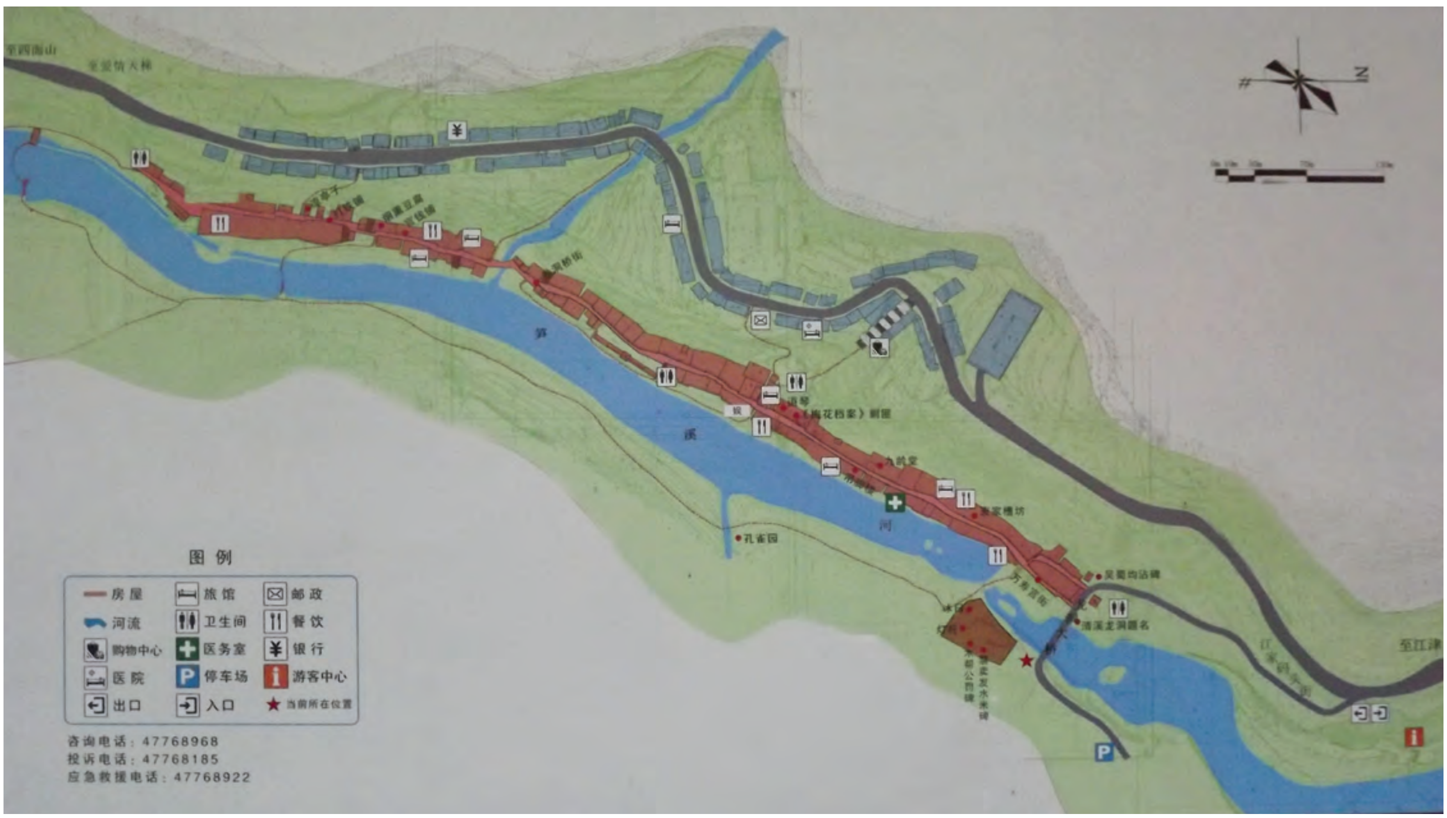


Figure i-1: Local Map of Zhongshan Ancient Town at Info Board. The Ancient Sanhe Street can be seen in red running along the riverbank and the modern street further up the hill bordered by blue buildings. Photo By Author

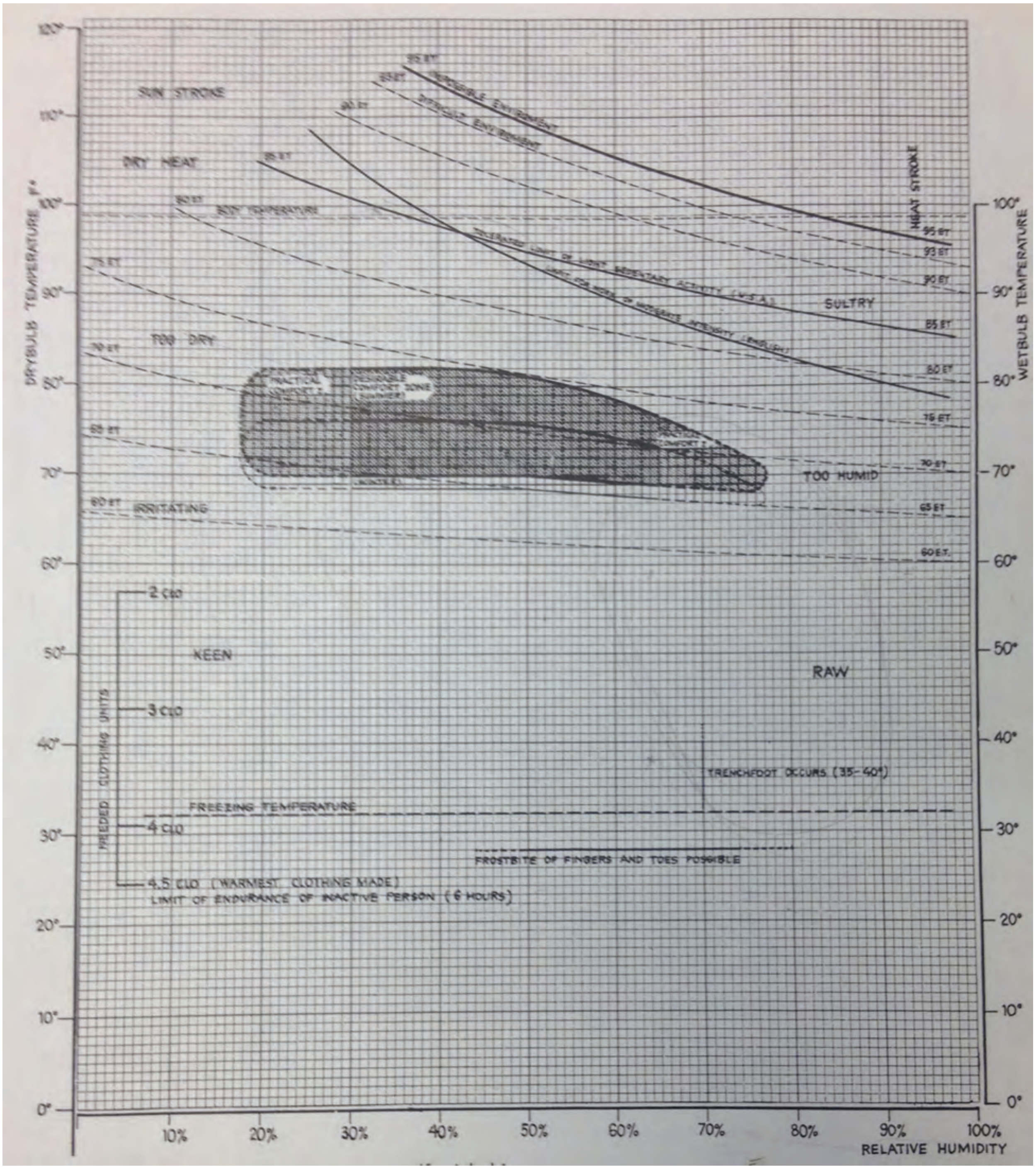


Figure 1-1: Victor and Aldar Olgyay's Bioclimatic Chart, from *Design with Climate*

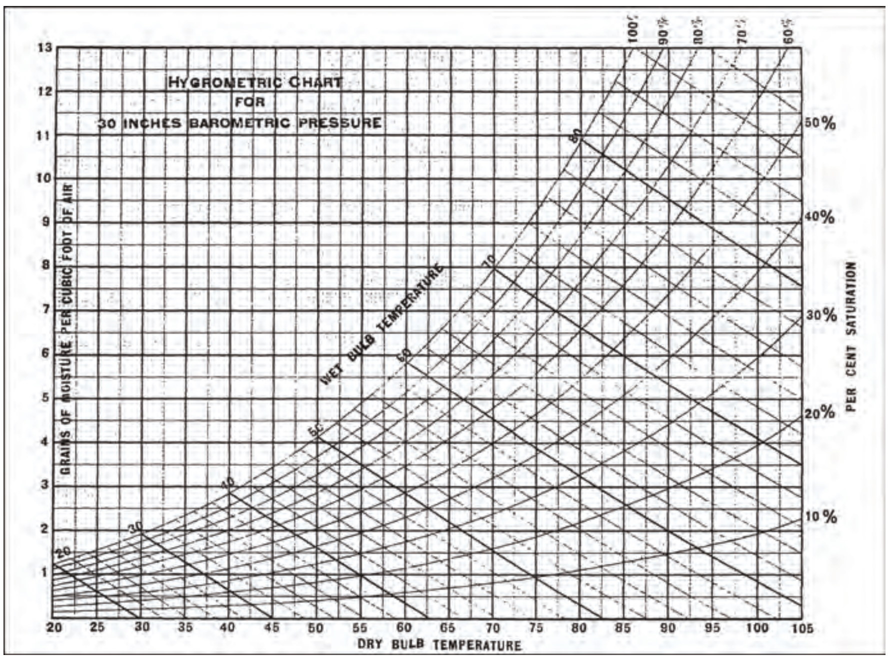


Figure 1-2: Willis Carrier's Original Psychrometric Chart, from *Psychrometric Chart Celebrates 100th Anniversary*, pg 18

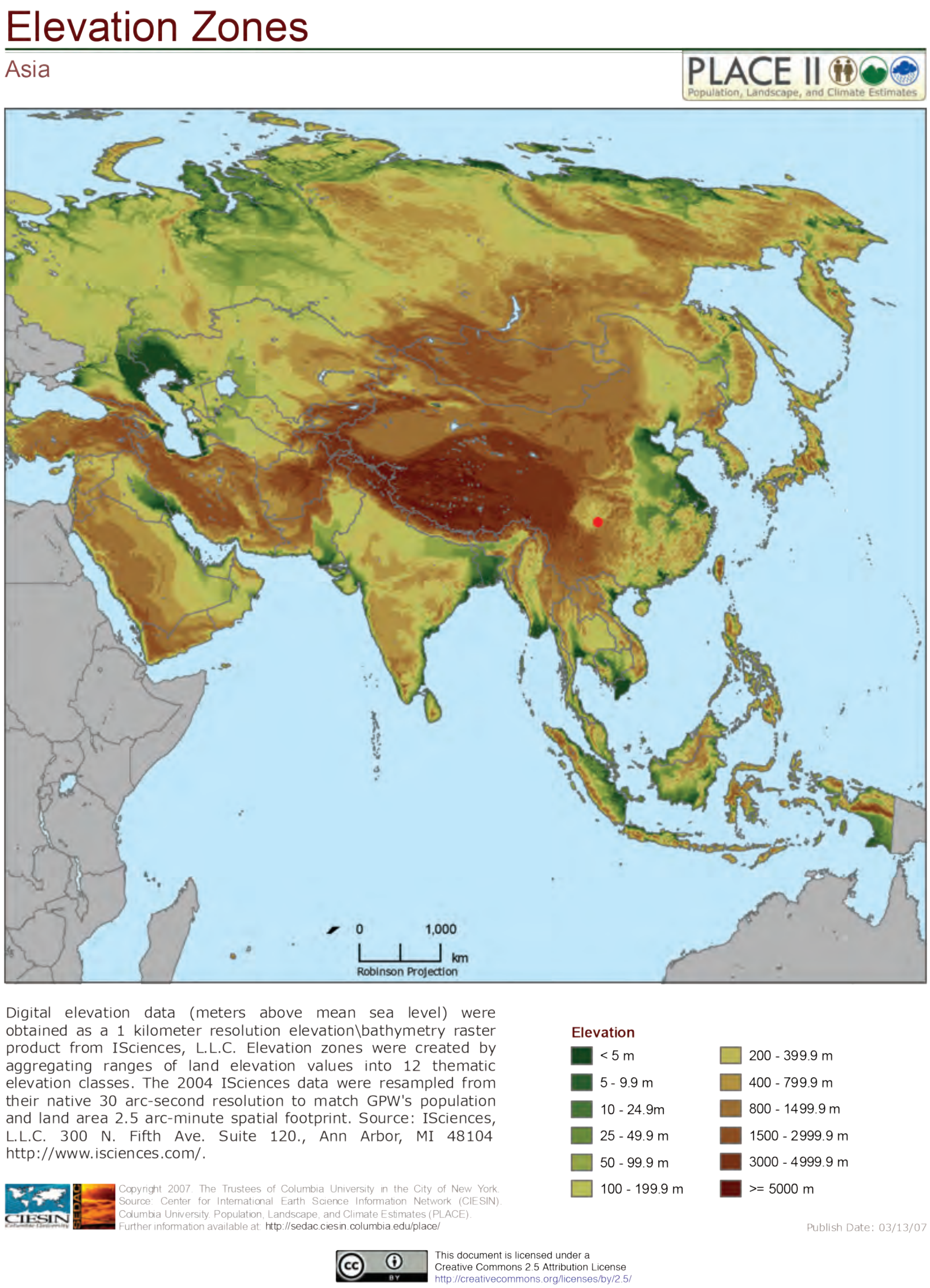


Figure 1-3: Asian Elevation Zones, with Chongqing noted. From SEDAC (The Socioeconomic Data and Application Center), http://sedac.ciesin.columbia.edu/downloads/maps/nagdc/nagdc-population-landscape-climate-estimates-v2/Continent_Asia_ElevationZone.pdf

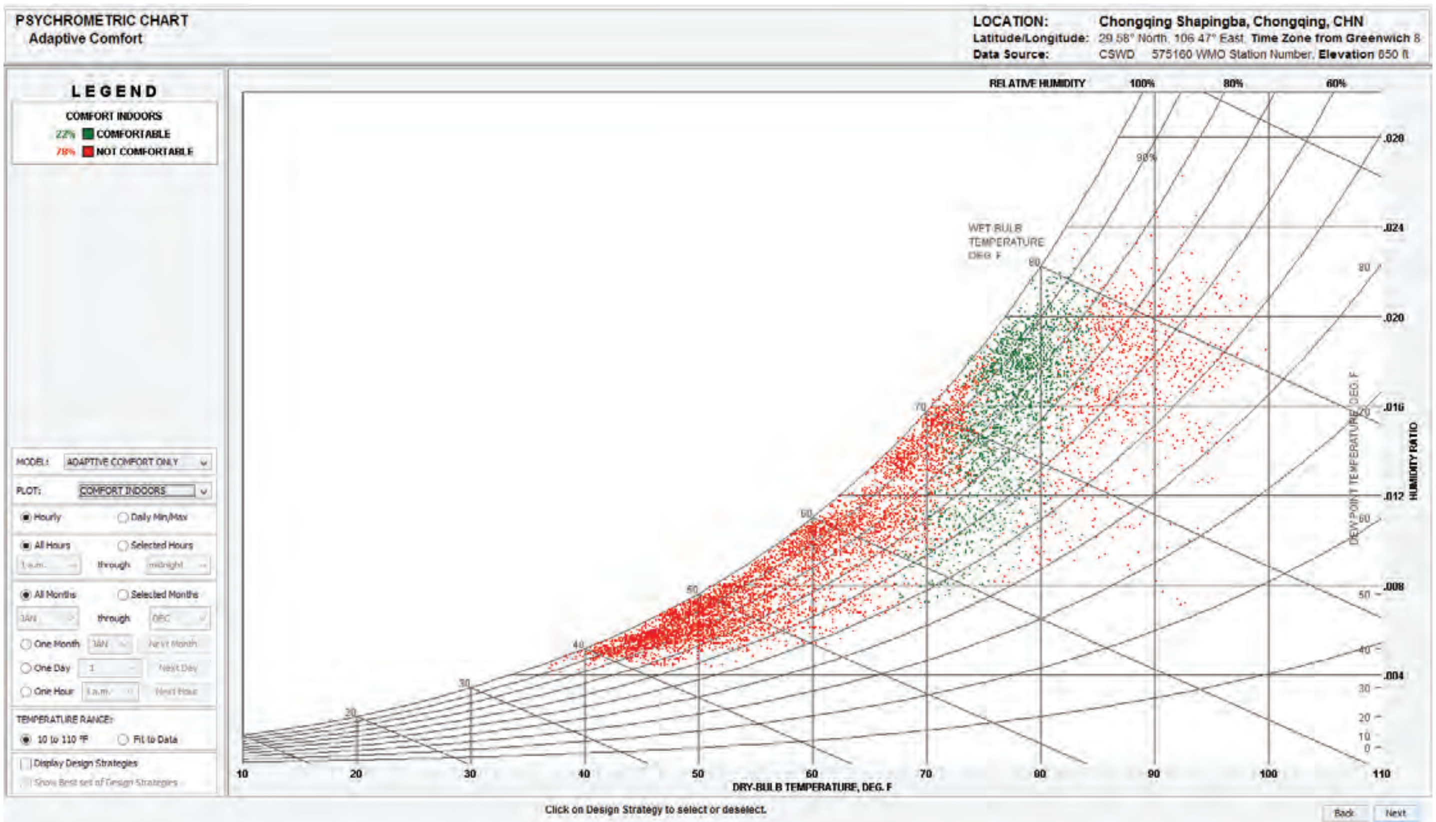


Figure 1-4: Psychrometric Chart for the Shapinba District of Chongqing.

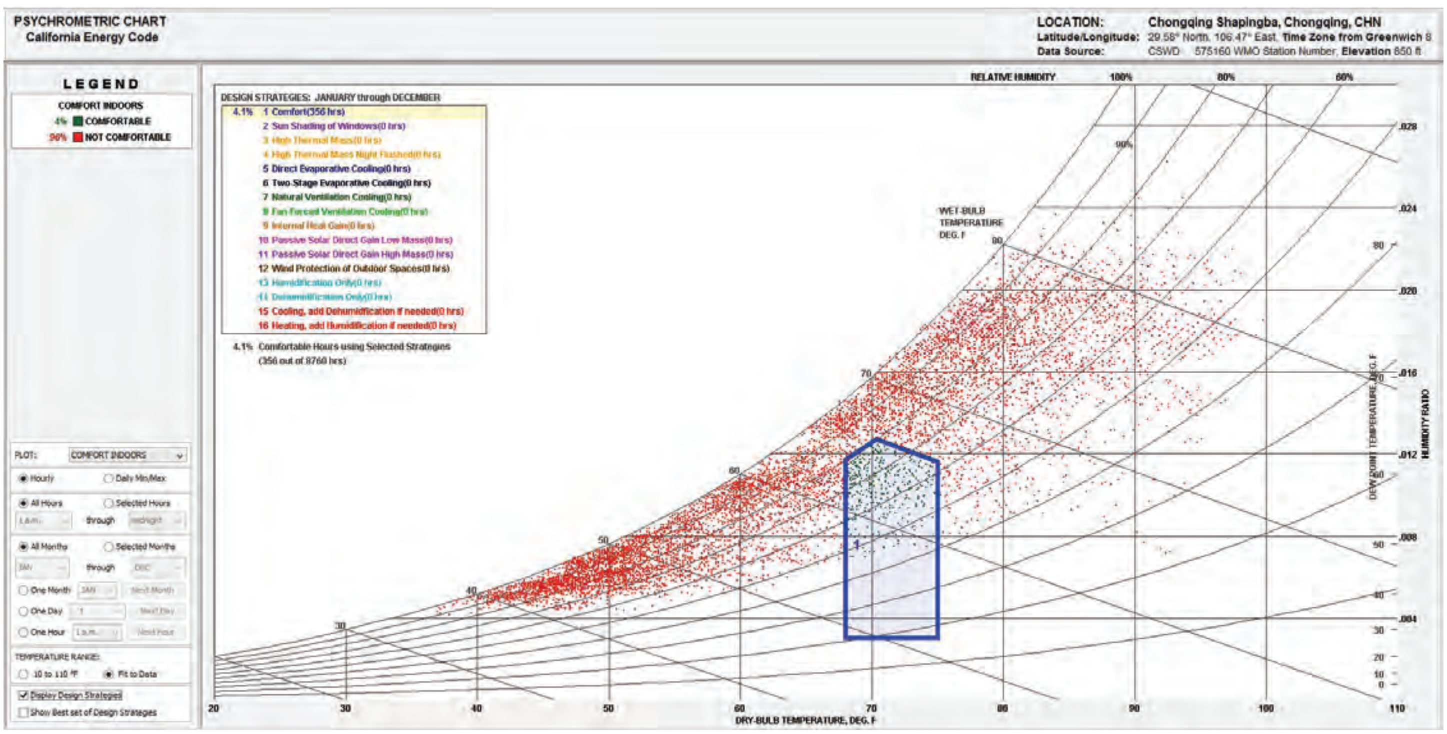


Figure 1-5: Psychrometric Chart for the Shapinba District on Chongqing with an overlay of the “Comfort Zone” as understood by the California Energy Code

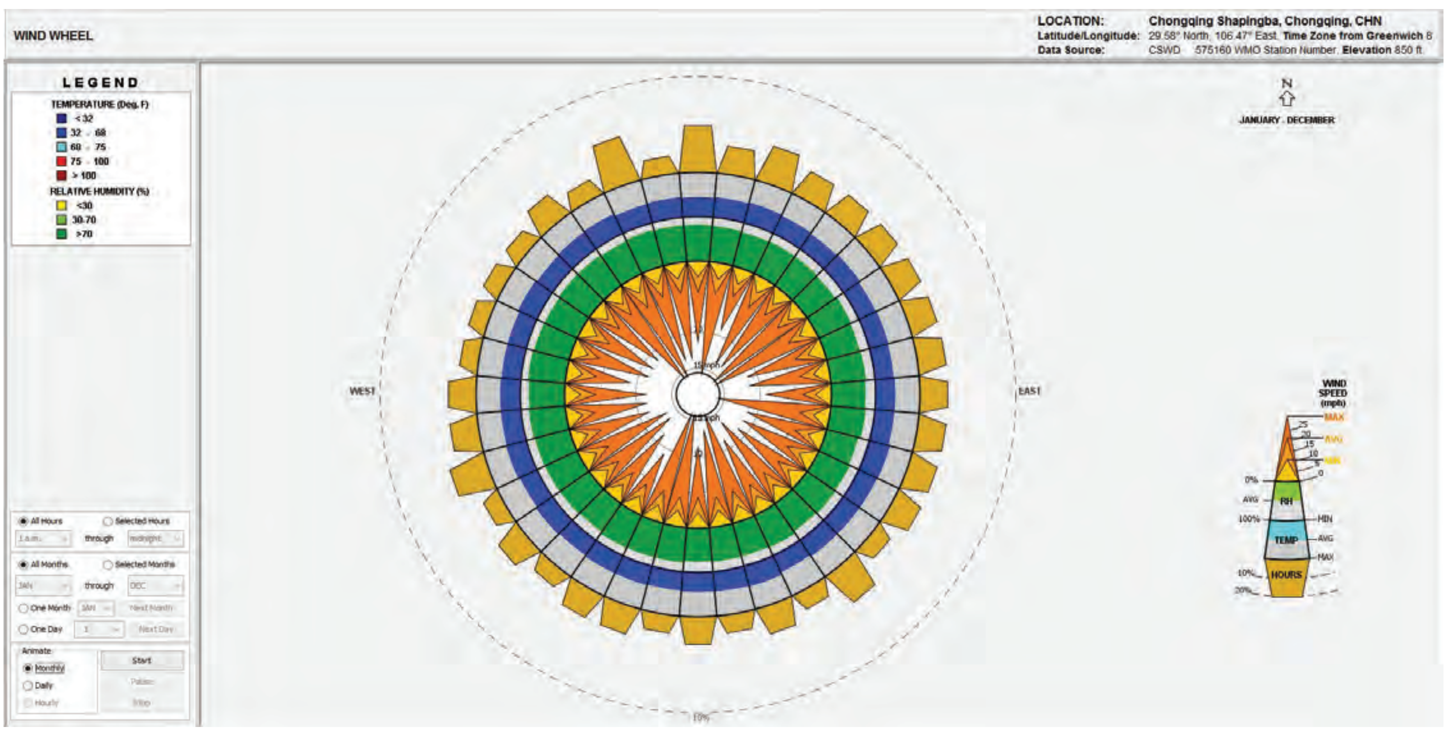


Figure 1-6: Wind Rose Generated for the Shapinba District of Chongqing

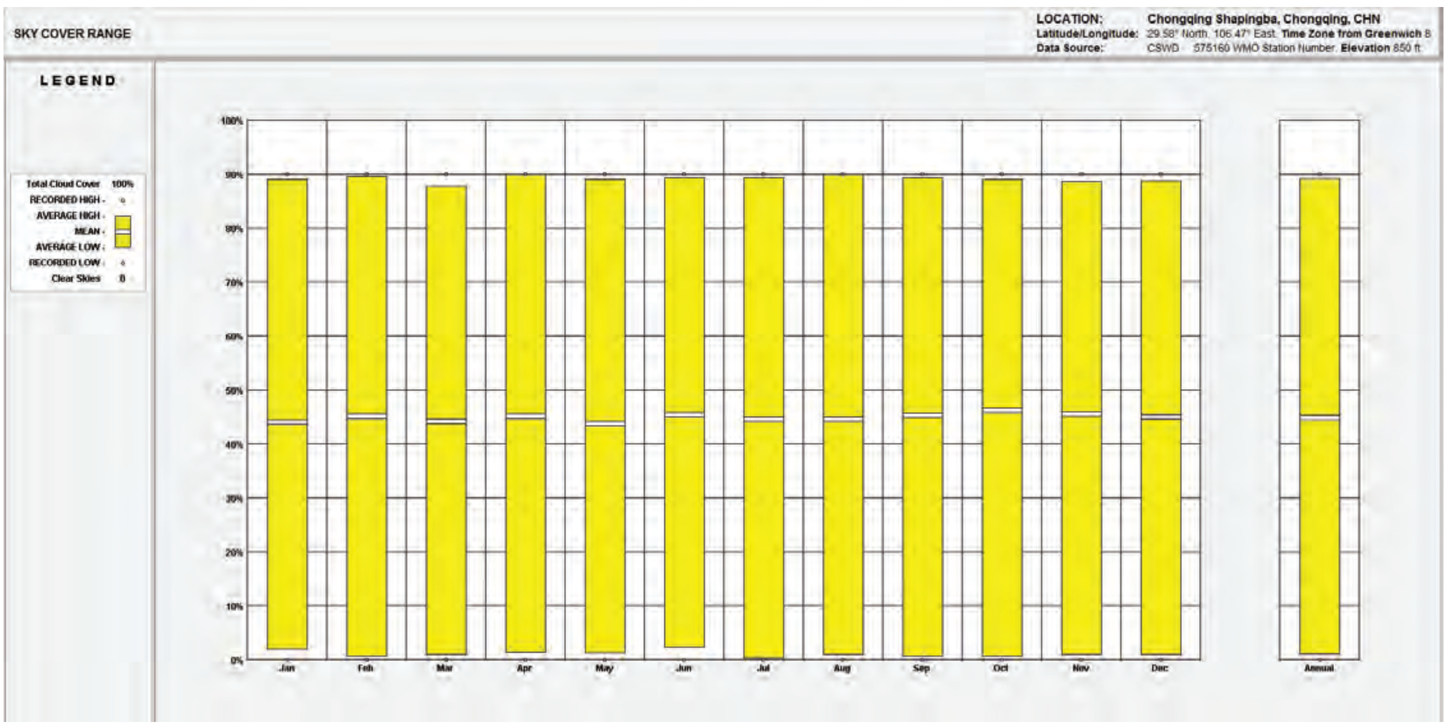


Figure 1-7: Average Sky Cover by Month Cover for the Shapinba District of Chongqing

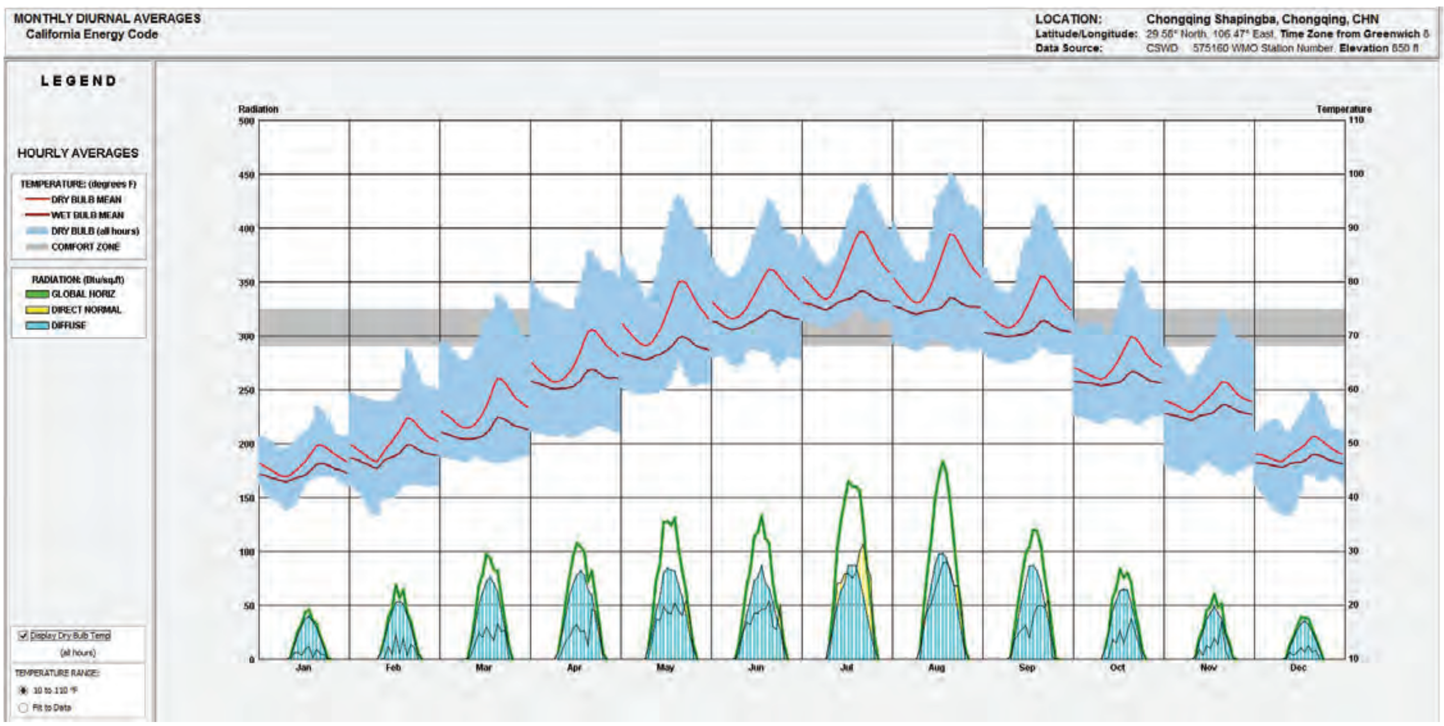


Figure 1-8: Solar Radiation, Direct and Difuse, by month for the Shapinba District of Chongqing

Figure 2-1: Diaojiaolou under construction in Gongtan, Photo By Author

Figure 2-2: Photo Example of the Structural System of Case Study 1

Figure 2-3: Photo Example of the Structural System of Case Study 2

Figure 2-4: Photo Example of the Structural System of Case Study 3

Figure 2-5: Photo Example of the Structural System of Case Study 4

Figure 2-6: Photo Example of the Structural System of Case Study 5

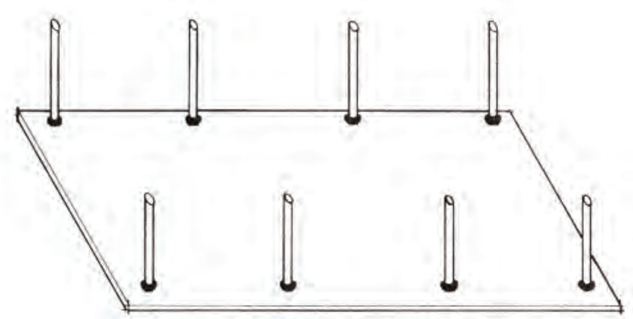


Figure 2-7: Figure Showing the difference between *jian* and *kaijian.* From *China's Vernacular Architecture*, by Ronald Knapp, pg. 33

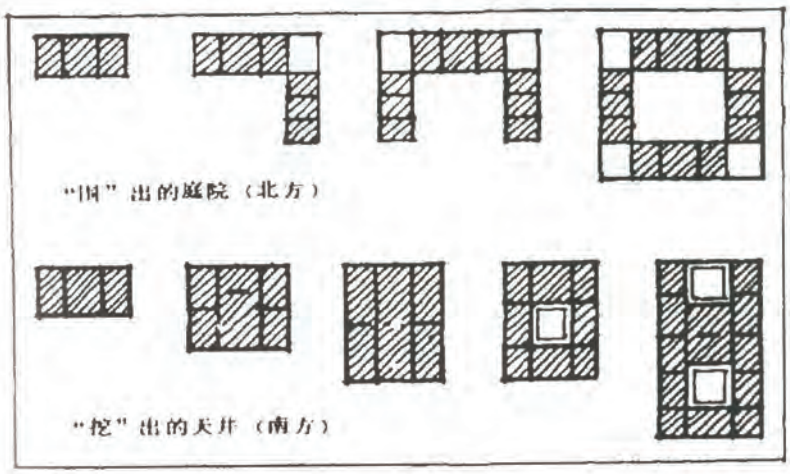


Figure 2.13. As a household becomes prosperous, its dwelling may grow from a simple three-*jian* rectangle to shapes that include open spaces. In northern China, according to the hypothetical progression shown across the top, the "enclosing" of open space begins with the addition of a wing and continues until a complete quadrangular dwelling, termed *siheyuan*, takes shape. In southern China, as shown in the bottom series, open space results from "excavating" a "well" in the interior, which may eventually emerge as a true skywell and then be duplicated as the dwelling grows. [Source: Huang et al. 1992, 5.]

Figure 2-8: Illustration from *China's Old Dwellings.* Discussing the different forms of expansions that can occur, particularly noting the different courtyard forms that develop in the north and in the south. pg. 29.

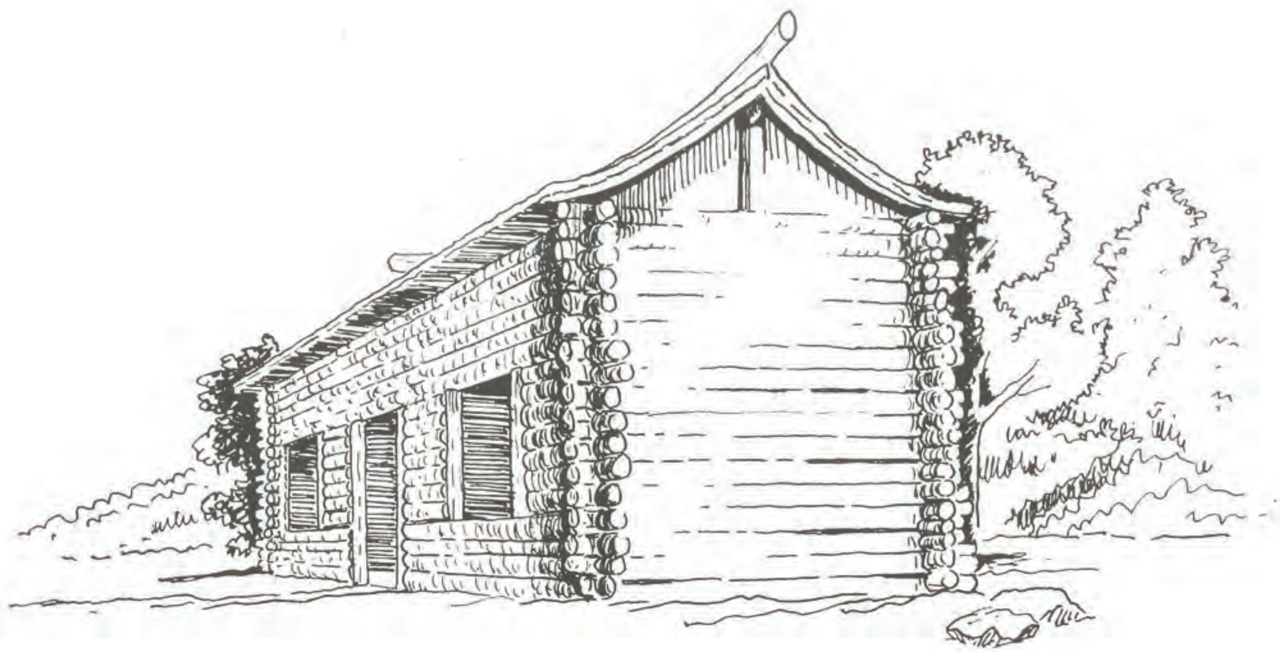


Figure 2-9: An example of a Load Bearing Wall found in Traditional Chinese Architecture, a *jinggan* Wood Masonry Log Cabin found in the Northwest and Southwest. From *China's Traditional Rural Architecture* by Ronald Knapp, pg 69.

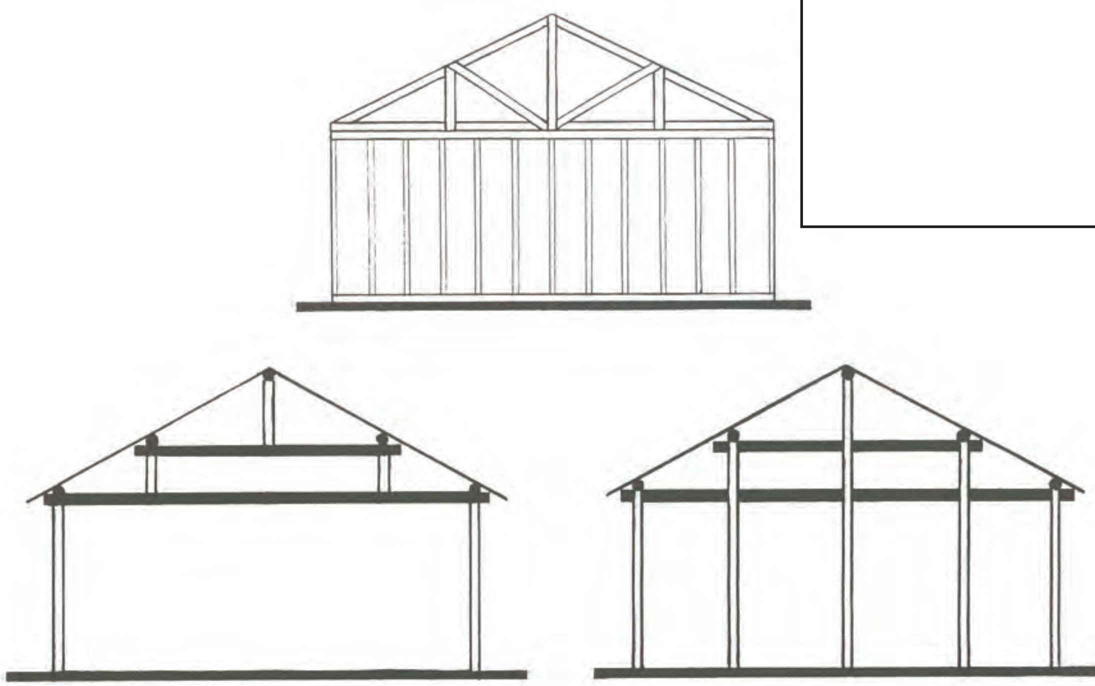


Figure 2-10: Comparison of a western timber truss frame (top) and the Chinese *Tialiang* (bottom left) and *Chuandou* (bottom right). From *China's Traditional Rural Architecture*, 71

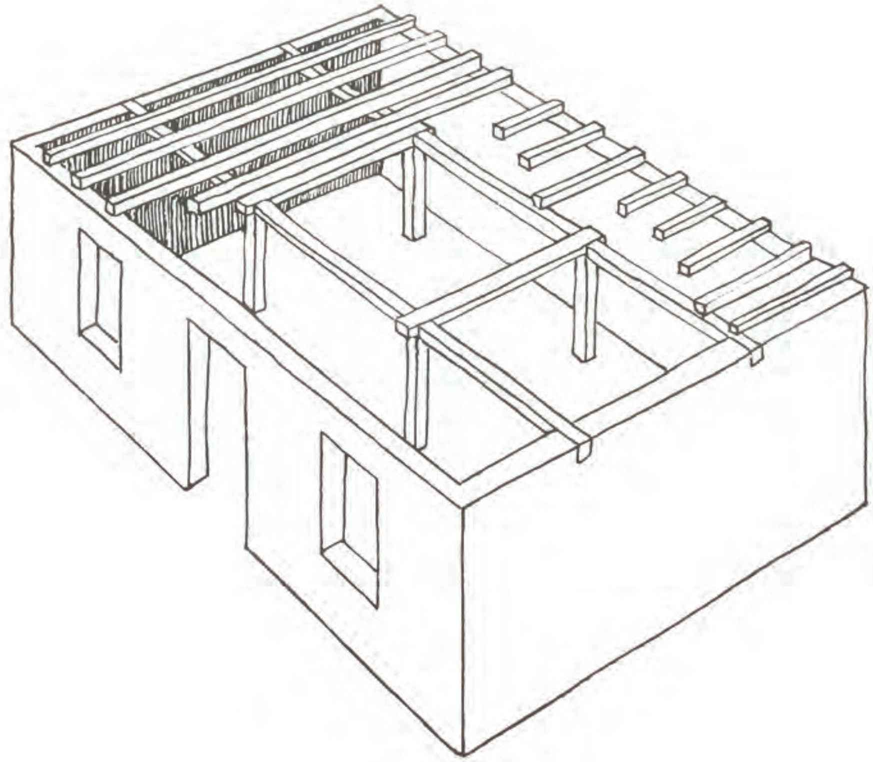


Figure 2-11: The *miliang pingding* or flat roof Timber frame. From *China's Traditional Rural Architecture*, 68

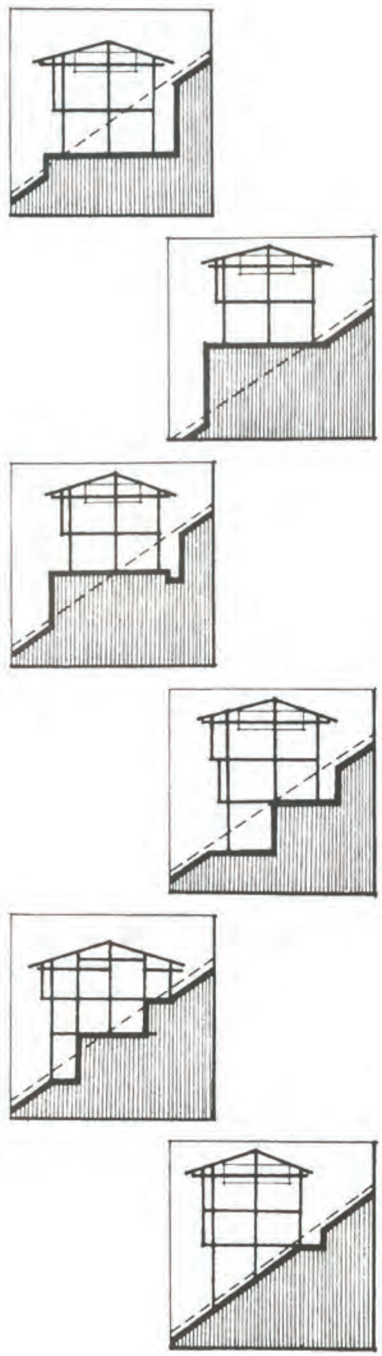


Figure 2-12: Illustration showing various ways *ganlan* type frames can sit on slopes. From *China's Old Dwellings,* 90

Figure 2-13: An example of a *diaojiaolou* building using its basement area for animal storage. Photo by the Author

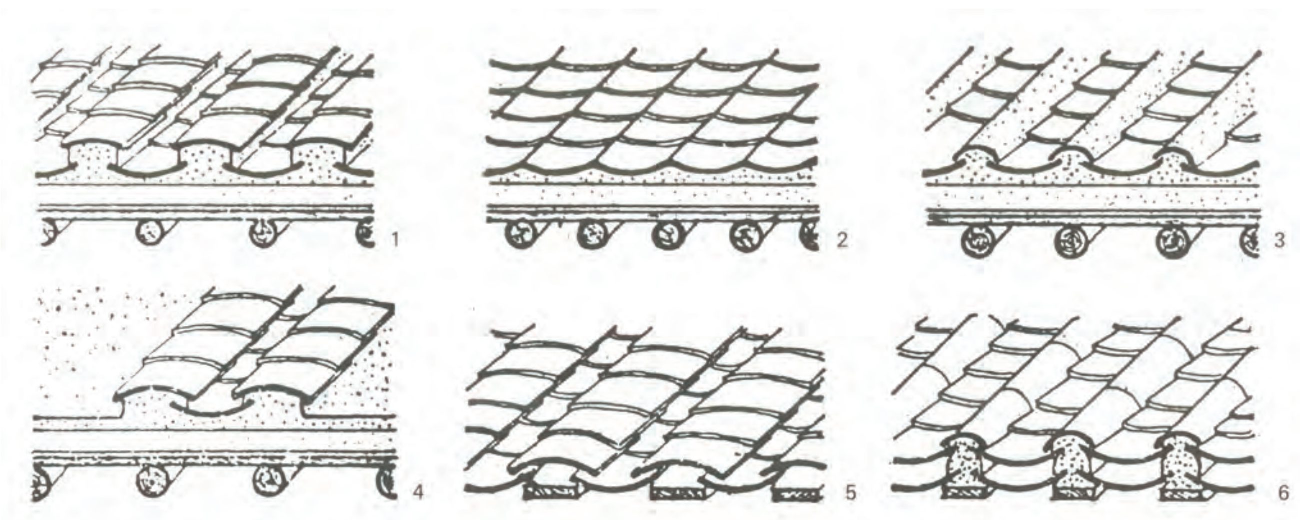


Figure 2-14: Common tile Laying Patterns, From *China's Old Dwellings* by Ronald G. Knapp, 153.
The six patterns are 1) Alternating concave and convex, 2) Adjacent concave, 3) concave with mortar cap, 4) tile and mortar alternating, 5) "southern over lapping concave and convex", 6) the "southern double-tile."

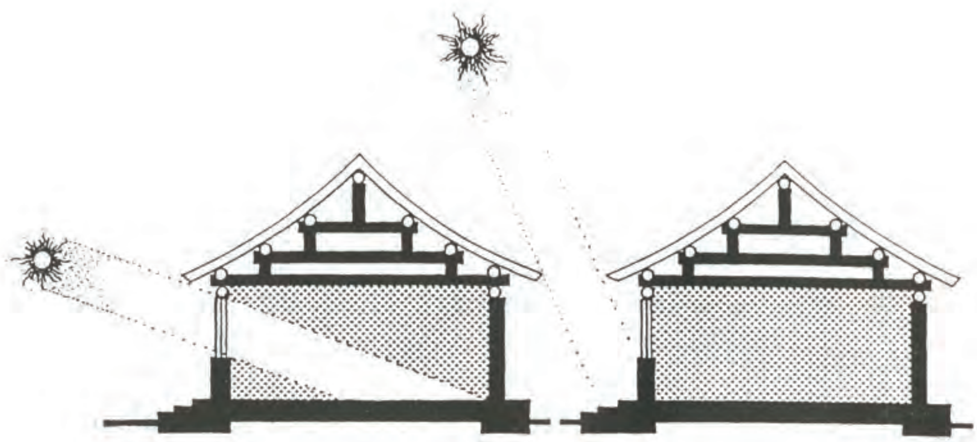


Figure 2-15: An example of curved Chinese roof forms: the short eve *yingshangding* roof. From *China's Old Dwellings*, 92.

Figure 3-1: Photo in Internal Glass tiles Skylight from Case Study One. Photo by the Author

Figure 3-2: Photo in Internal Glass tiles Skylight from Case Study Two. Photo By the Author

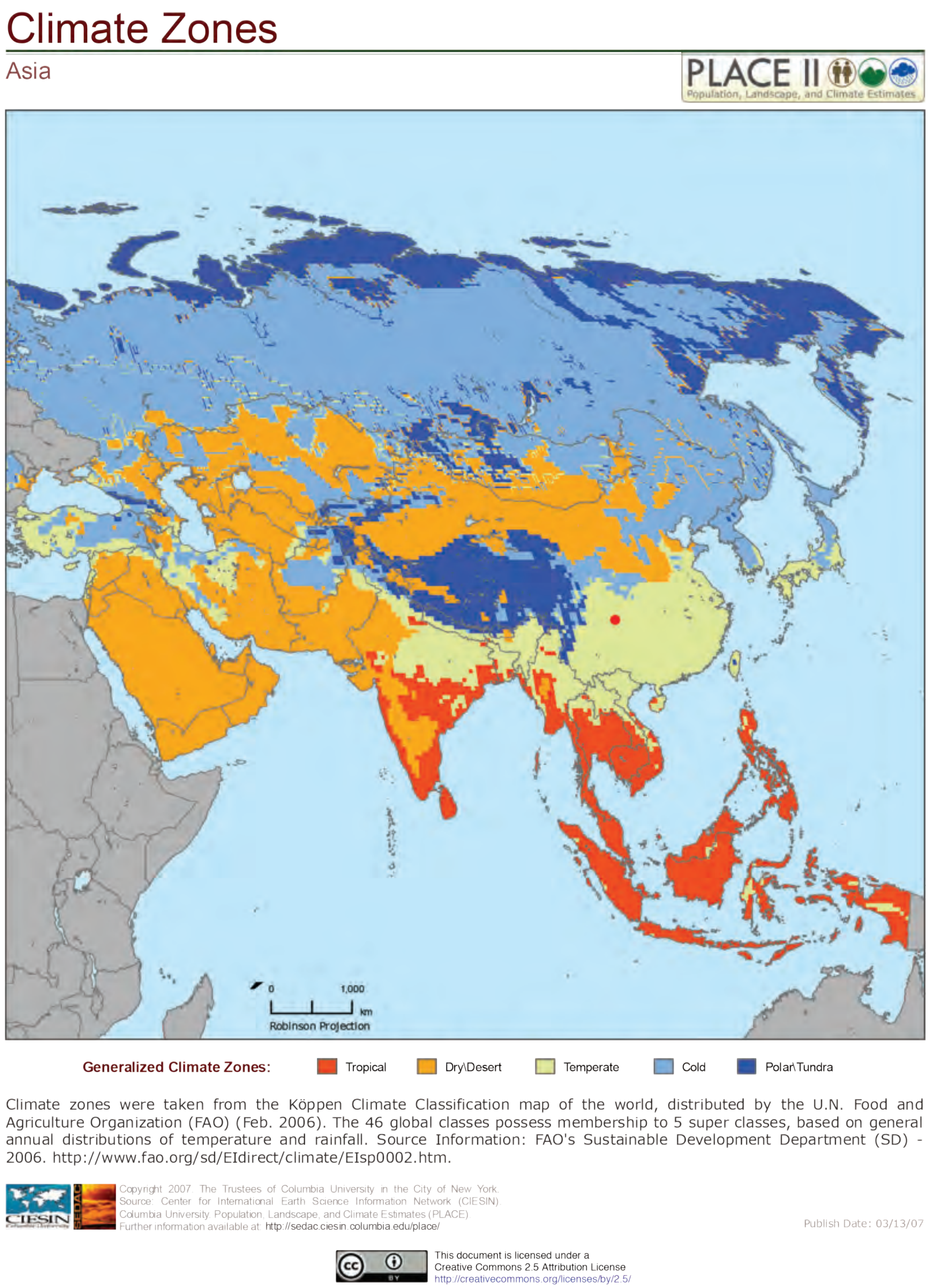


Figure 3-3: Climate Zones and Biomes of Asia, http://sedac.ciesin.columbia.edu/downloads/maps/nagdc/nagdc-population-landscape-climate-estimates-v2/Continent_Asia_ClimateZone.pdf

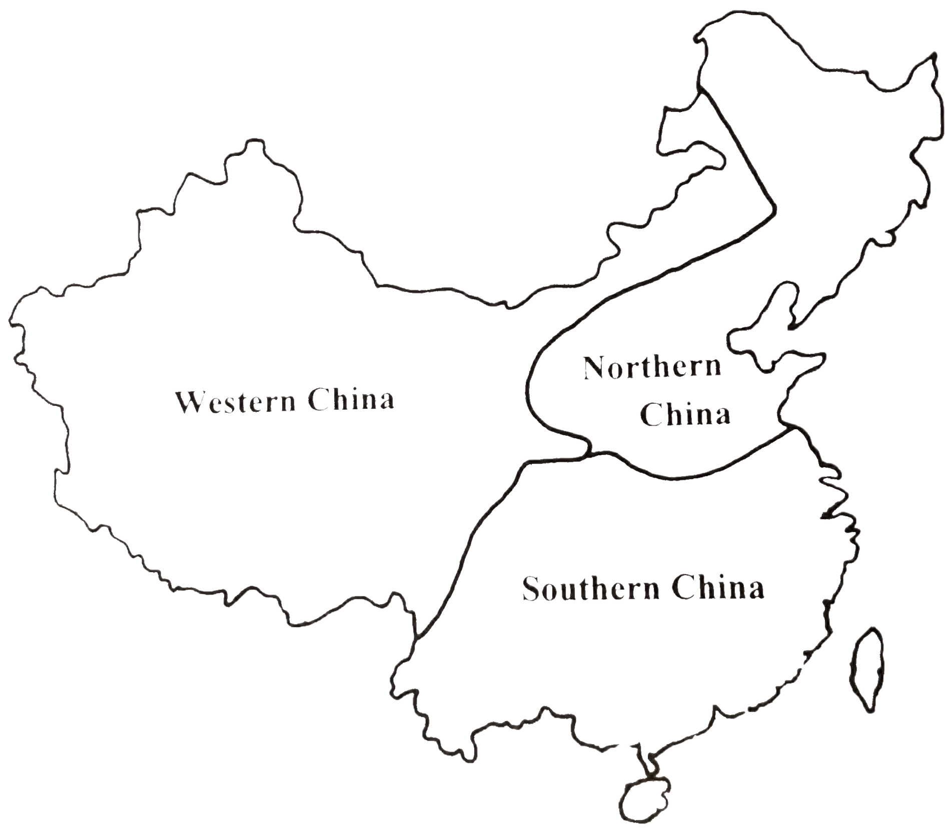


Figure 3-4: Geographer Jin Qiming's 3 Regions of Chinese Architectural Heritage as Illustrated by Ronald Knapp in *China's Old Dwellings*

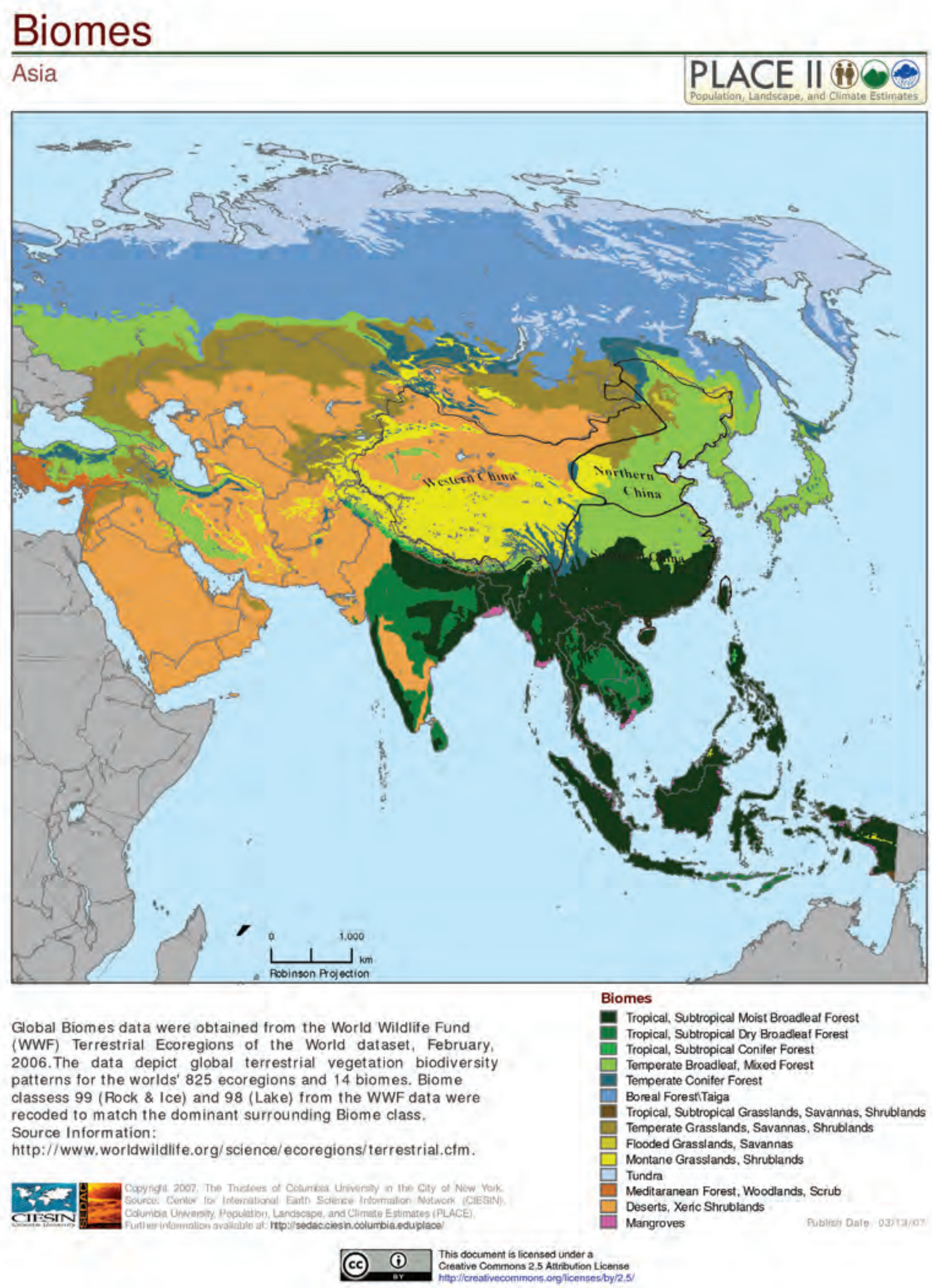
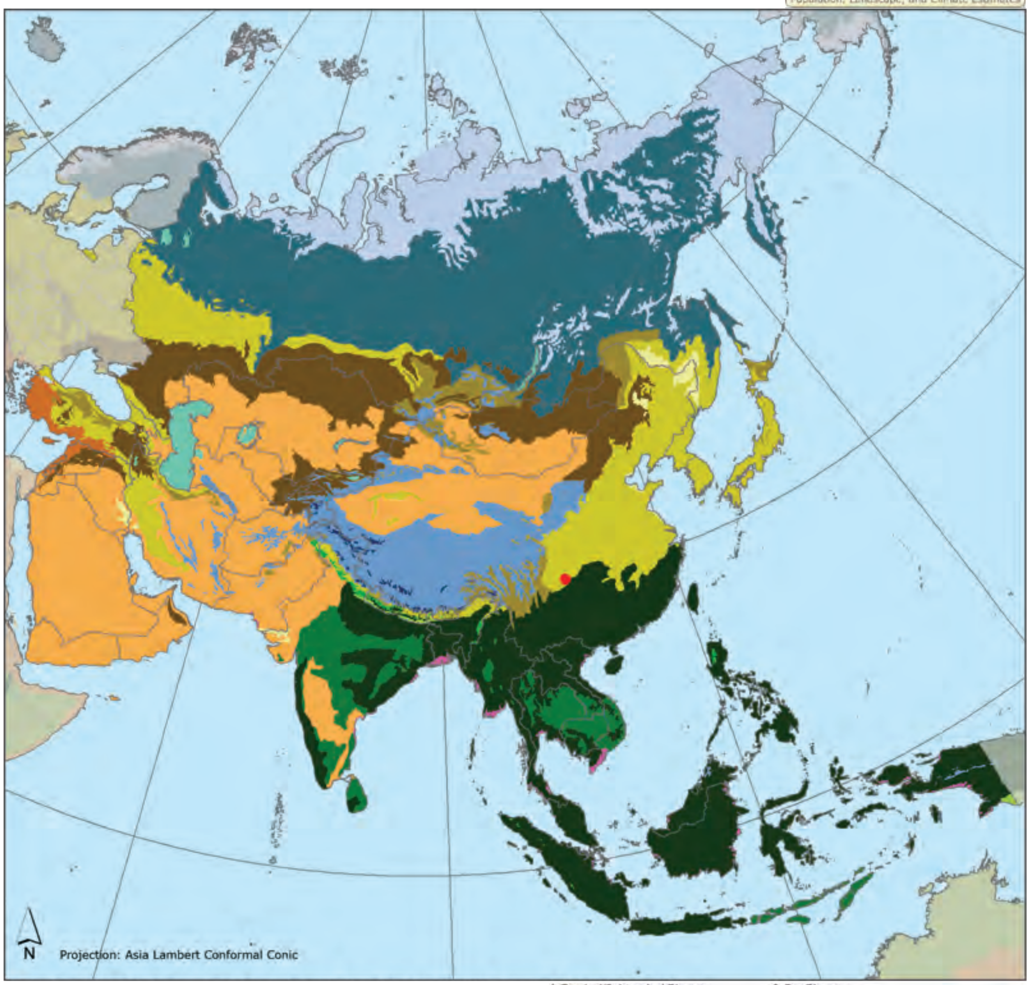


Figure 3-5: An overlay of Geographer Jin Qiming's 3 Regions of Chinese Architectural Heritage as Illustrated by Ronald Knapp in *China's Old Dwellings* on top of the SEDAC Climate Zones and Biomes of Asia map revealing their coincidence.

Population, Landscape and Climate Estimates, v3: Biomes, Asia

National Aggregates of Geospatial Data Collection

PLACE III
Population, Landscape, and Climate Estimates



Global Biomes data were obtained from the World Wildlife Fund (WWF) Terrestrial Ecoregions of the World dataset, in February, 2006. The data depict global terrestrial vegetation biodiversity patterns for the worlds' 825 ecoregions and 14 biomes. The data are distributed in vector format, which were created to be used at the scale of 1:1 million. CIESIN converted the data to raster grid format at a 30 arc-second resolution and clipped to match the extent of GRUMPv1.

1. Tropical/Subtropical Biomes
- Flooded Grasslands and Savannas
- Coniferous Forests
- Dry Broadleaf Forests
- Grasslands, Savannas, and Shrublands
- Moist Broadleaf Forests

2. Temperate Biomes
- Broadleaf and Mixed Forests
- Coniferous Forests
- Grasslands, Savannas, and Shrublands

3. Dry Biomes
- Deserts and Xeric Shrublands
- Mediterranean Forests, Woodlands, and Scrub

4. Polar/Montane Biomes
- Boreal Forests/Taiga
- Montane Grasslands and Shrublands
- Rock and Ice
- Tundra

5. Aquatic Biomes
- Lakes
- Mangroves

Center for International Earth Science Information Network
Earth Institute | Columbia University

SEDAC

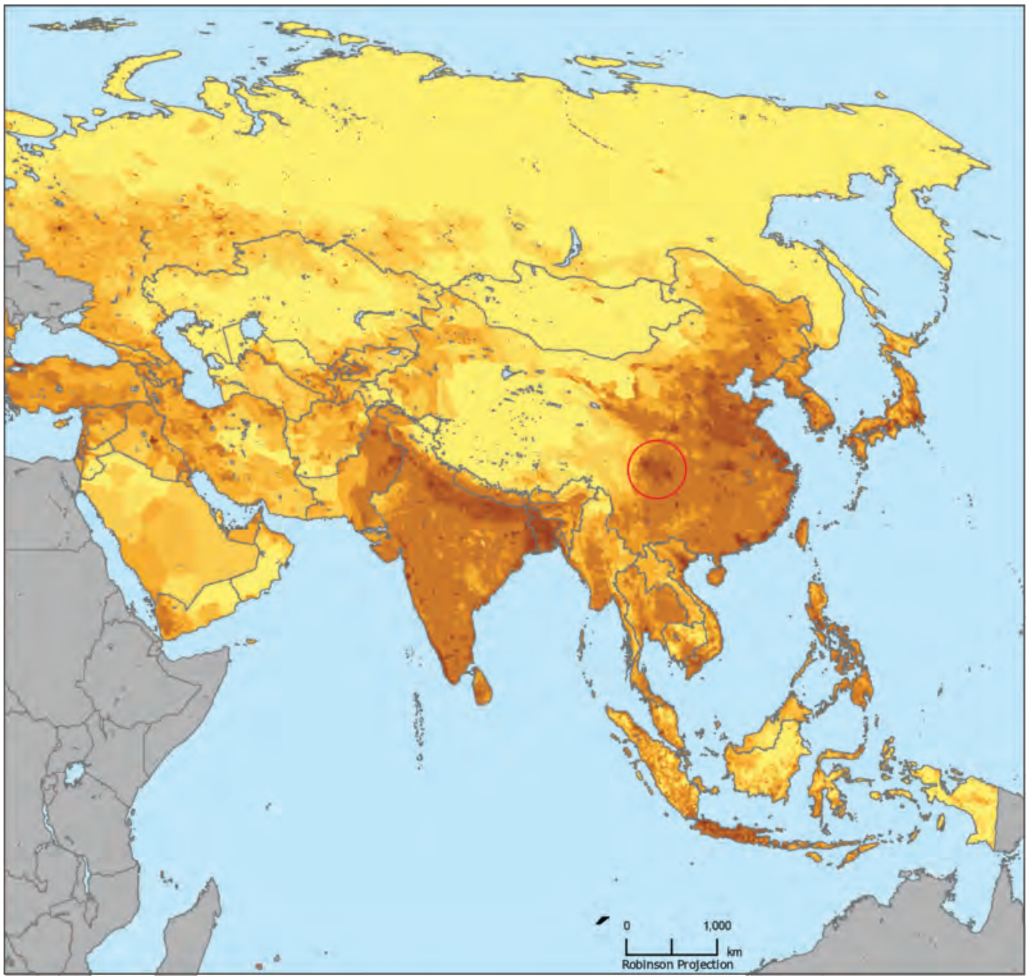
Publication Date:
March 2012

Figure 3-6: Population, Landscape and Climate Estimates of the Asian Biomes. From http://sedac.ciesin.columbia.edu/downloads/maps/nagdc/nagdc-population-landscape-climate-estimates-v2/Continent_Asia_Biome.pdf

Population Density

Asia

PLACE II
Population, Landscape, and Climate Estimates



Population Density 2000

- 0 Persons \ Sq.Km
- 0-2 Persons \ Sq.Km
- 2-5 Persons \ Sq.Km
- 5-10 Persons \ Sq.Km
- 10-15 Persons \ Sq.Km
- 15- 50 Persons \ Sq.Km
- 50- 100 Persons \ Sq.Km
- 100- 500 Persons \ Sq.Km
- 500- 1000 Persons \ Sq.Km
- 1000- 10000 Persons \ Sq.Km
- 10000- 50000 Persons \ Sq.Km
- > 50000 Persons \ Sq.Km

Population density (persons per square kilometer) layers, for 1990 and 2000 were created by dividing the 1990 and 2000 UN-adjusted population (POP) count grids by the land area (LA) grid. The resulting grid layers, one each for 1990 and 2000, were then aggregated to match the 12 population density classes. Source information: http://sedac.ciesin.columbia.edu/gpw/.

Publish Date: 03/13/07

Figure 3-7: Population Density of Asia http://sedac.ciesin.columbia.edu/downloads/maps/nagdc/nagdc-population-landscape-climate-estimates-v2/Continent_Asia_PopDensity.pdf

Figure 3-8: Woven Bamboo panel from Case Study 5. Photo By the Author

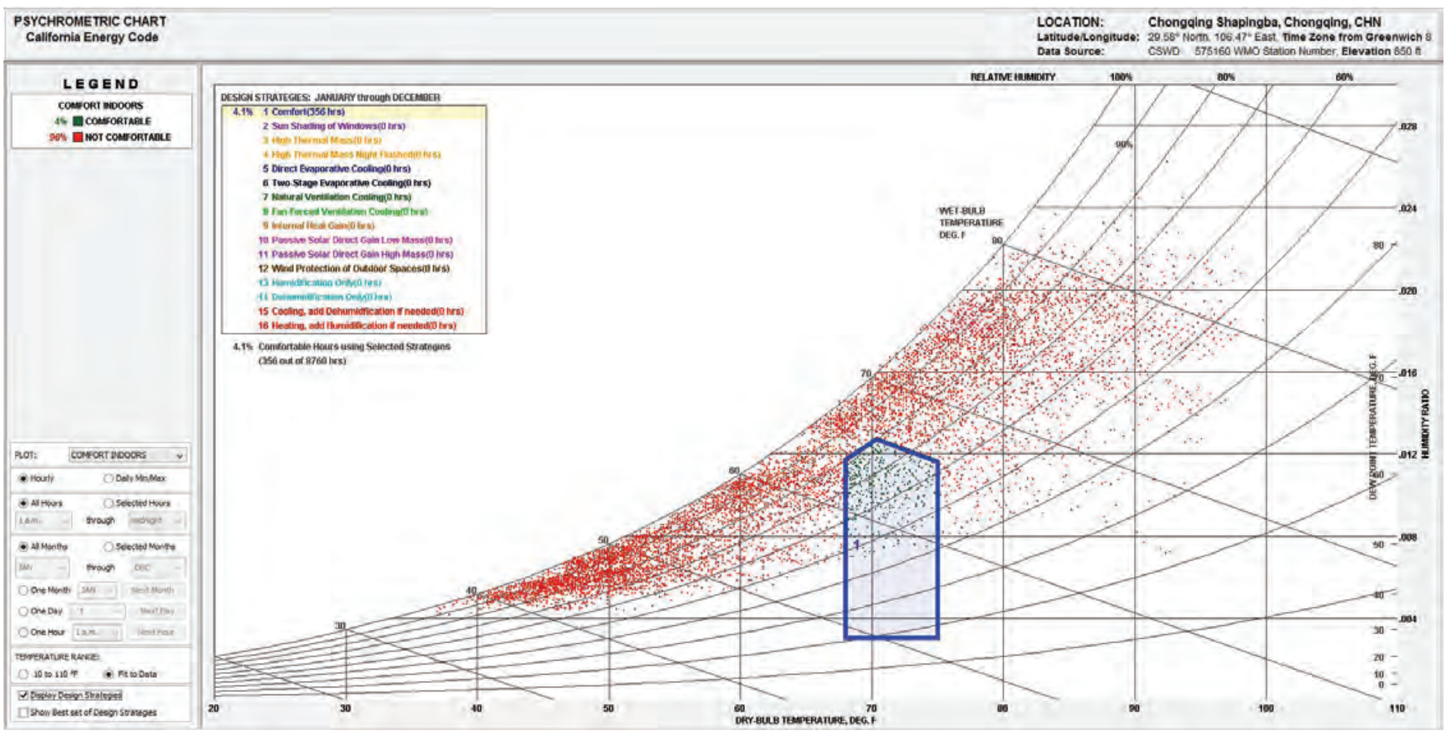


Figure 3-9: Psychrometric Chart from Climate Consultant of EERE Data for Shapinba District of Chongqing, China with California Energy Code's Comfort Area Overlay

Figure 3-10: Photo example of a Diaojiaolou from the Miao village in the mountains surrounding Gongtan.
Photo by Author

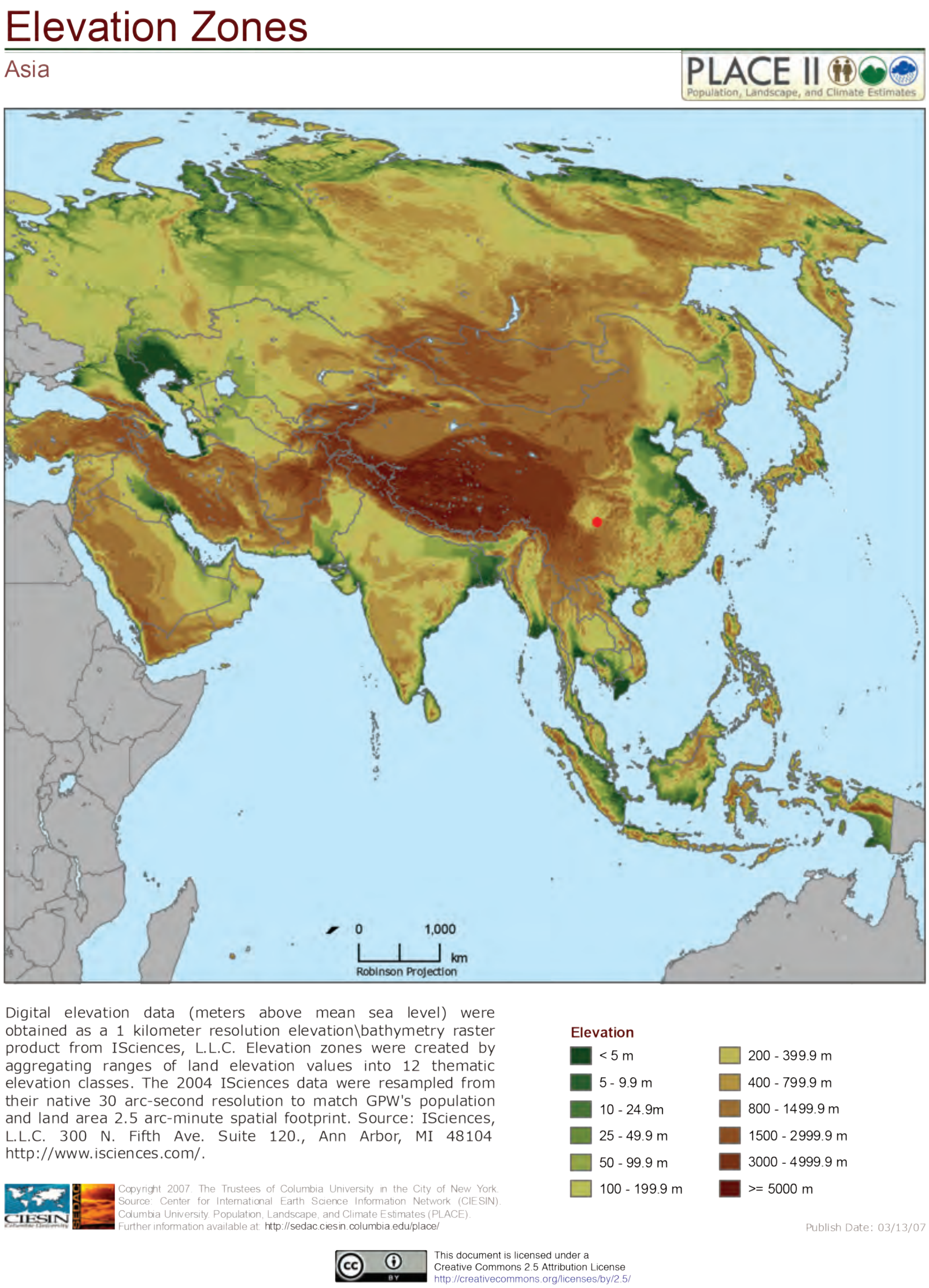


Figure 3-11: Asian Elevation Zones, with Chongqing noted. From SEDAC (The Socioeconomic Data and Application Center), http://sedac.ciesin.columbia.edu/downloads/maps/nagdc/nagdc-population-landscape-climate-estimates-v2/Continent_Asia_ElevationZone.pdf

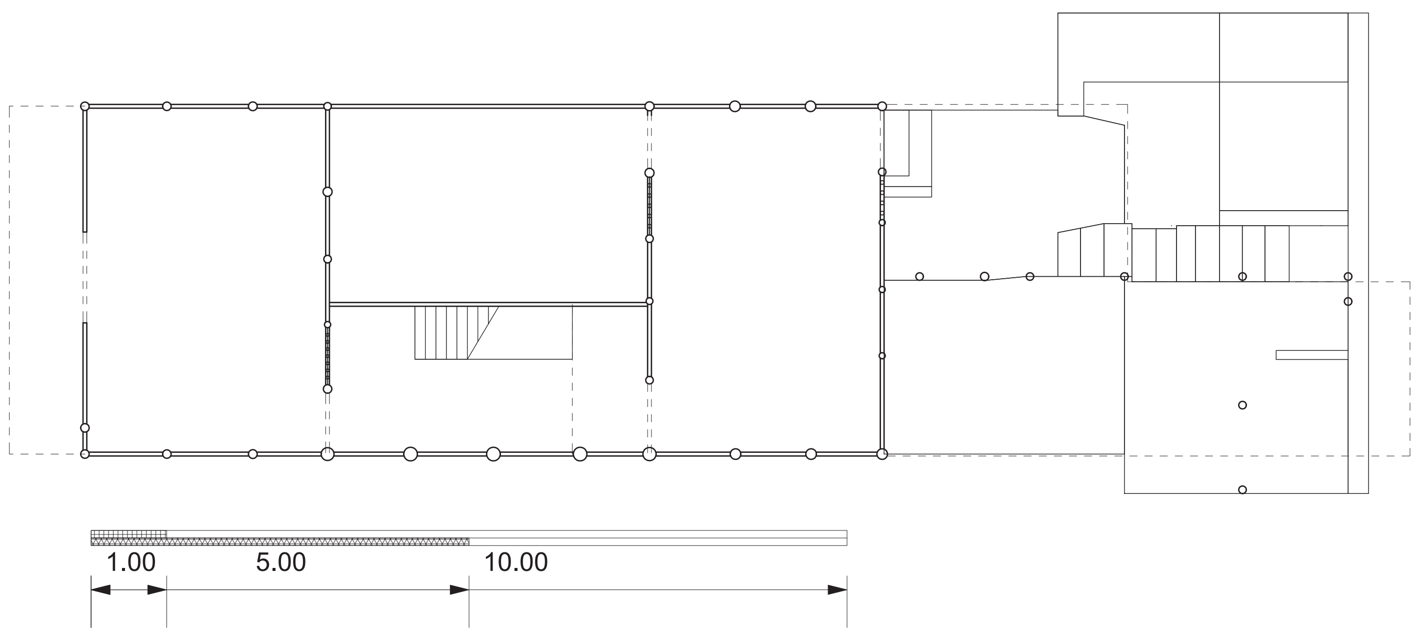


Figure A-1: Case Study One, First Floor Plan

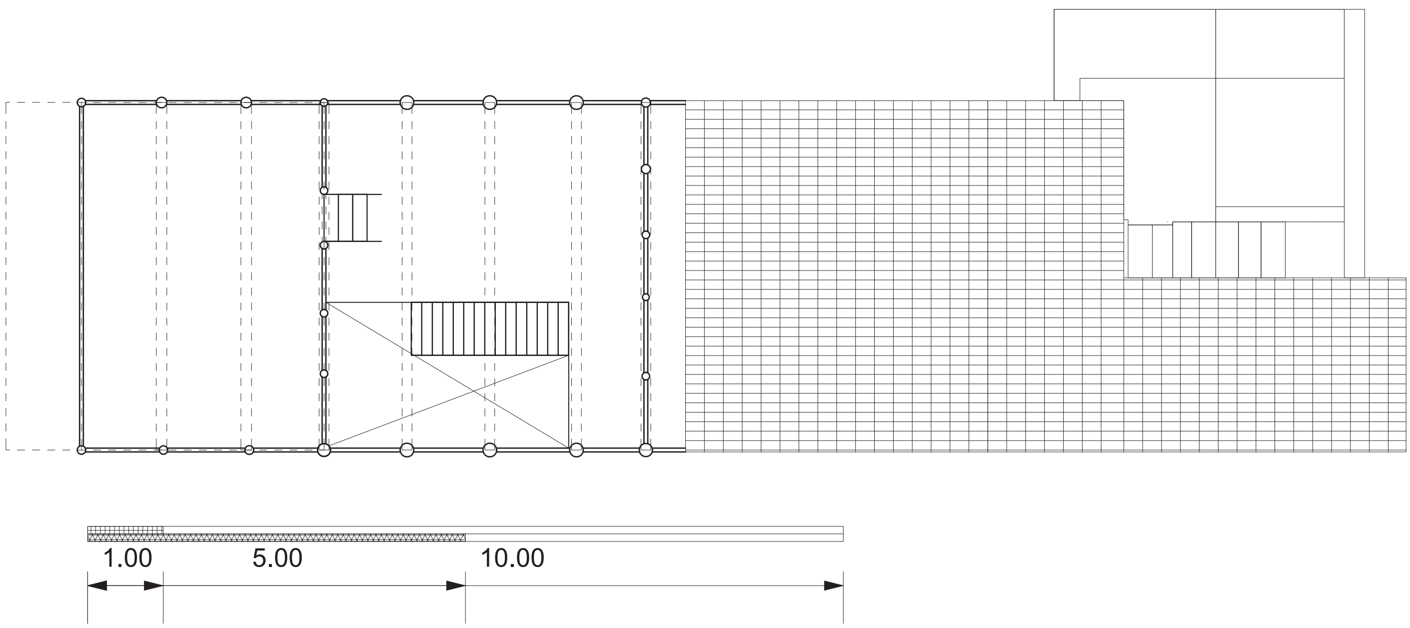


Figure A-2: Case Study One, Second Floor Plan

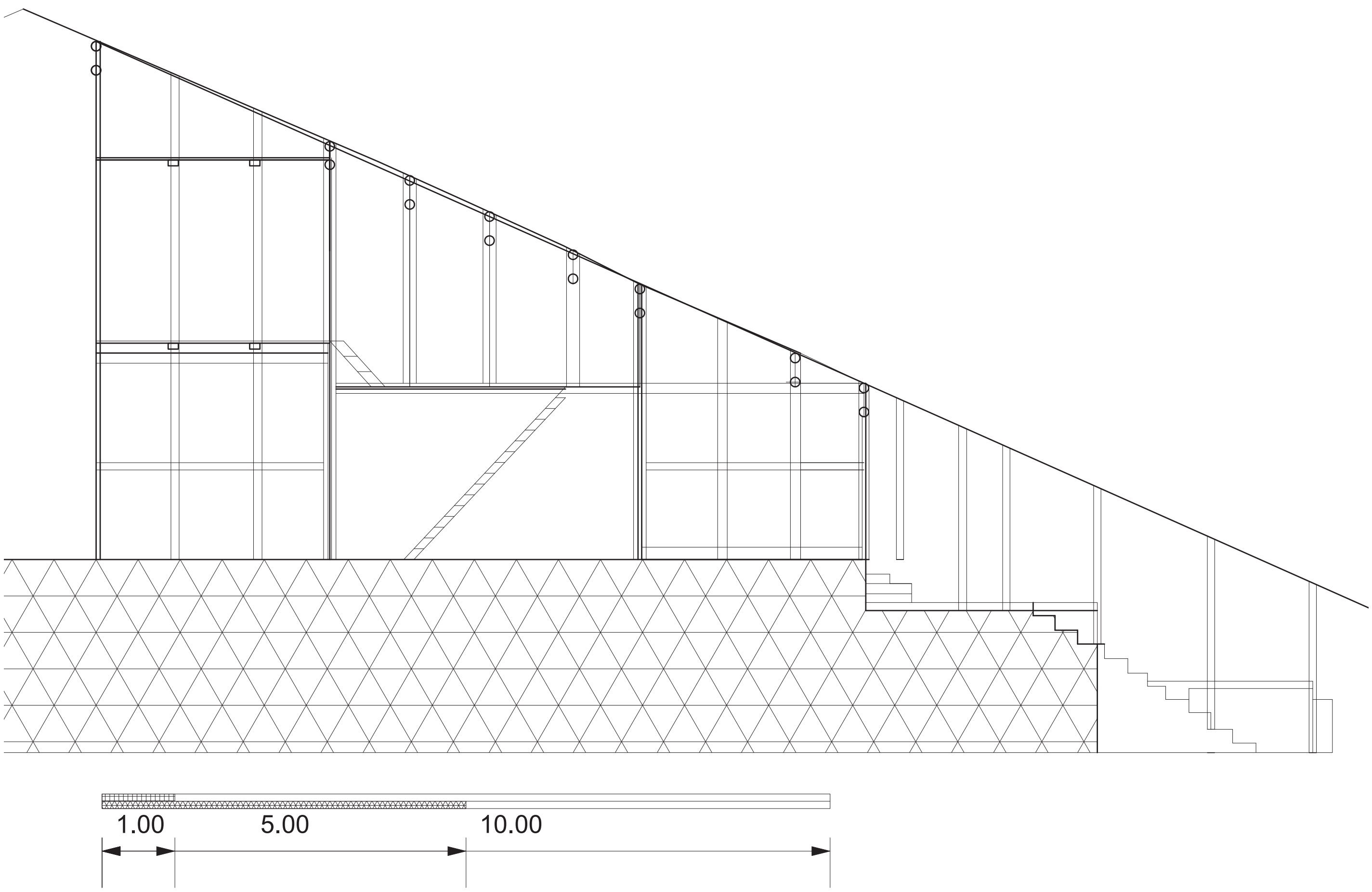


Figure A-3: Case Study One, Longitudinal Section

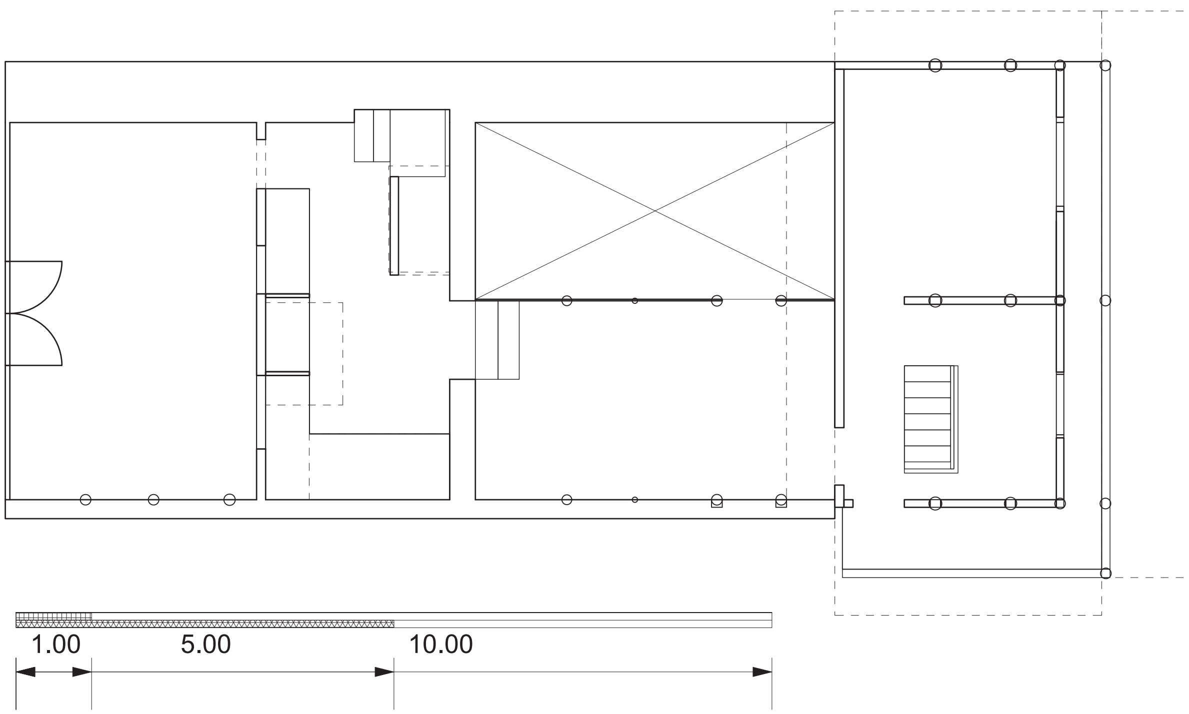


Figure A-4: Case Study Two, First Floor Plan

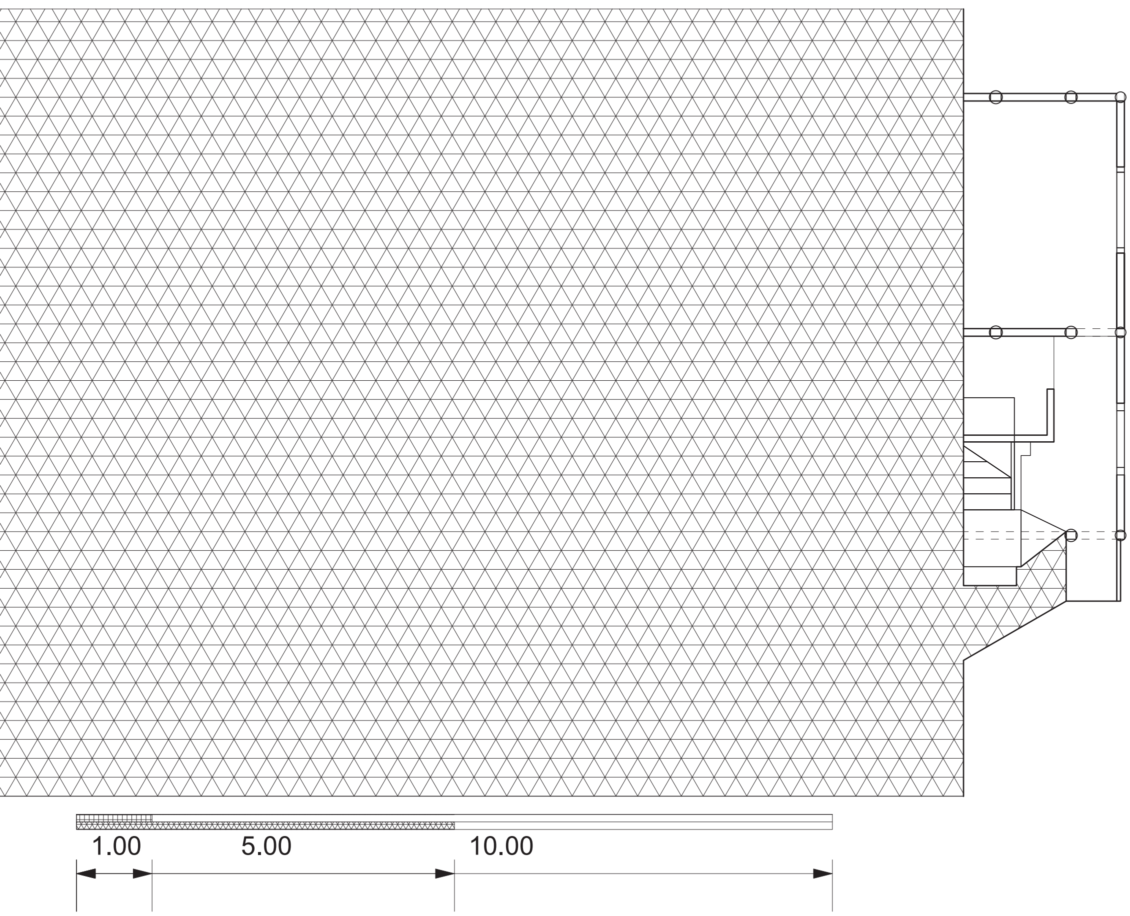


Figure A-5: Case Study Two, Basement Floor Plan

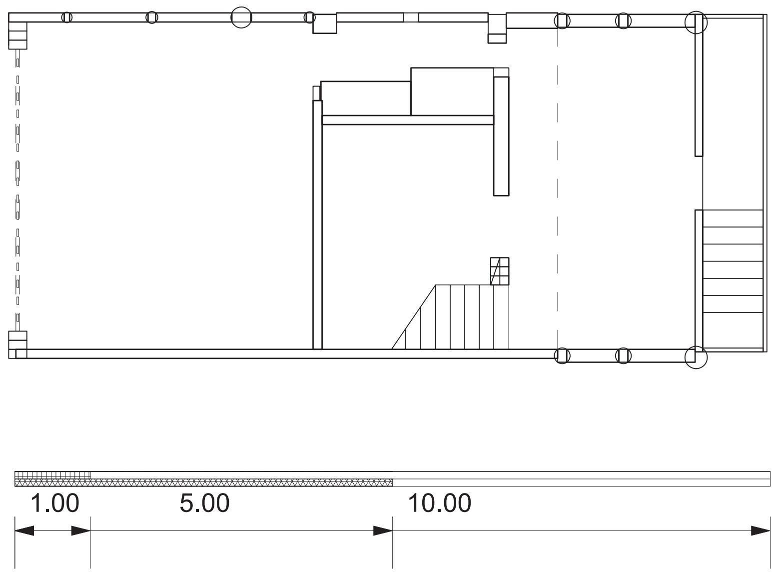


Figure A-6: Case Study Three, First Floor Plan

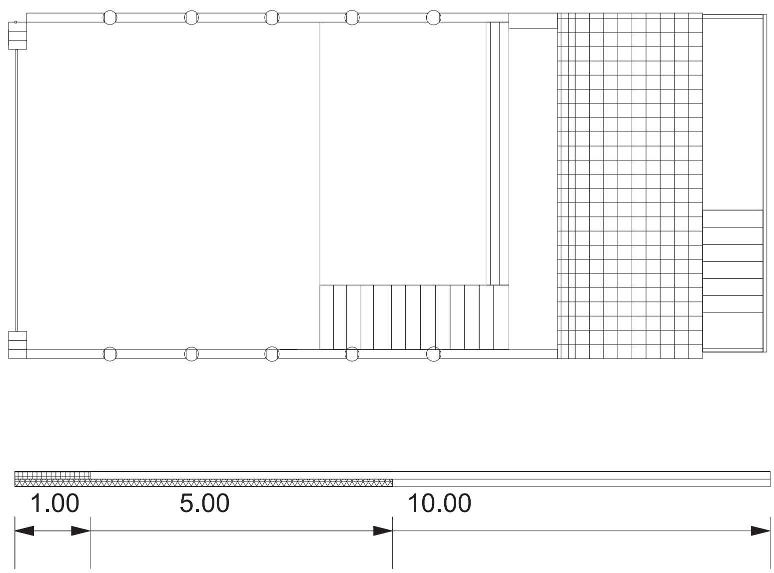


Figure A-7: Case Study Three, Second Floor Plan

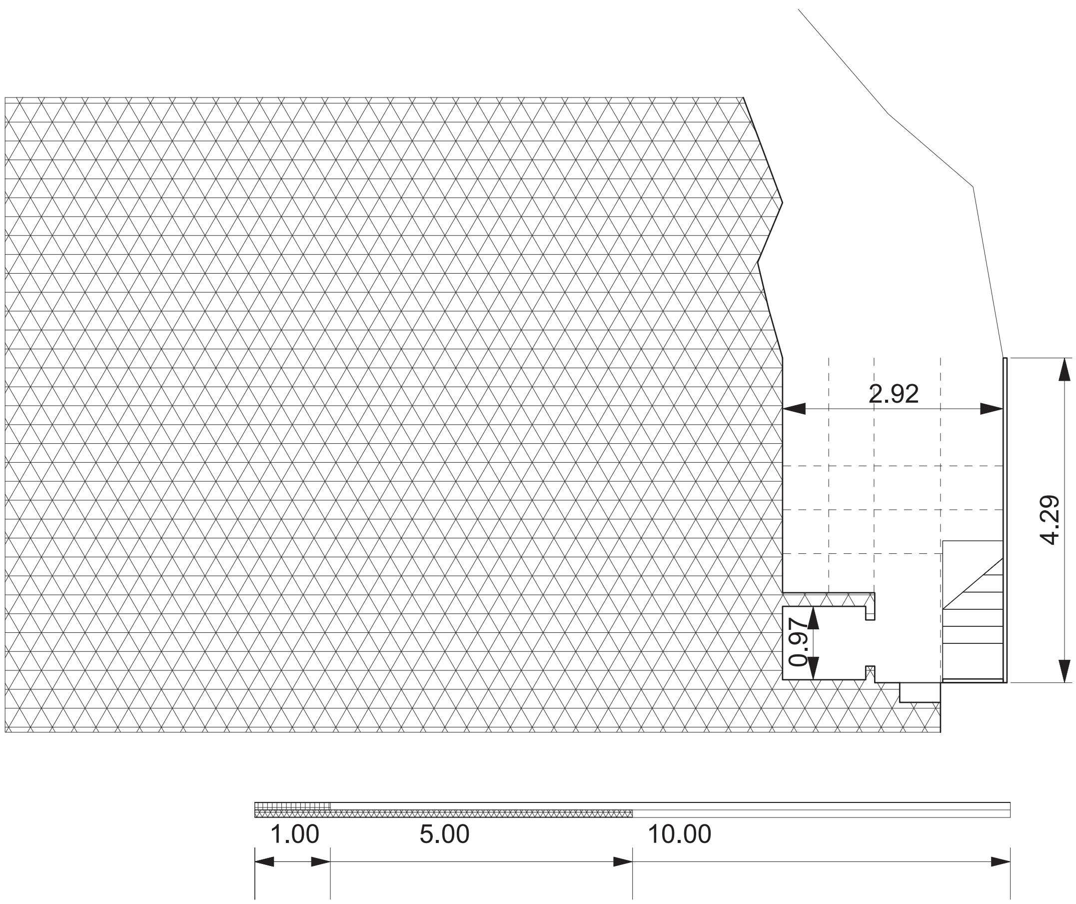


Figure A-8: Case Study Three, Basement Floor Plan

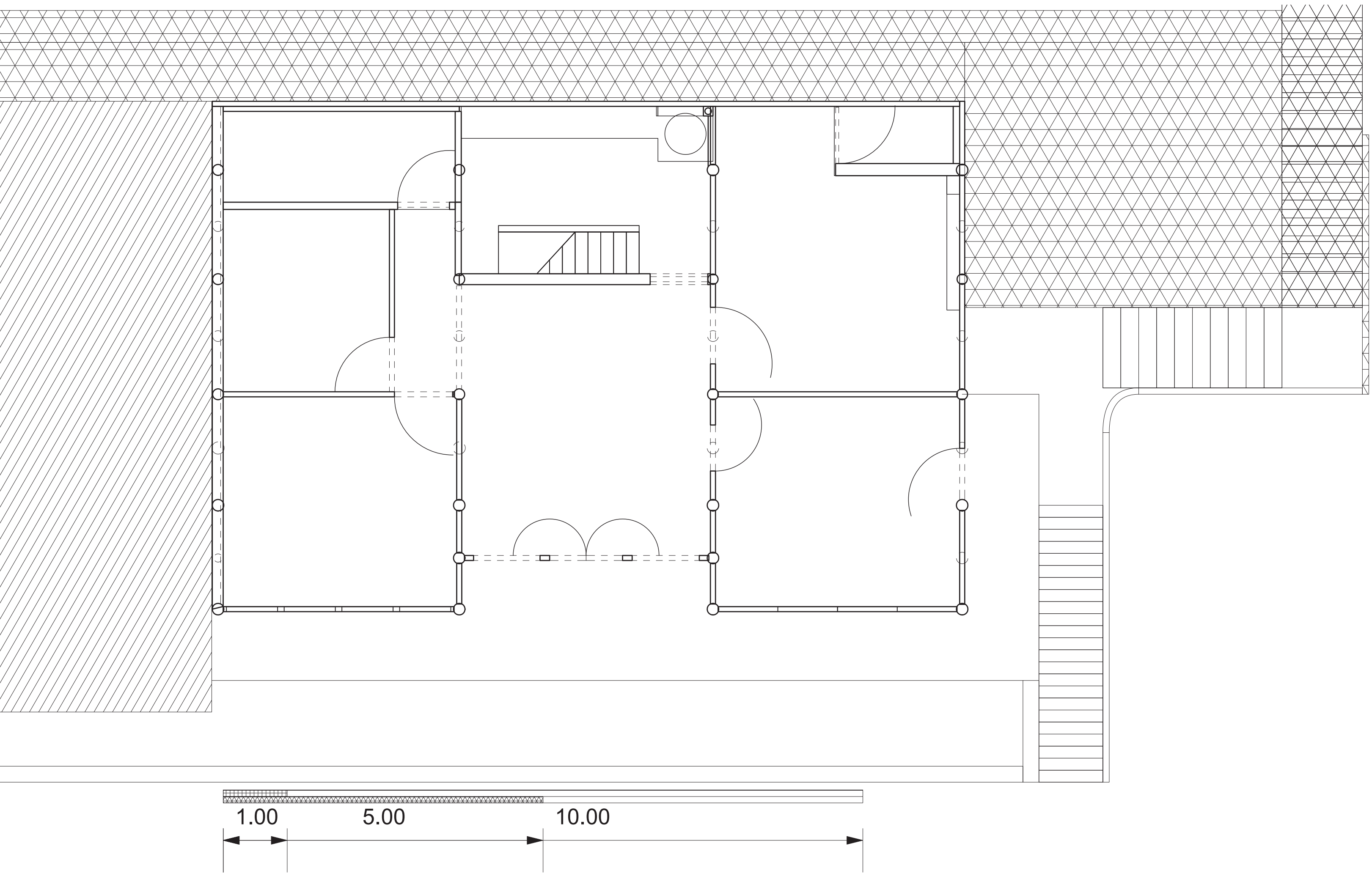


Figure A-9: Case Study Four, First Floor Plan

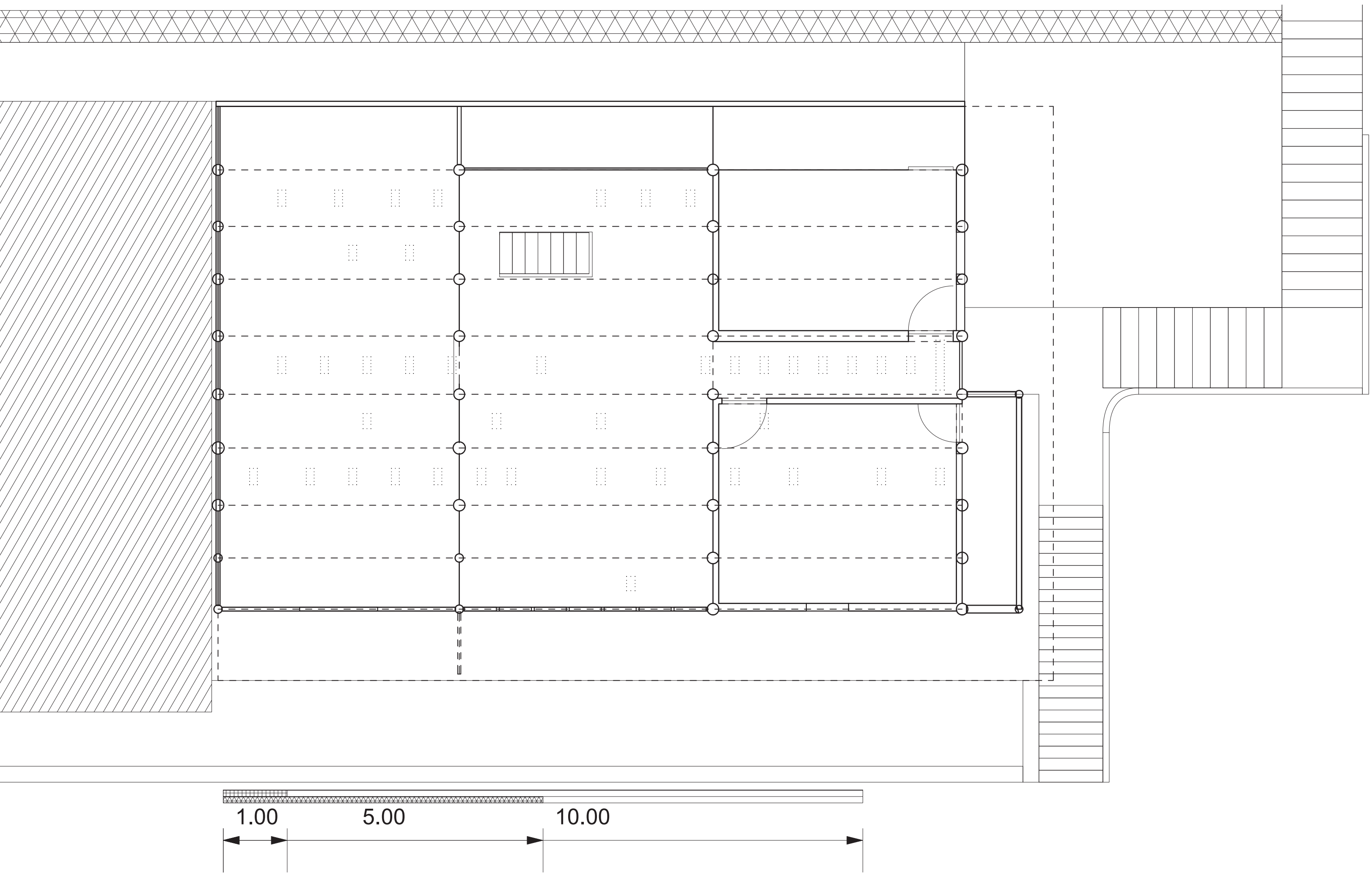


Figure A-10: Case Study Four, Second Floor Plan

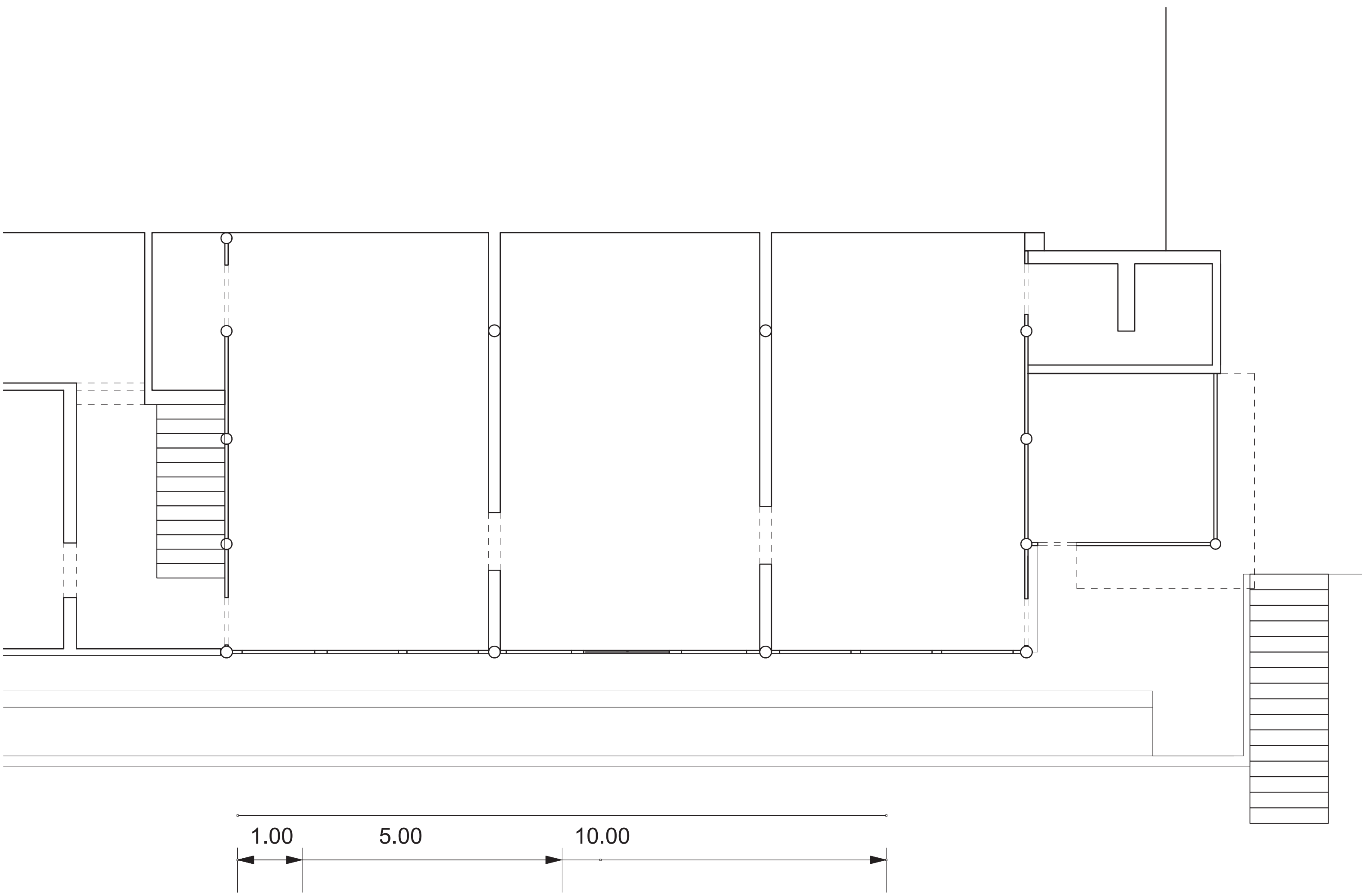


Figure A-11: Case Study Five, Basement Floor Plan

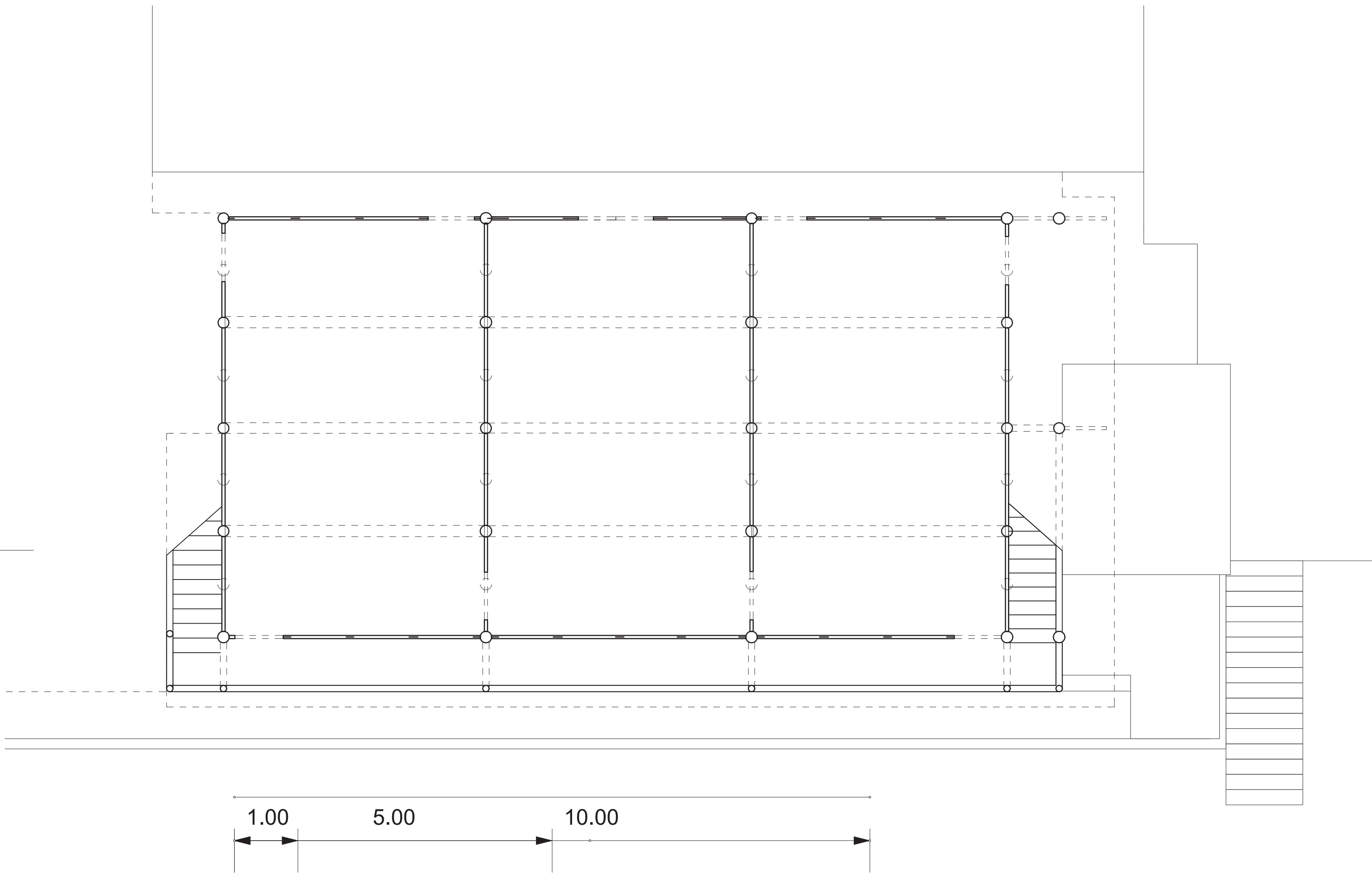


Figure A-12: Case Study Five, First Floor Plan

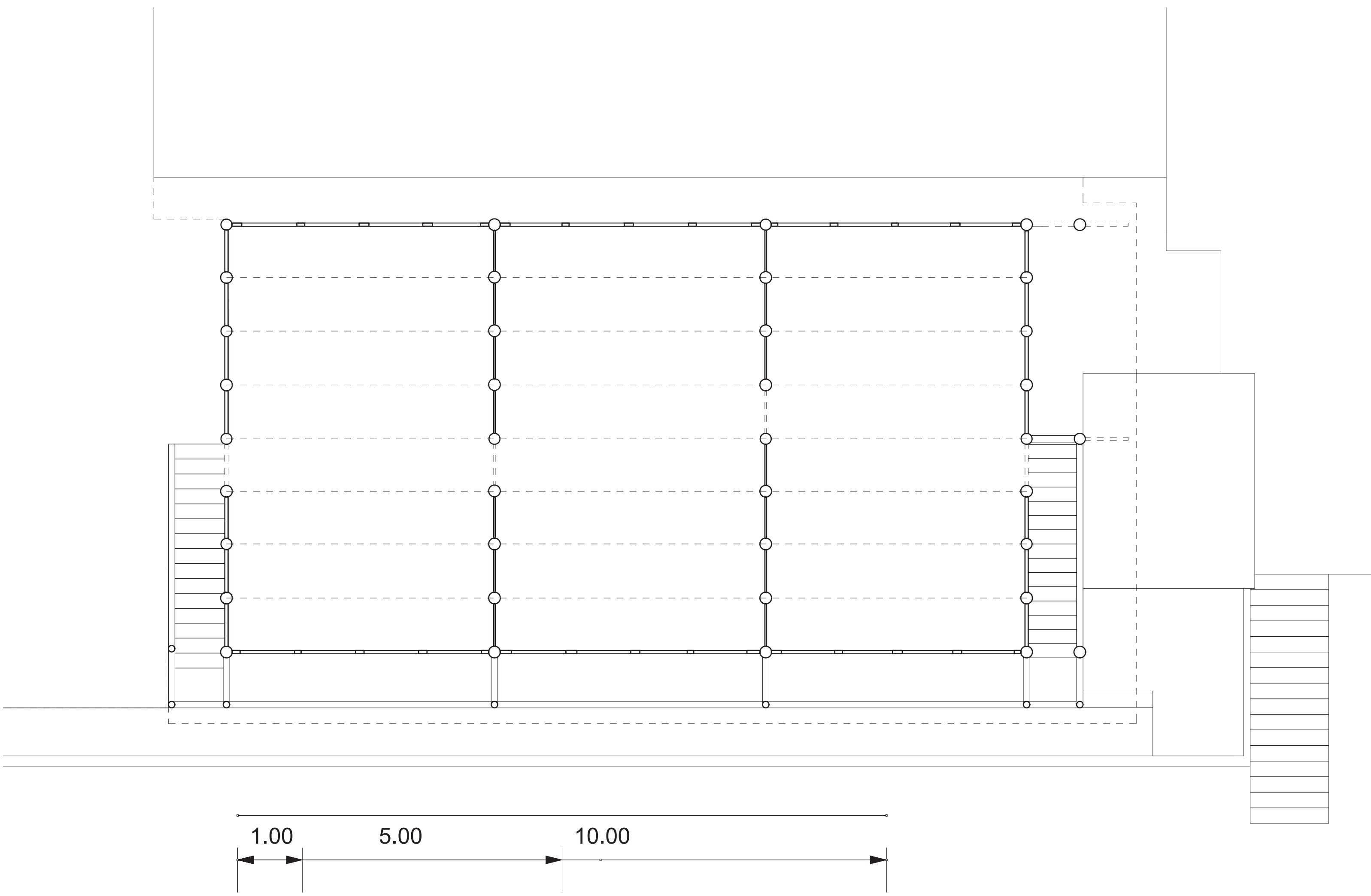


Figure A-13: Case Study Five, Second Floor Plan

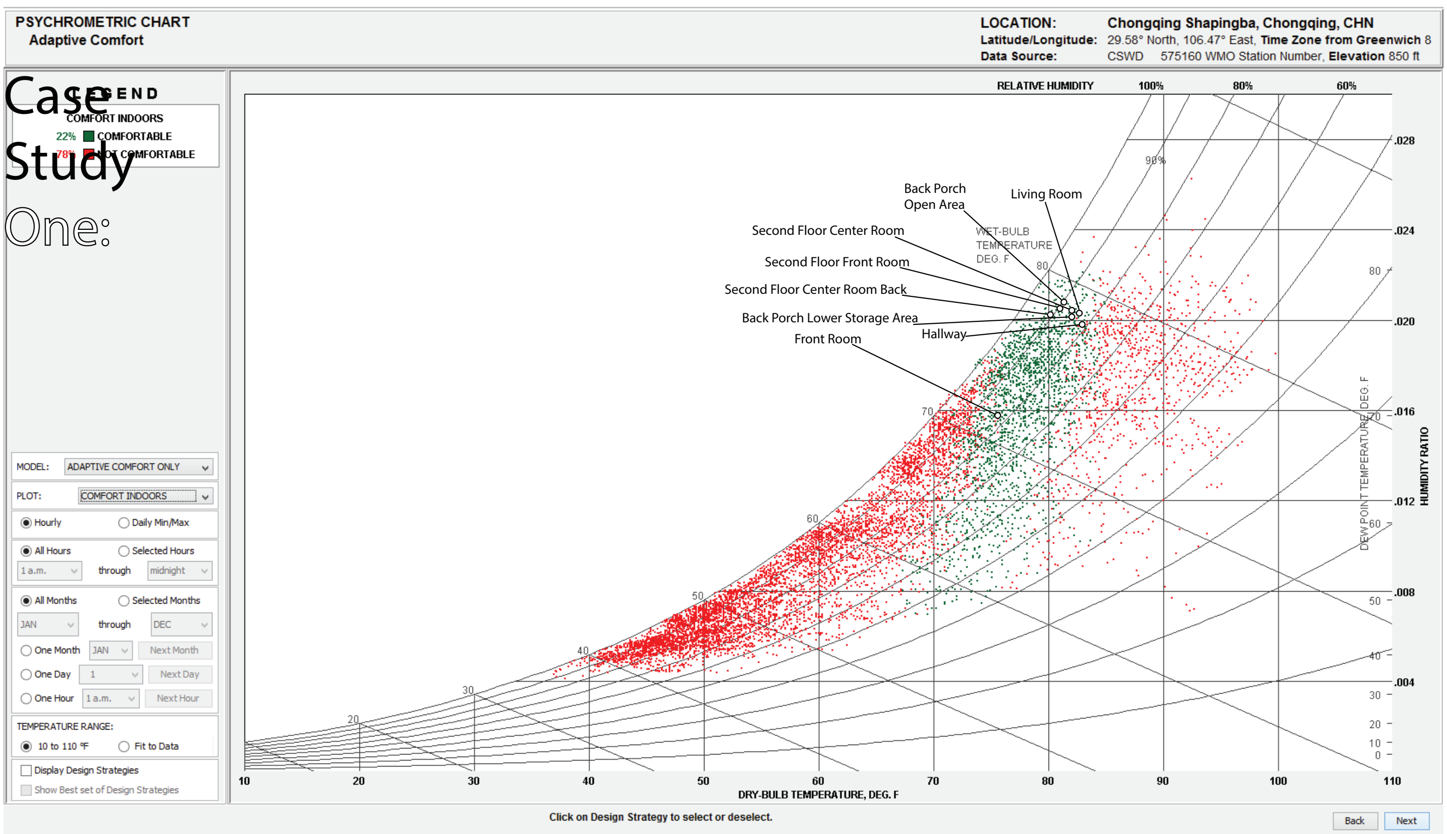


Figure A-14: Case Study One Psychrometric Chart Analysis of Temperature and Humidity Data

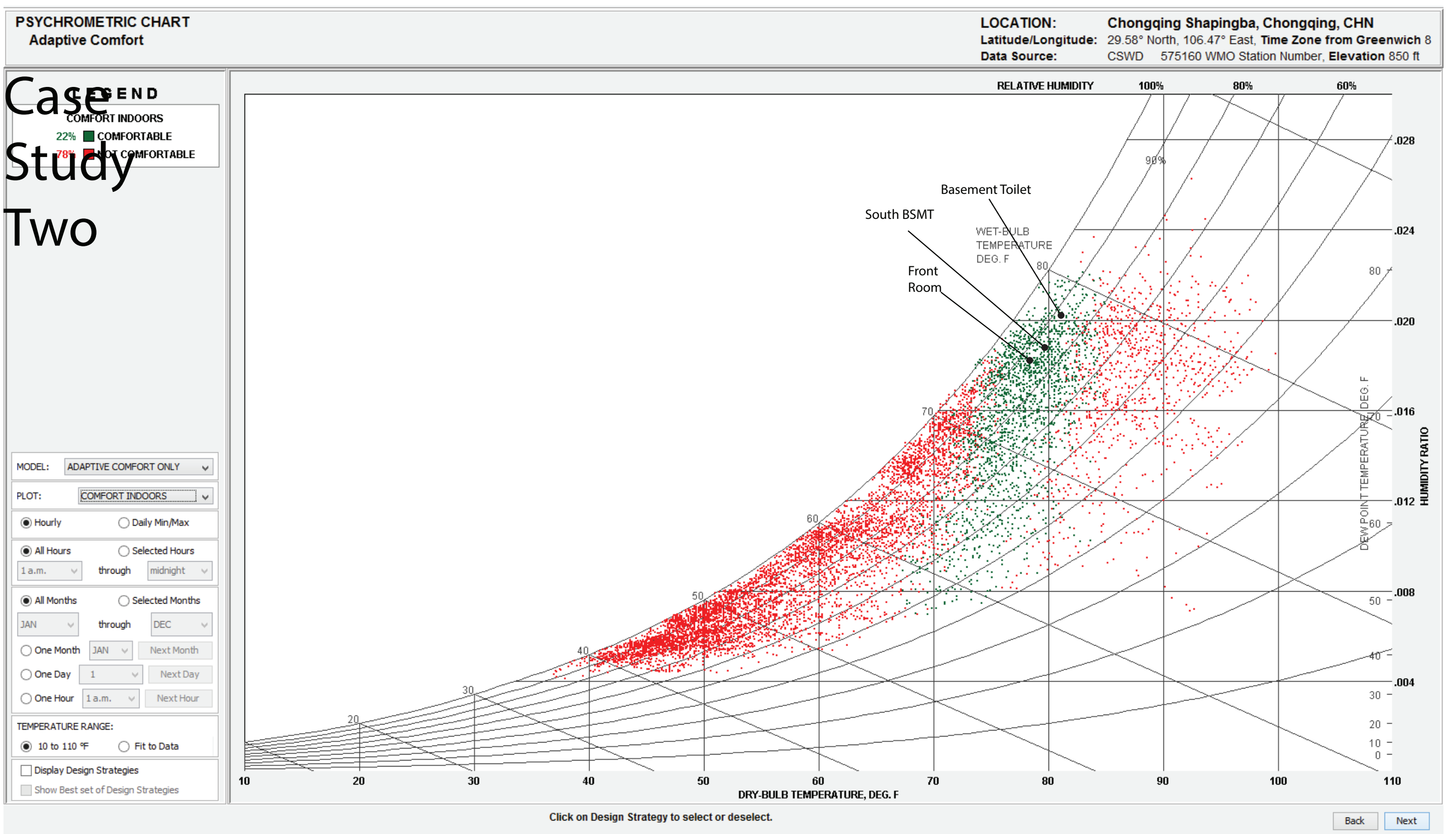


Figure A-15: Case Study Two Psychrometric Chart Analysis of Temperature and Humidity Data

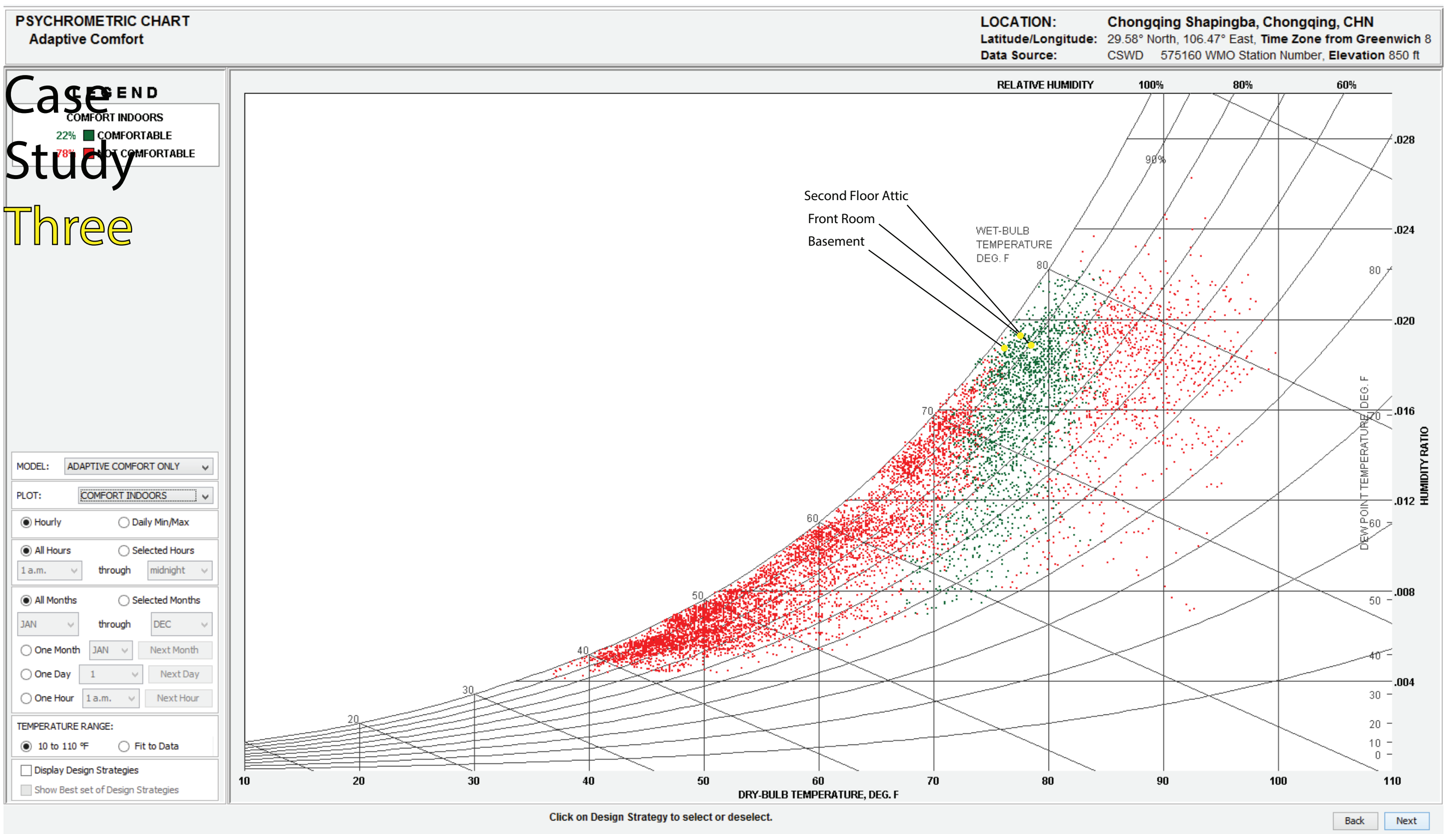


Figure A-16: Case Study Three Psychrometric Chart Analysis of Temperature and Humidity Data

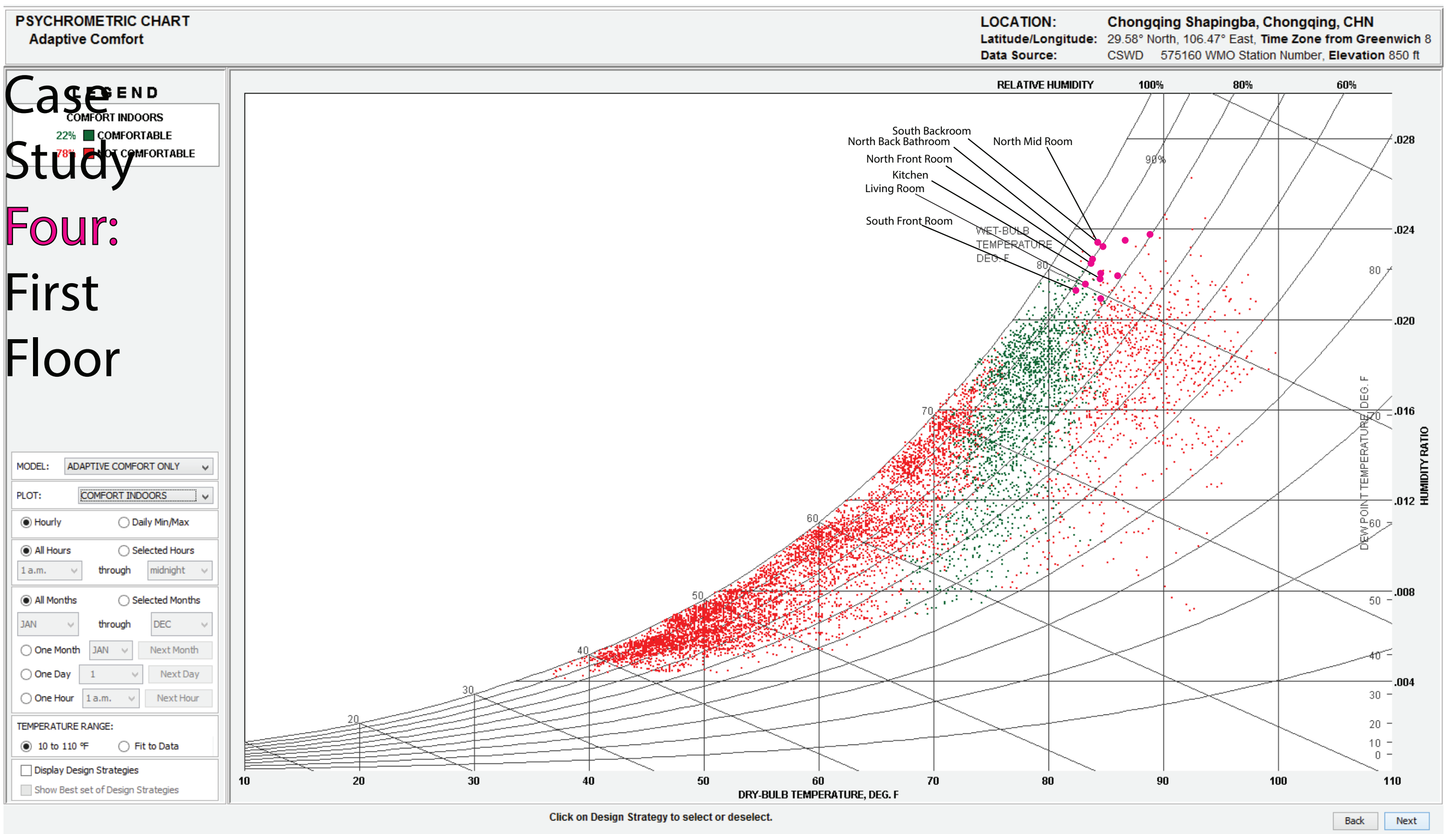


Figure A-17: Case Study Four, First Floor Psychrometric Chart Analysis of Temperature and Humidity Data

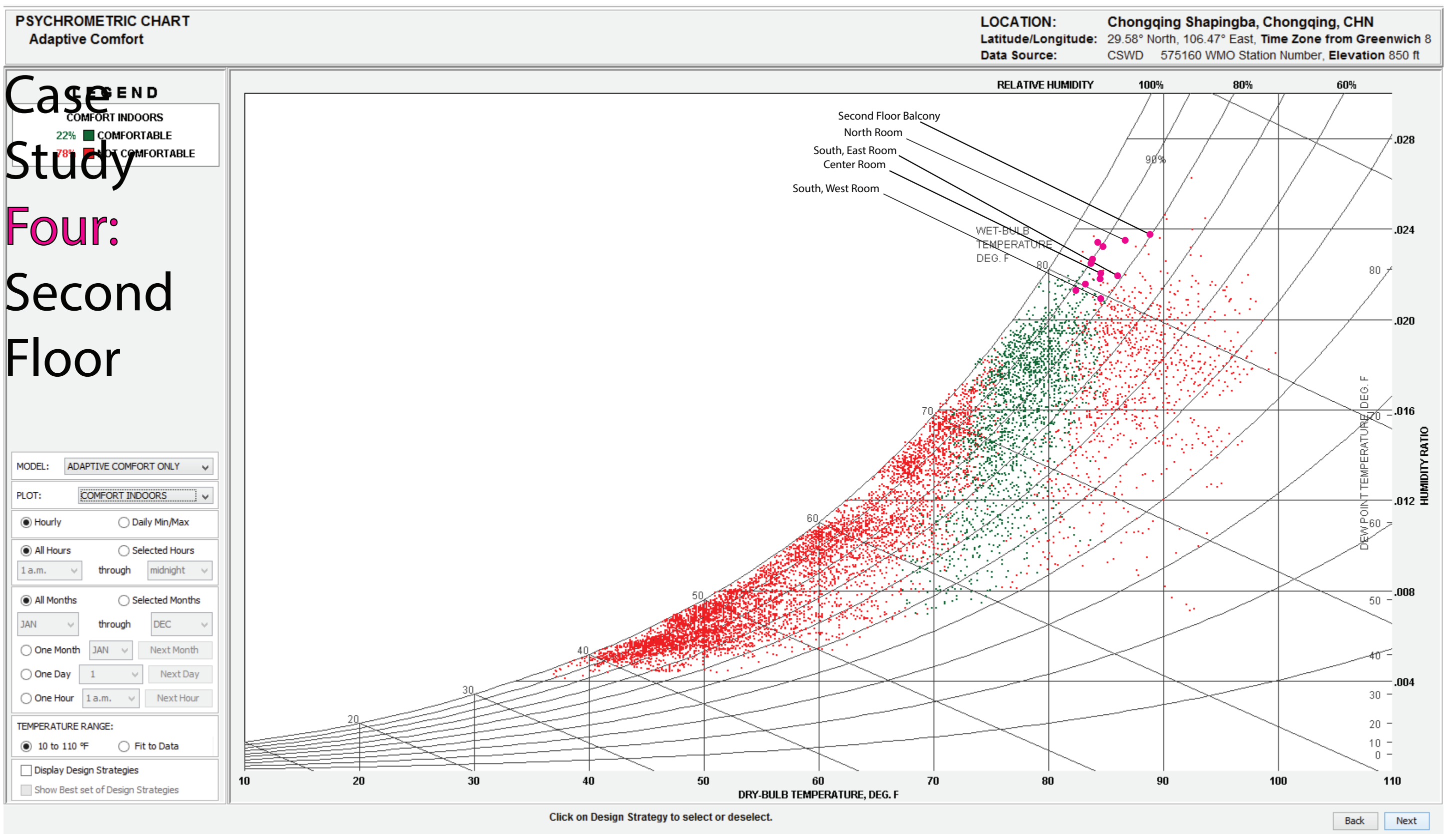


Figure A-18: Case Study Four, Second Floor Psychrometric Chart Analysis of Temperature and Humidity Data

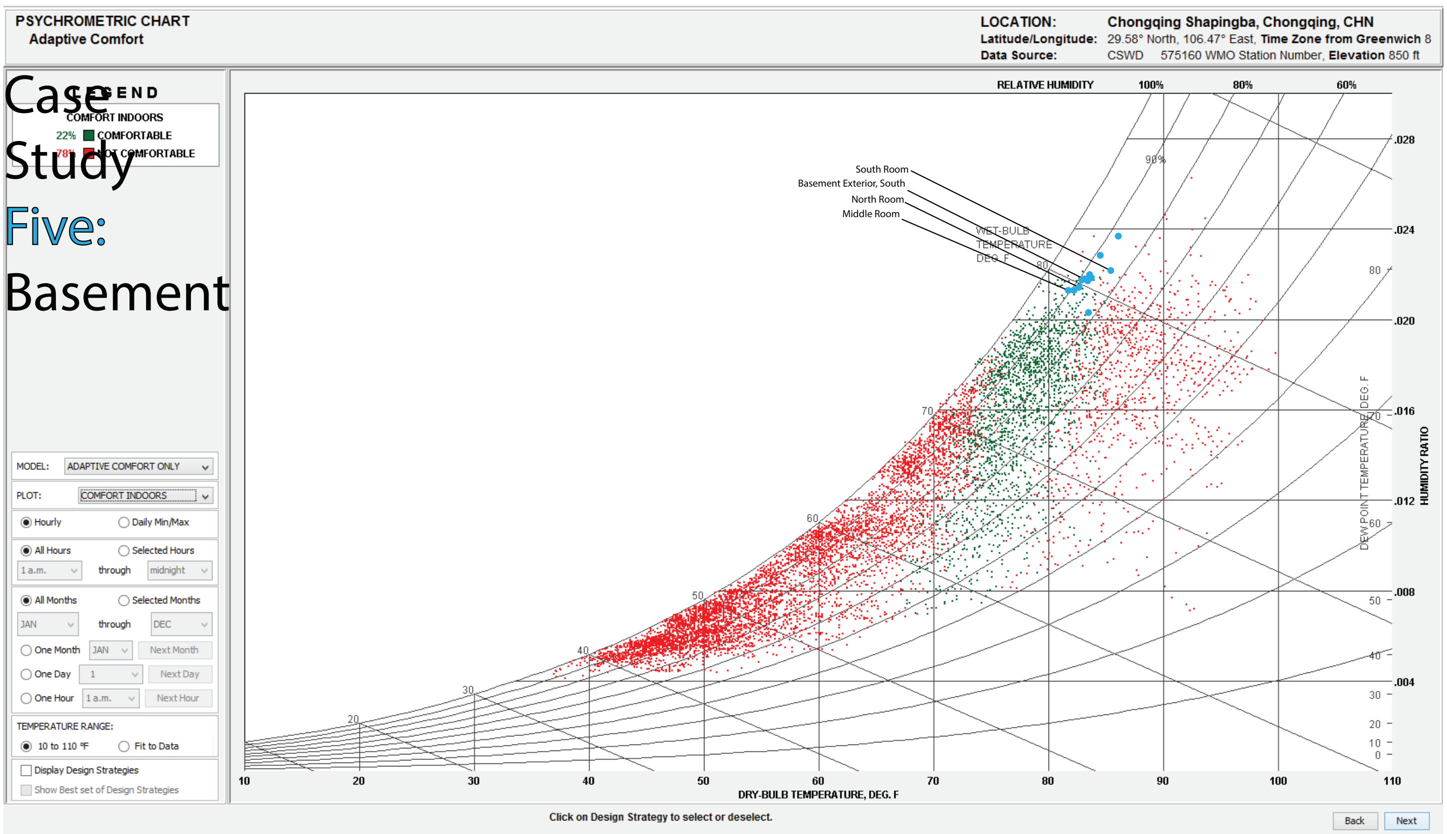


Figure A-19: Case Study Five, Basement Psychrometric Chart Analysis of Temperature and Humidity Data

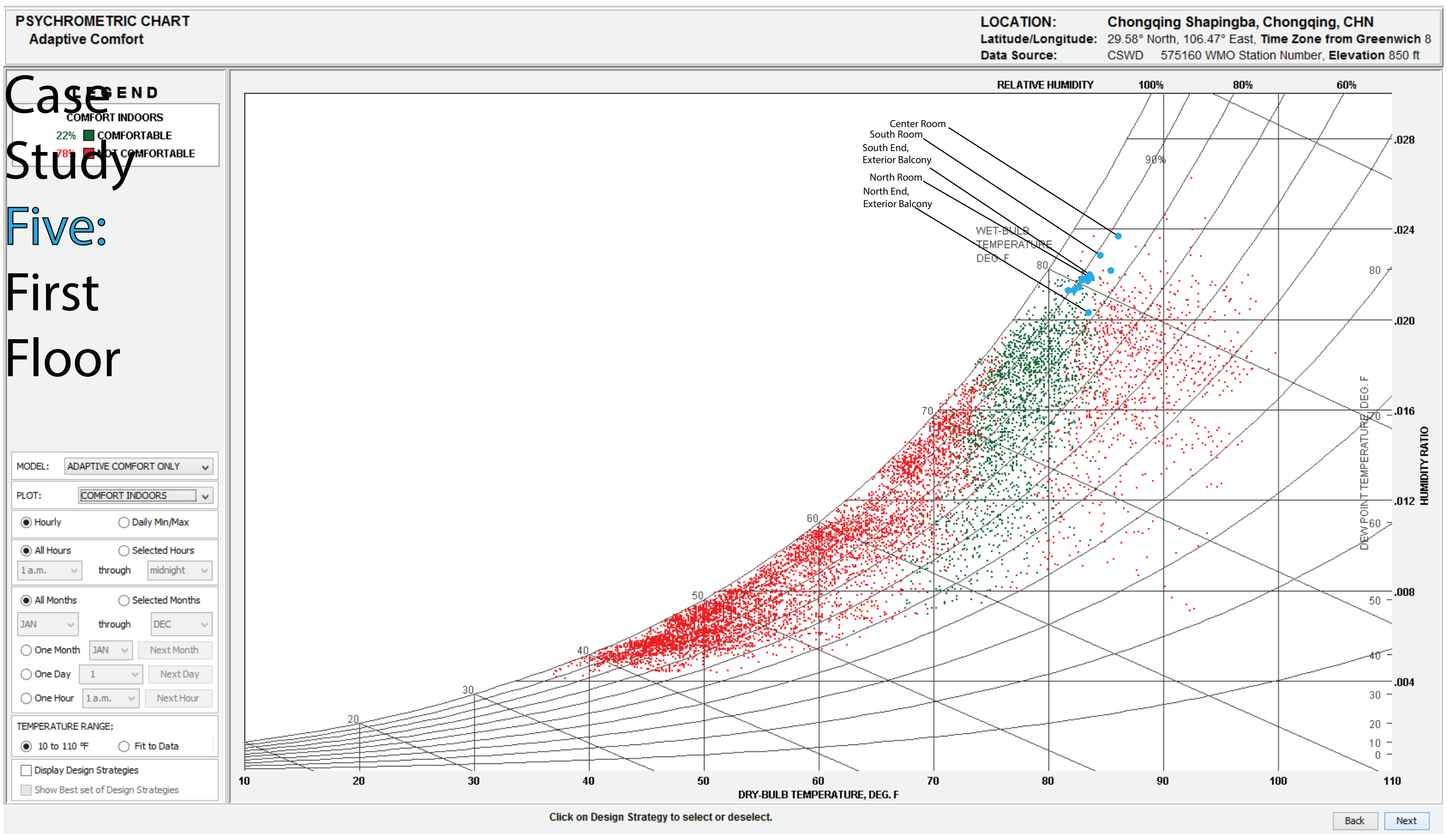


Figure A-20: Case Study Five, First Floor Psychrometric Chart Analysis of Temperature and Humidity Data

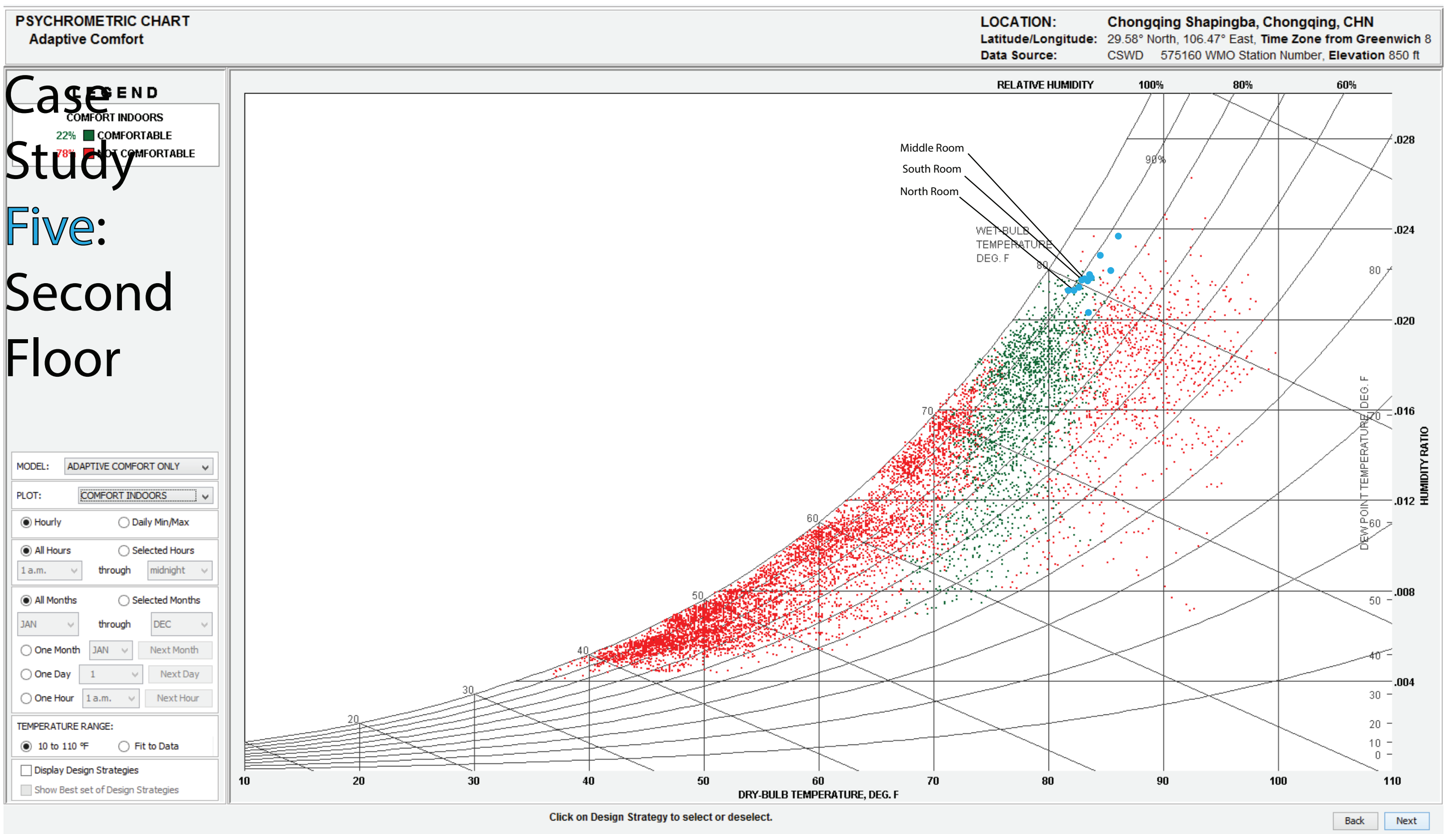


Figure A-21: Case Study Five, Second Floor Psychrometric Chart Analysis of Temperature and Humidity Data

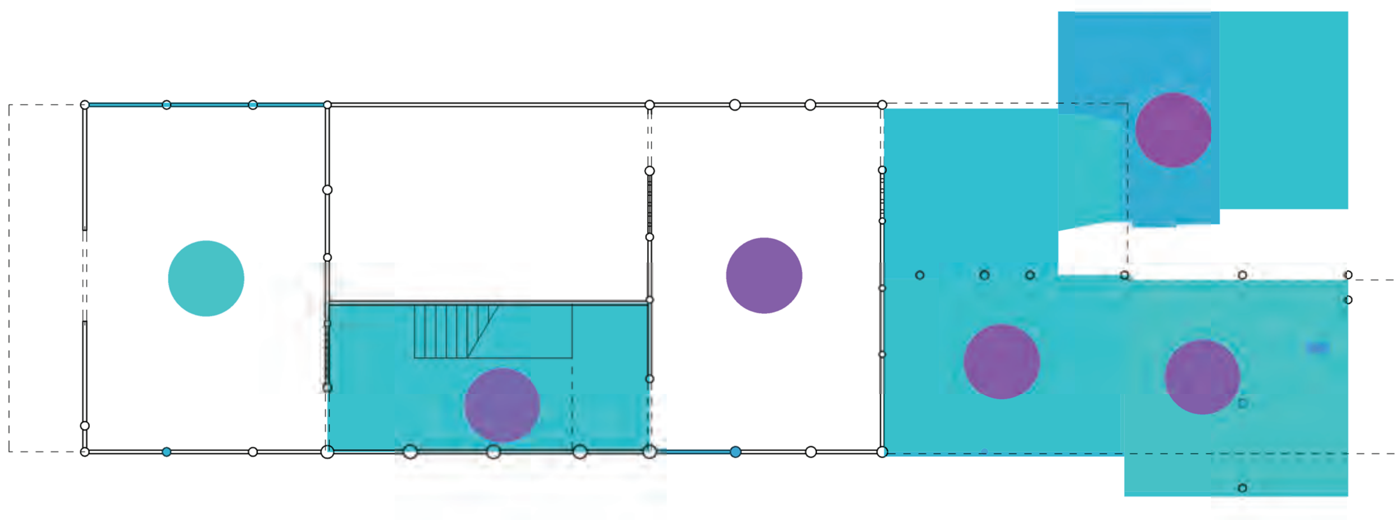


Figure A-22: Case Study One Material Temperature Diagram, First Floor

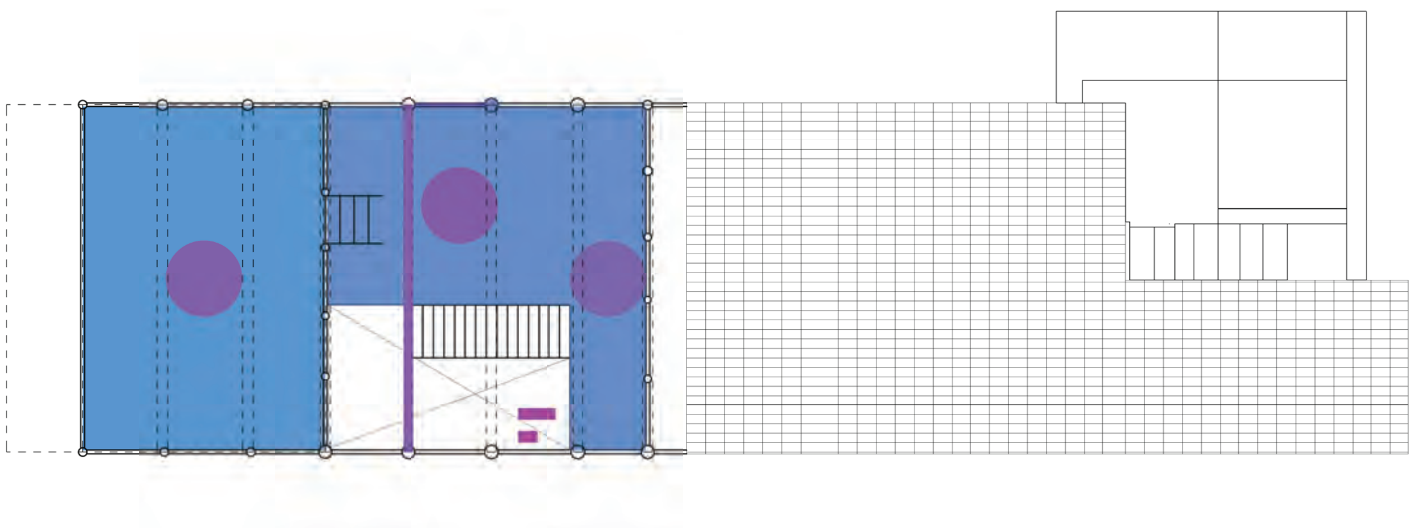


Figure A-23: Case Study One Material Temperature Diagram, Second Floor

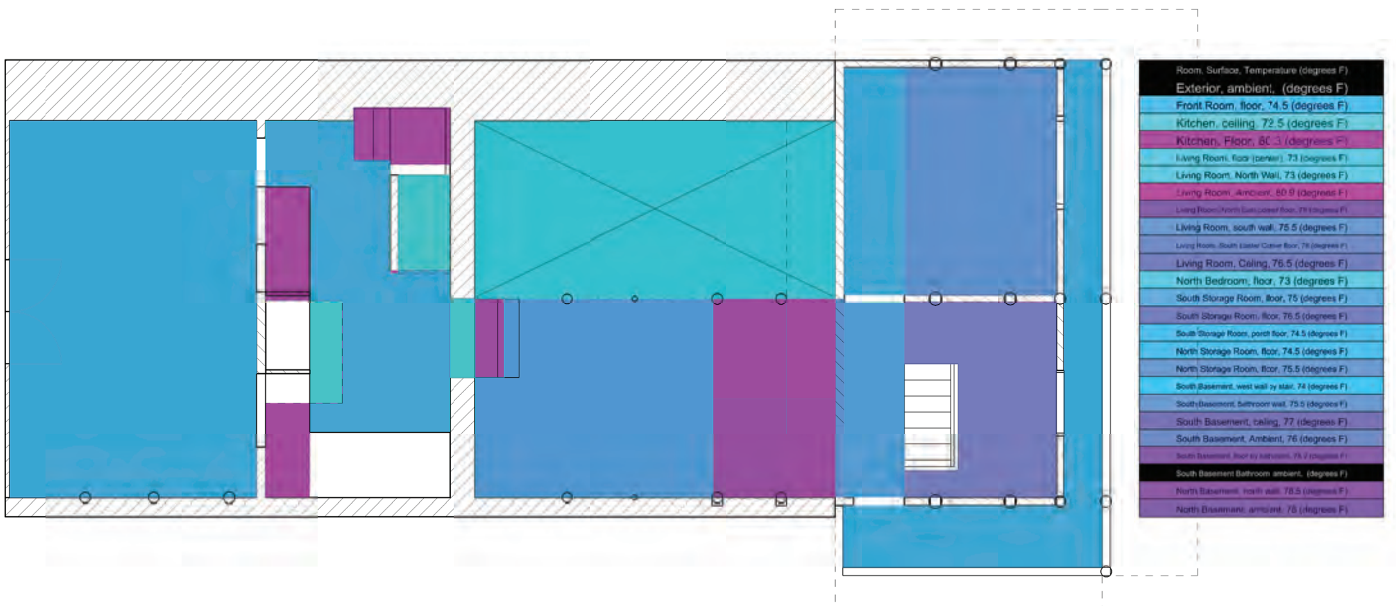


Figure A-24: Case Study Two Material Temperature Diagram, First Floor

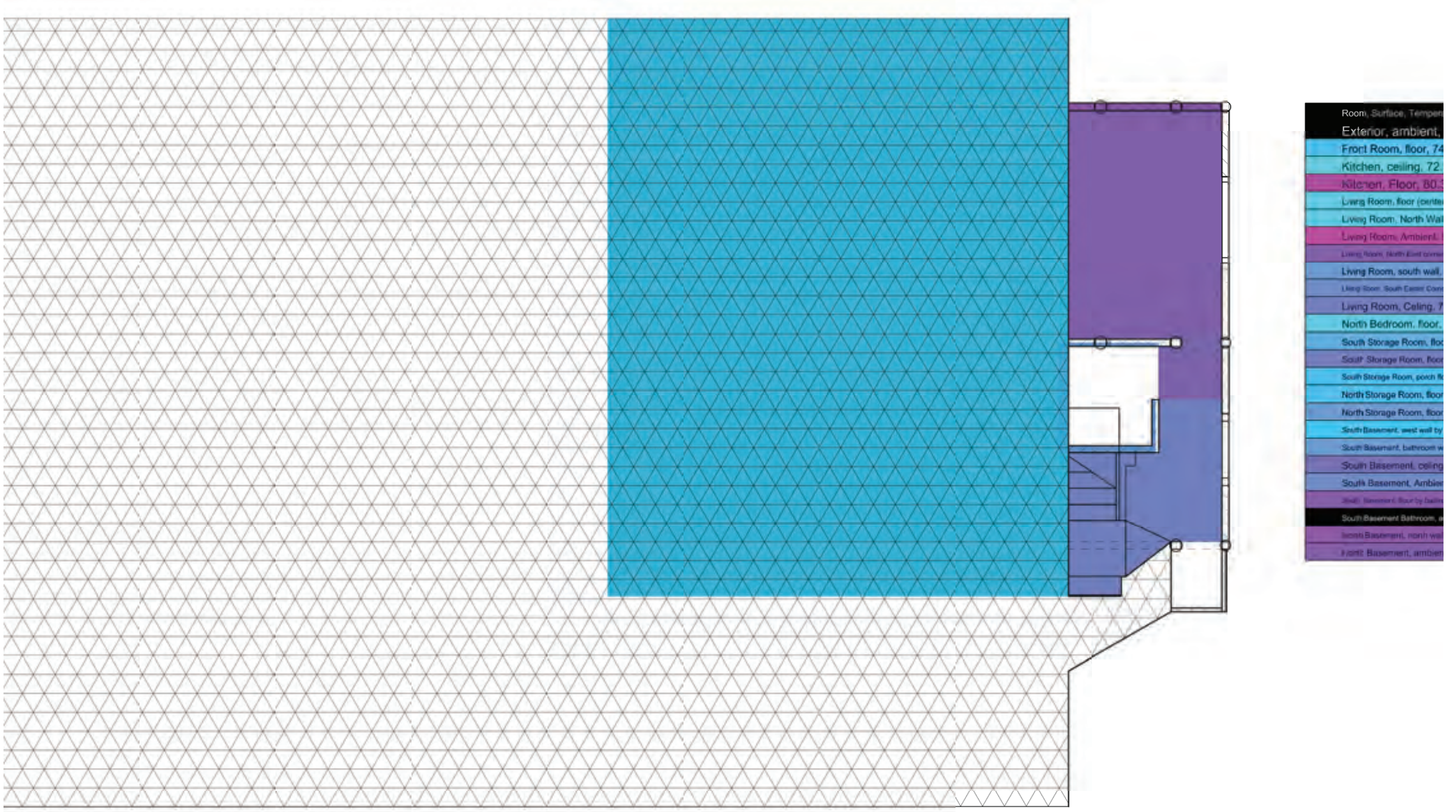


Figure A-25: Case Study Two Material Temperature Diagram, Basement Floor

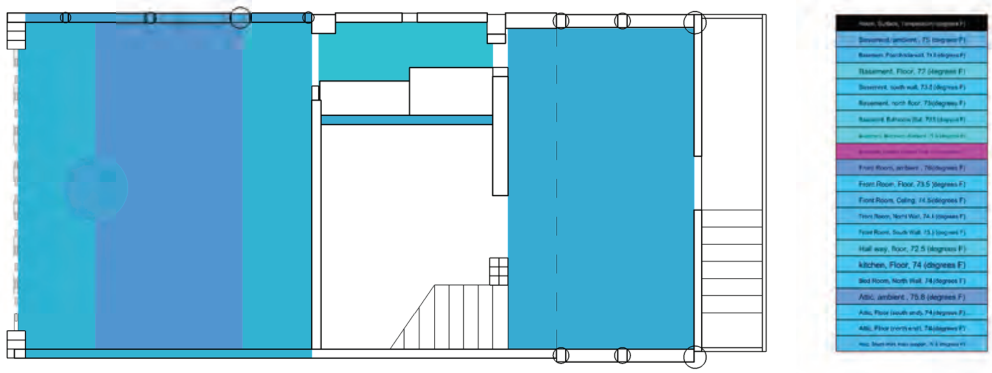


Figure A-26: Case Study Three Material Temperature Diagram, First Floor

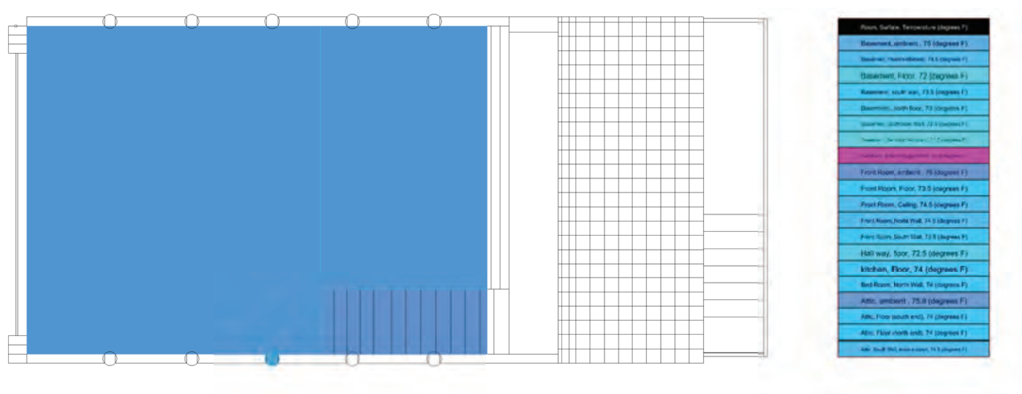


Figure A-27: Case Study Three Material Temperature Diagram, Second Floor

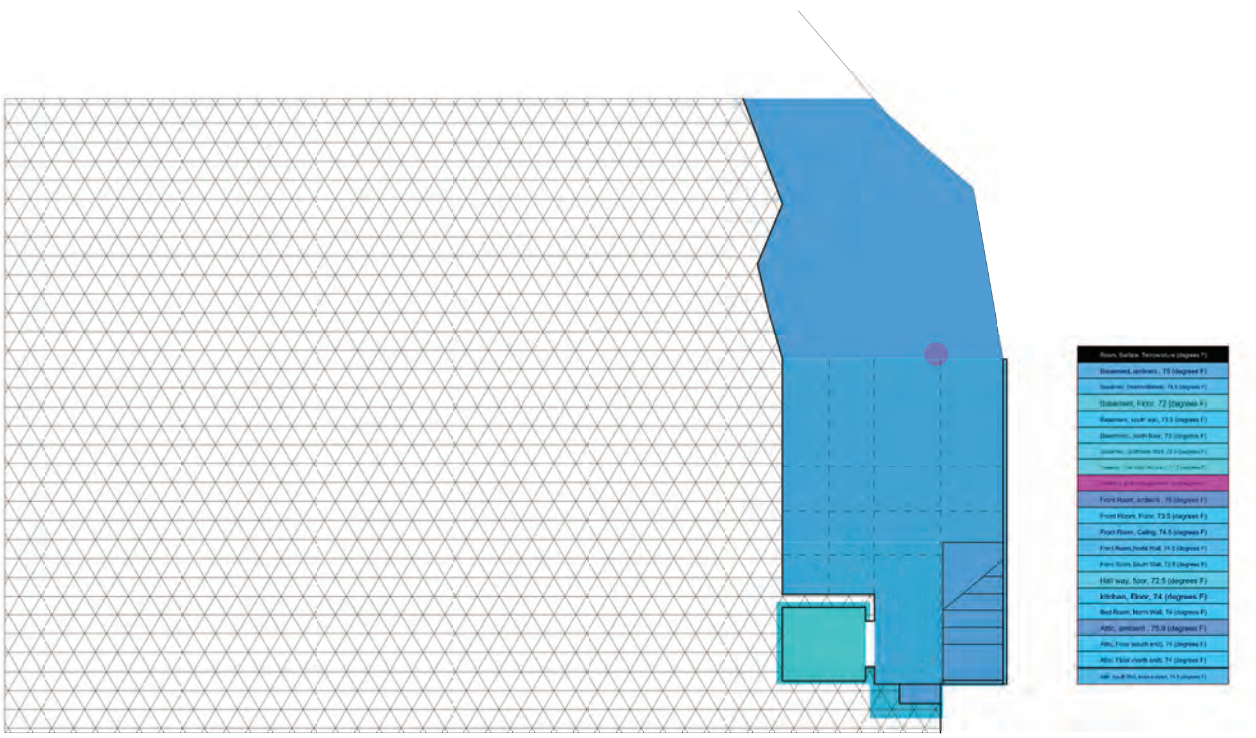


Figure A-28: Case Study Three Material Temperature Diagram, Basement Floor

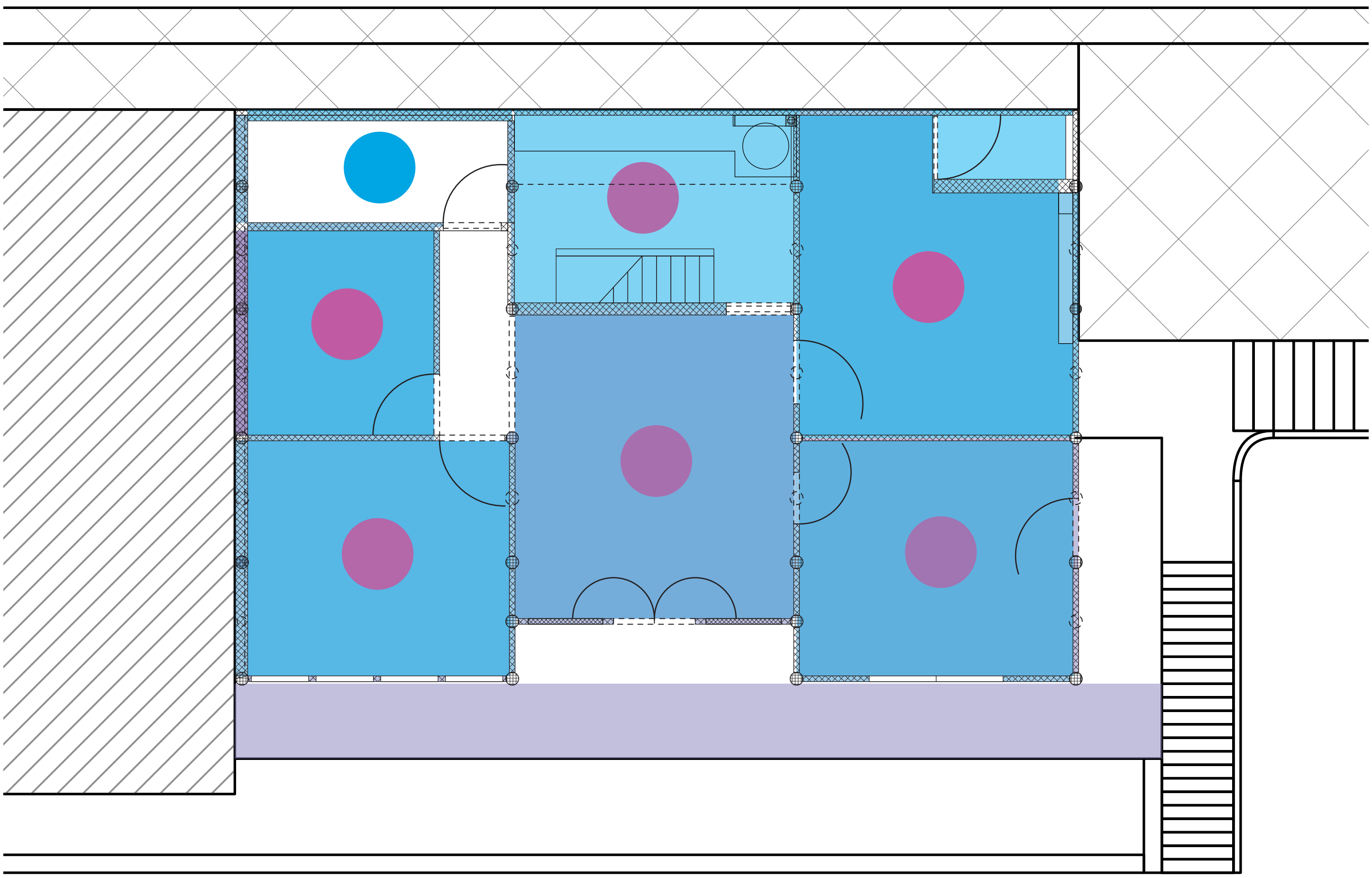


Figure A-29: Case Study Four Material Temperature Diagram, First Floor

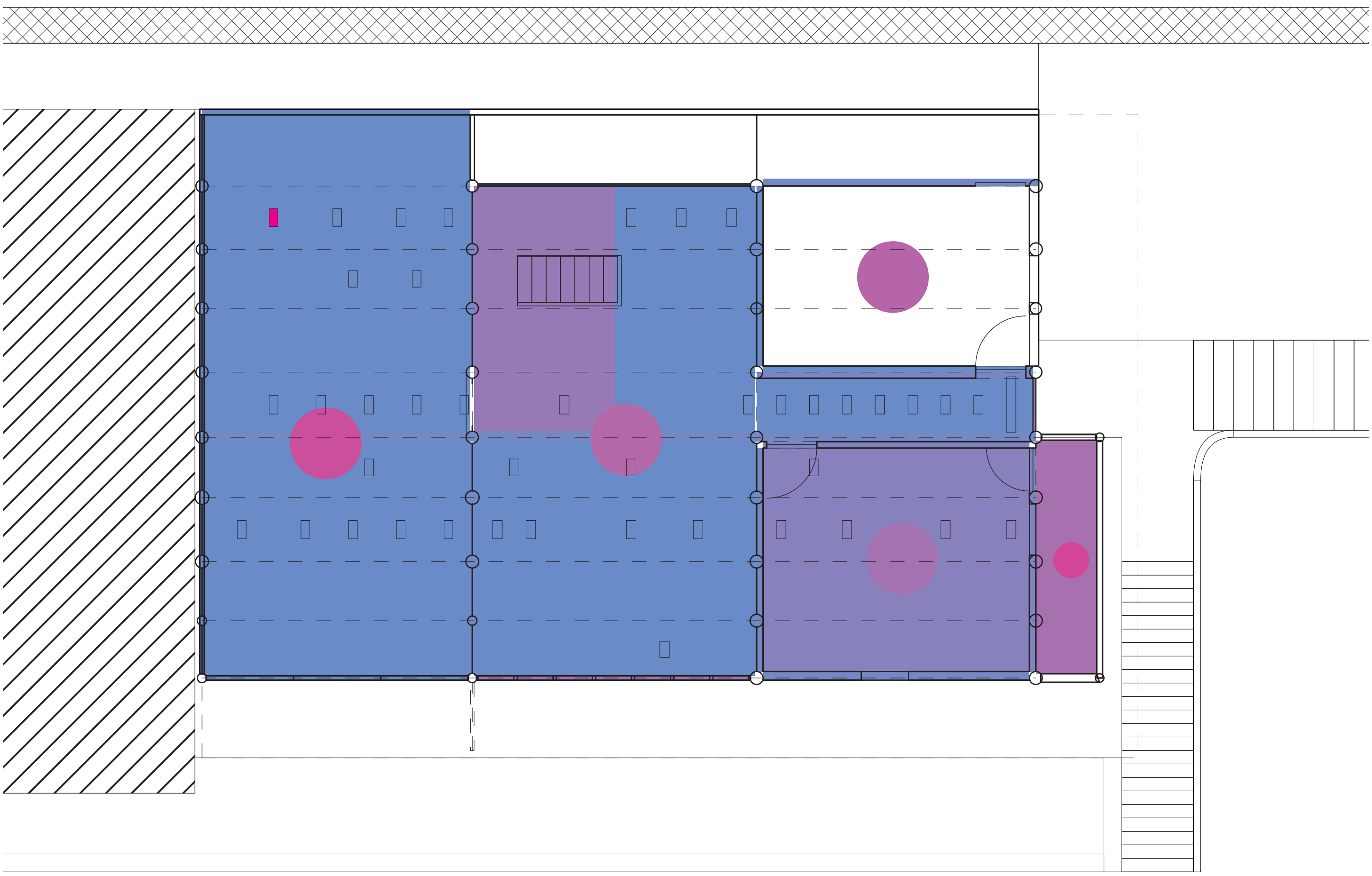


Figure A-30: Case Study Four Material Temperature Diagram, Second Floor

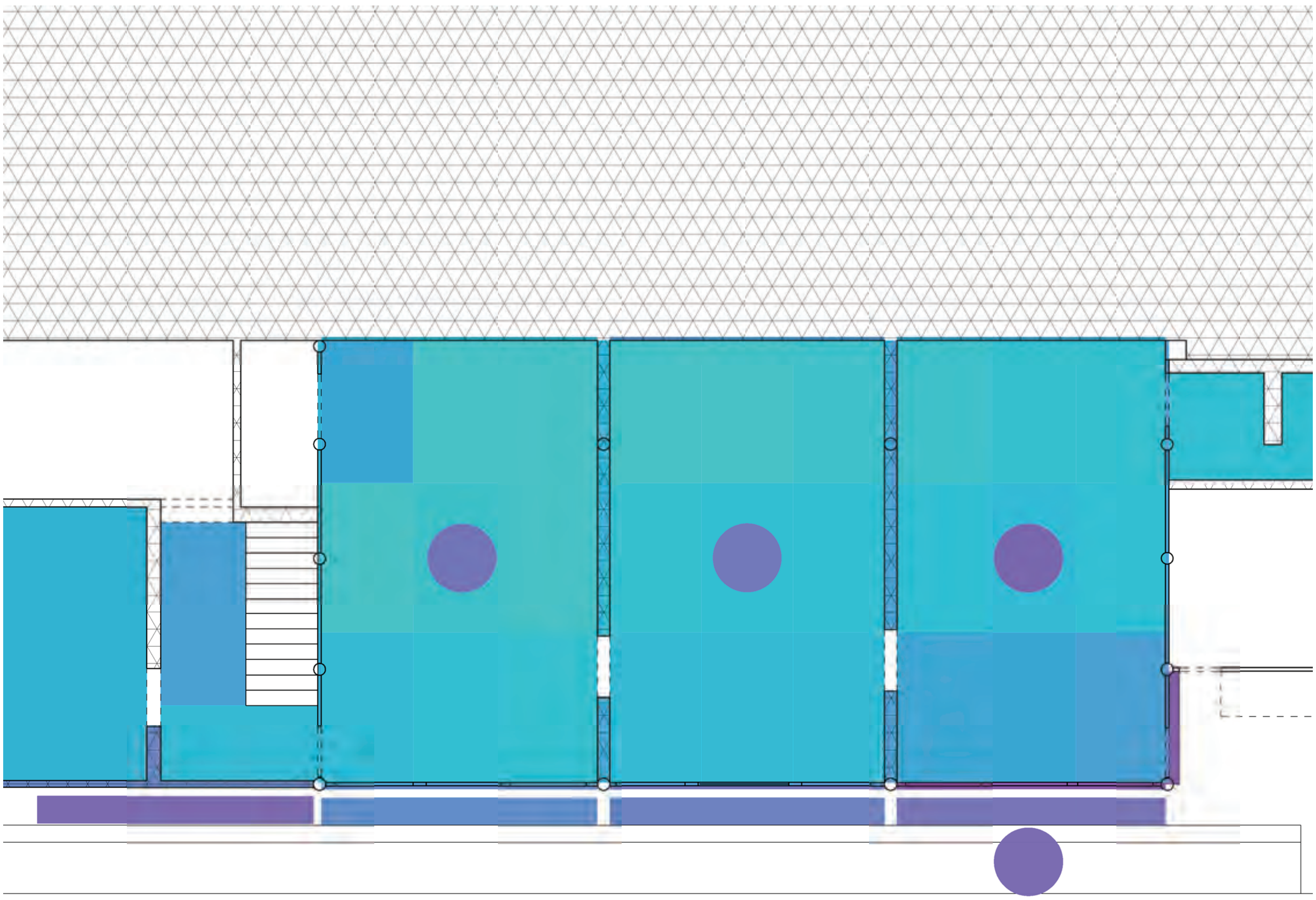


Figure A-31: Case Study Five Material Temperature Diagram, Basement Floor

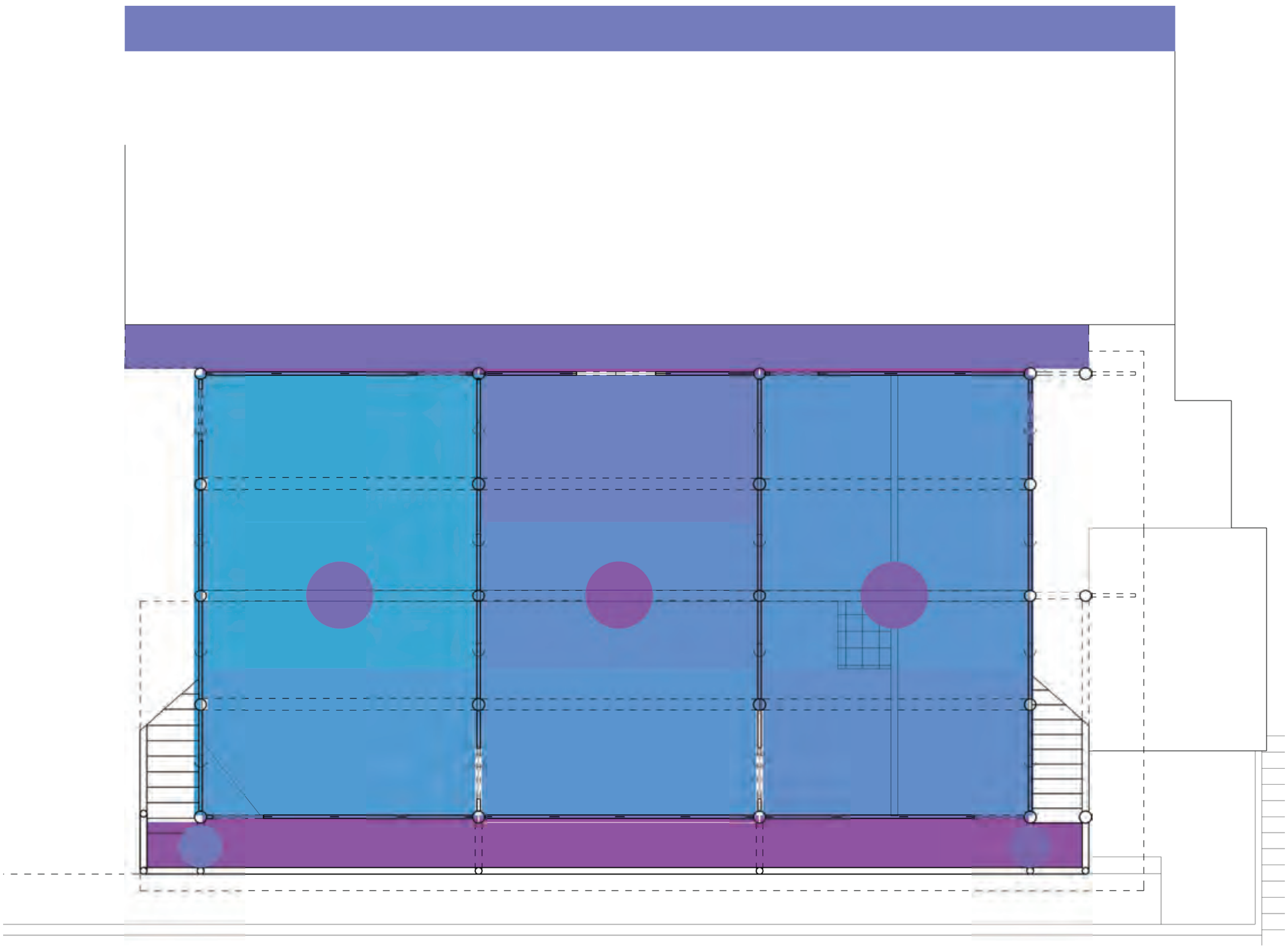


Figure A-32: Case Study Five Material Temperature Diagram, First Floor

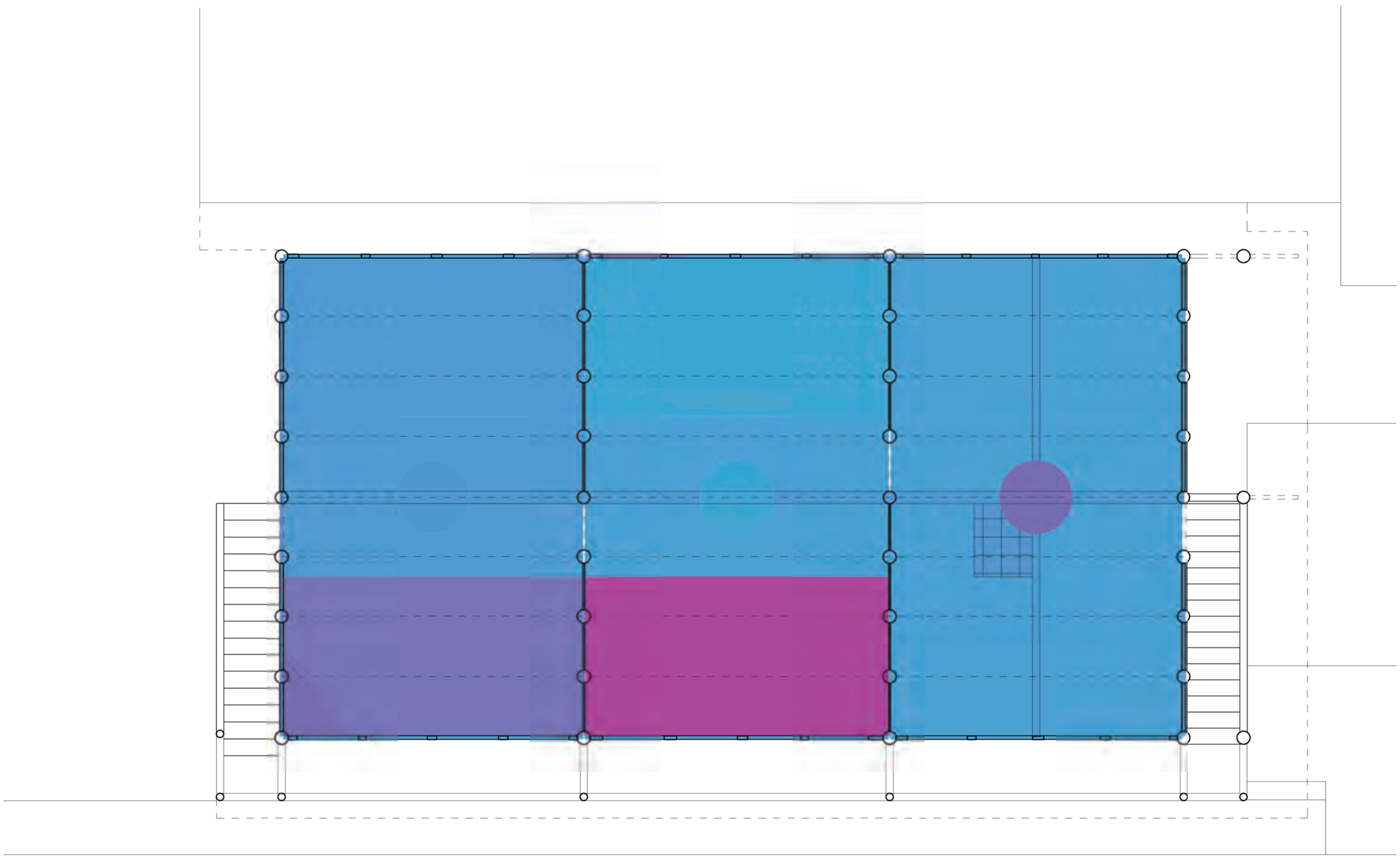


Figure A-33: Case Study Five Material Temperature Diagram, Second Floor

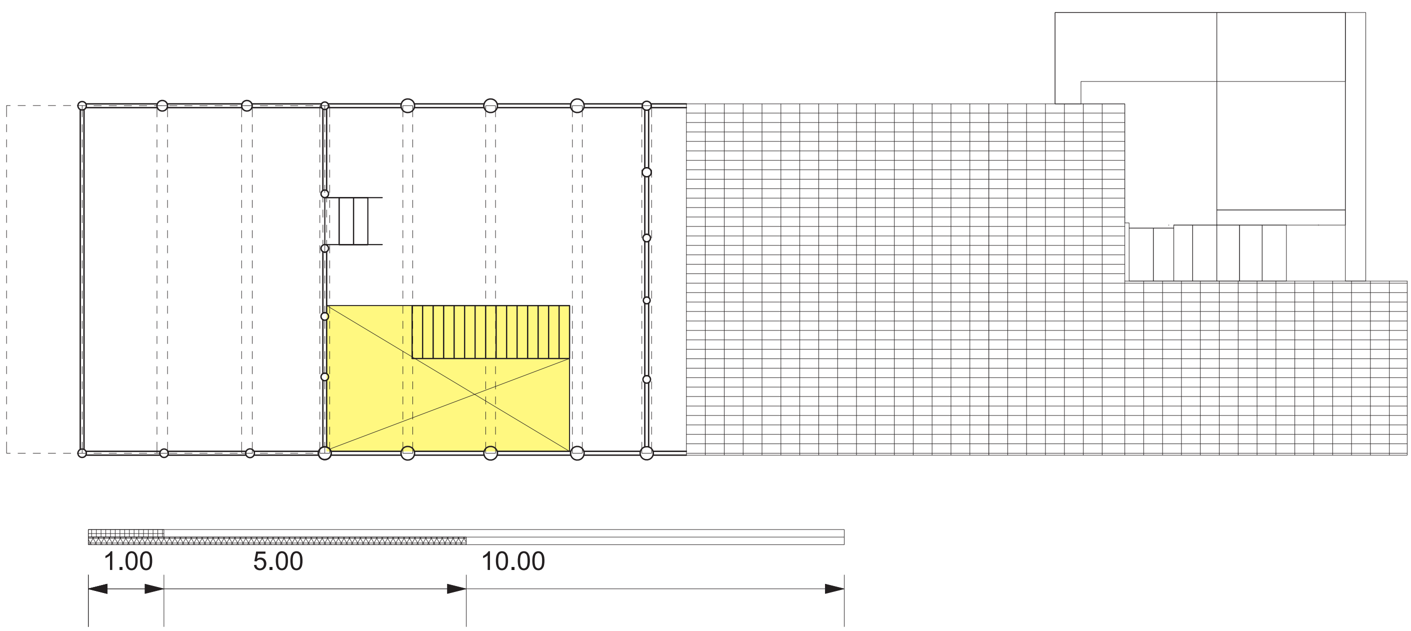


Figure A-34: Case Study One Light Source Diagram, First Floor

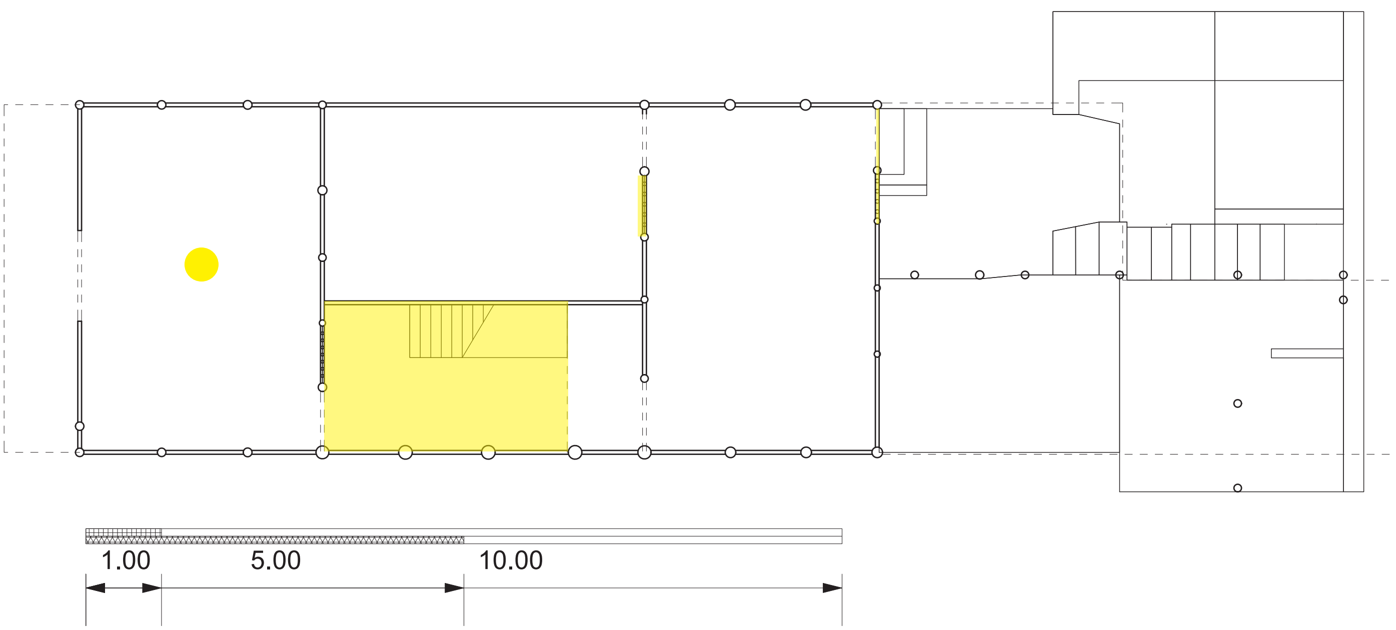


Figure A-35: Case Study One Light Source Diagram, Second Floor

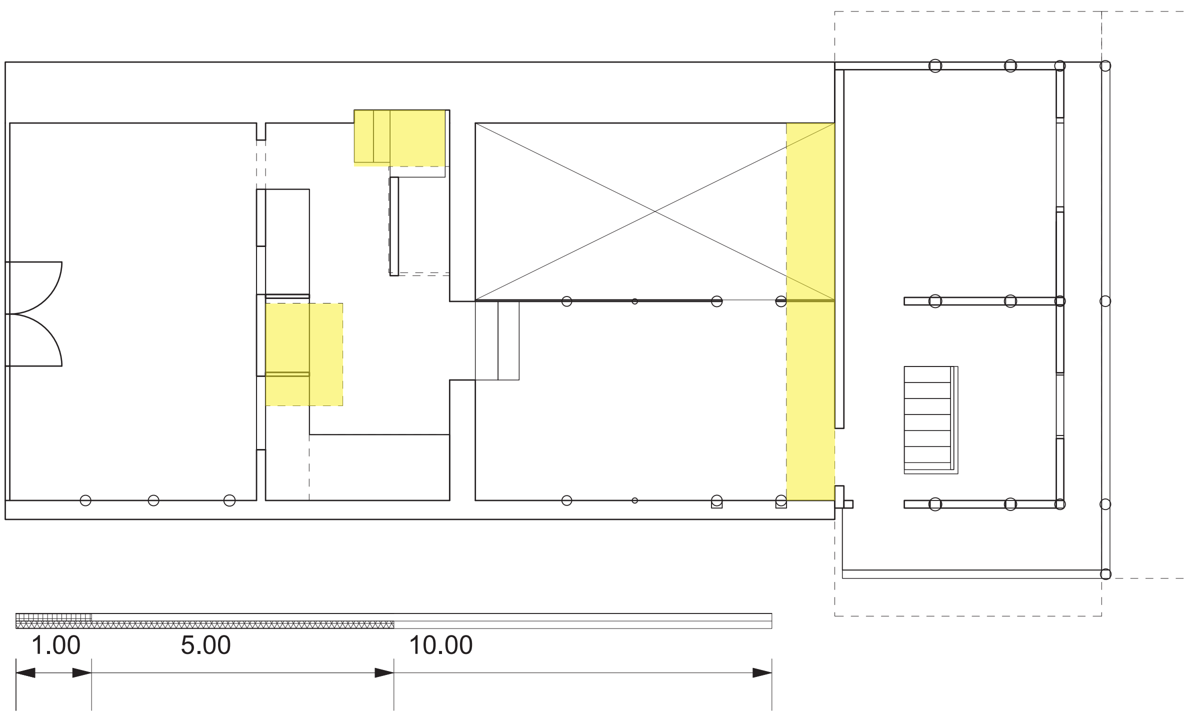


Figure A-36: Case Study Two Light Source Diagram, First Floor

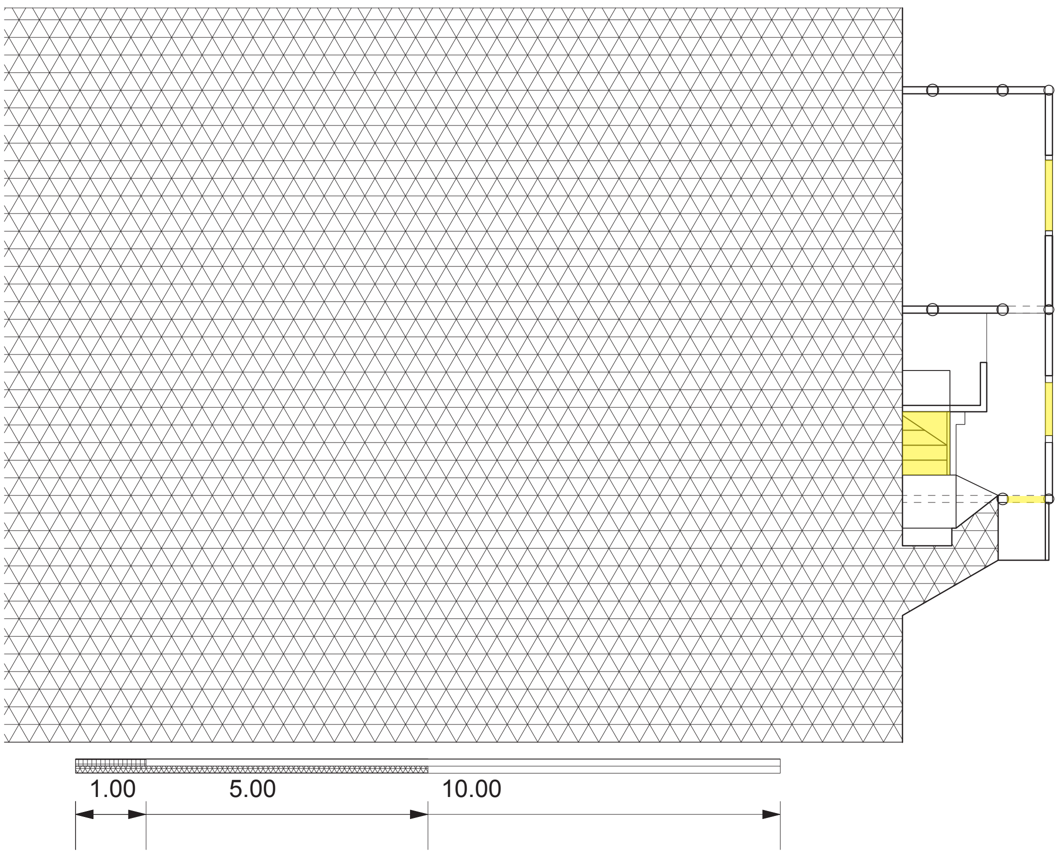


Figure A-37: Case Study Two Light Source Diagram, Basement Floor

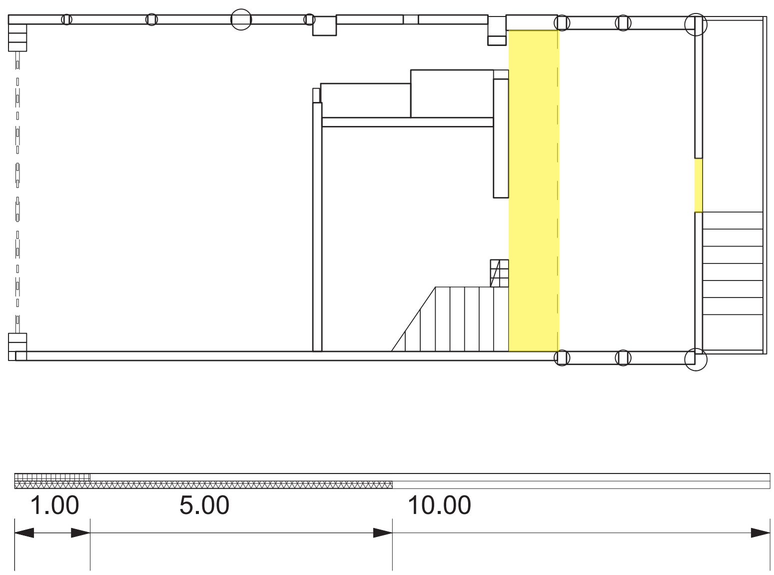


Figure A-38: Case Study Three Light Source Diagram, First Floor

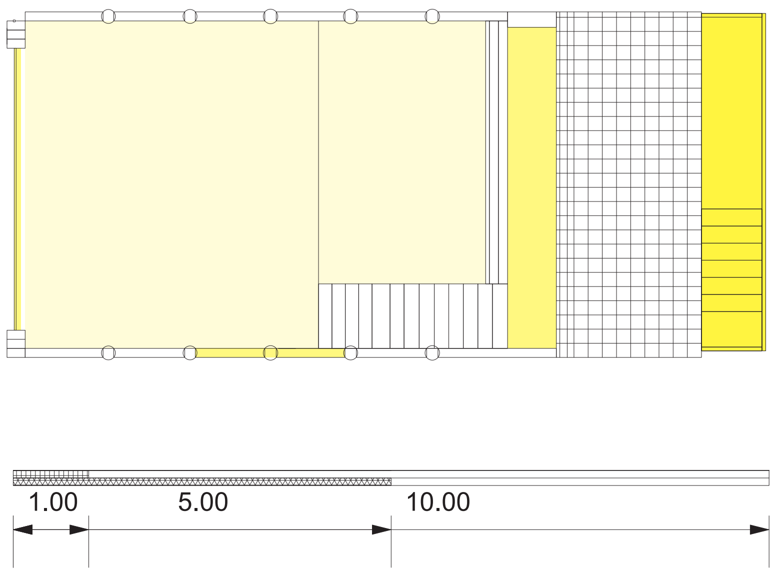


Figure A-39: Case Study Three Light Source Diagram, Second Floor

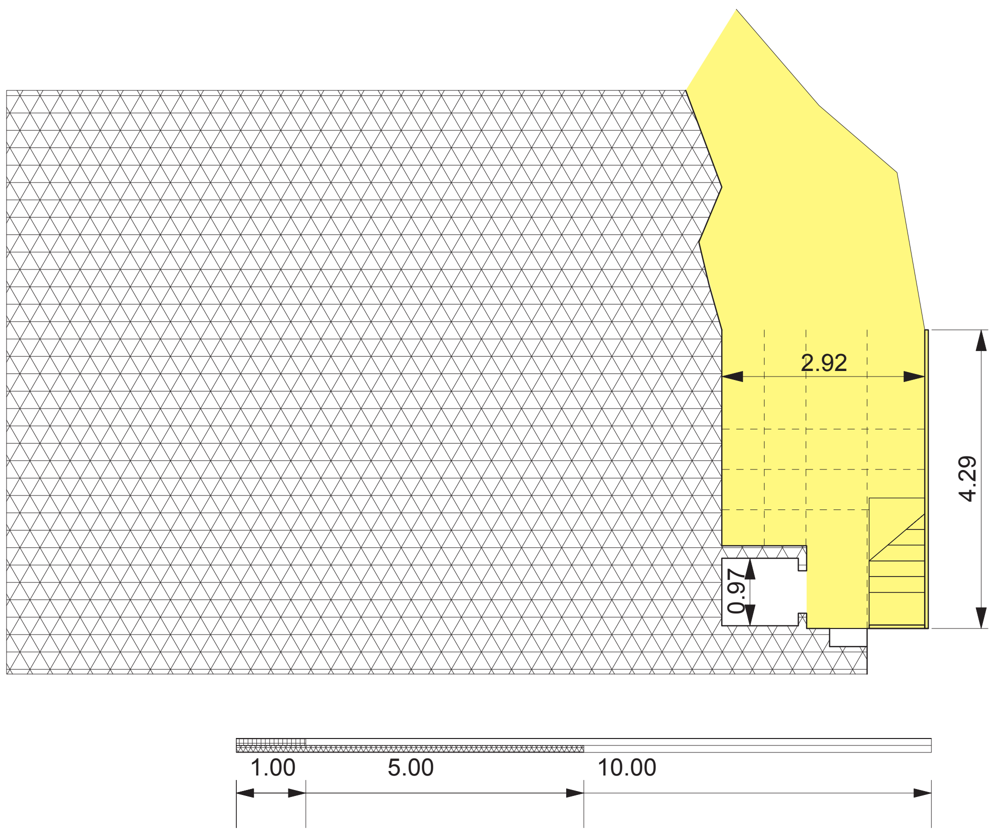


Figure A-40: Case Study Three Light Source Diagram, Basement Floor

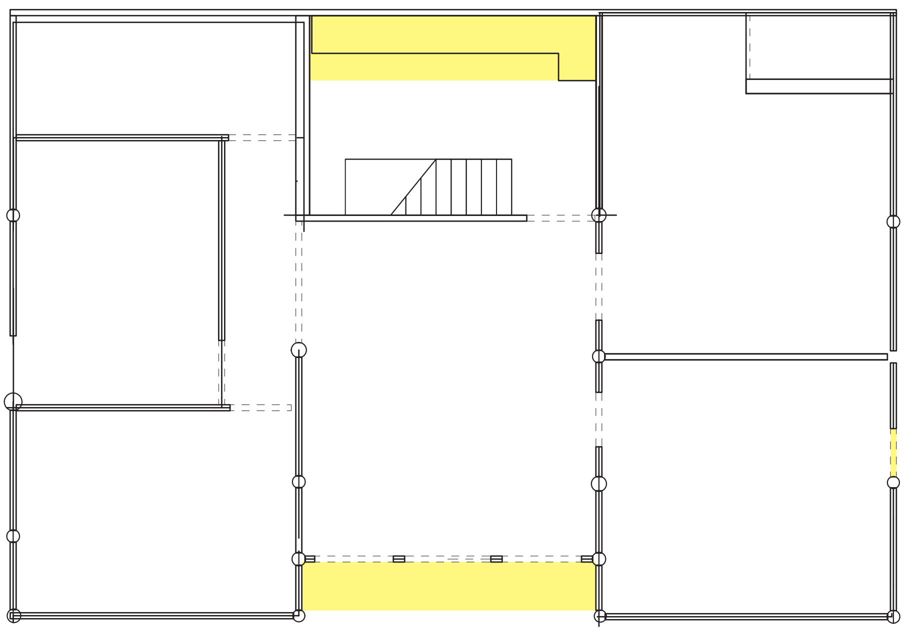


Figure A-41: Case Study Four Light Source Diagram, First Floor

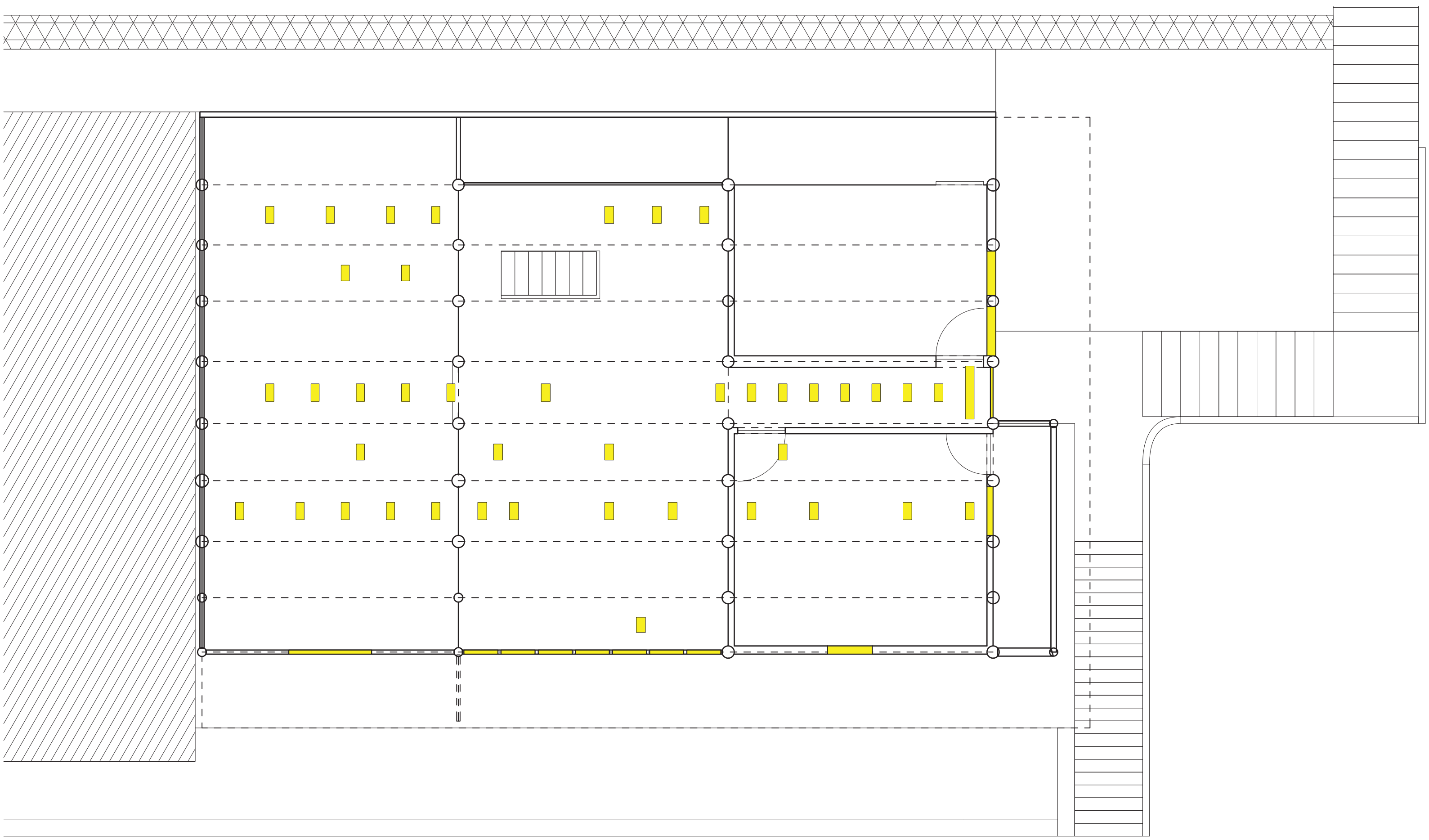


Figure A-42: Case Study Four Light Source Diagram, Second Floor

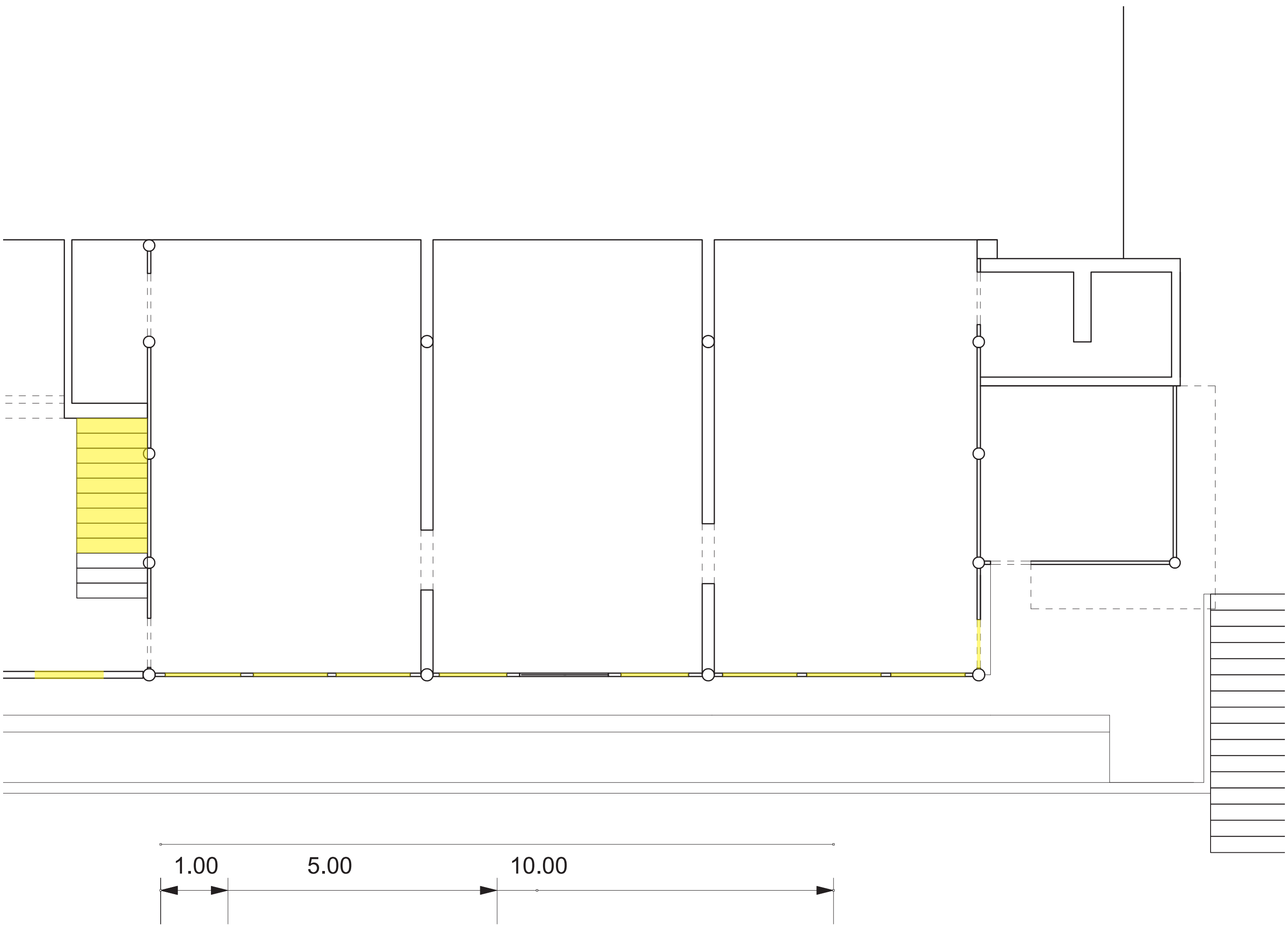


Figure A-43: Case Study Five Light Source Diagram, Basement Floor

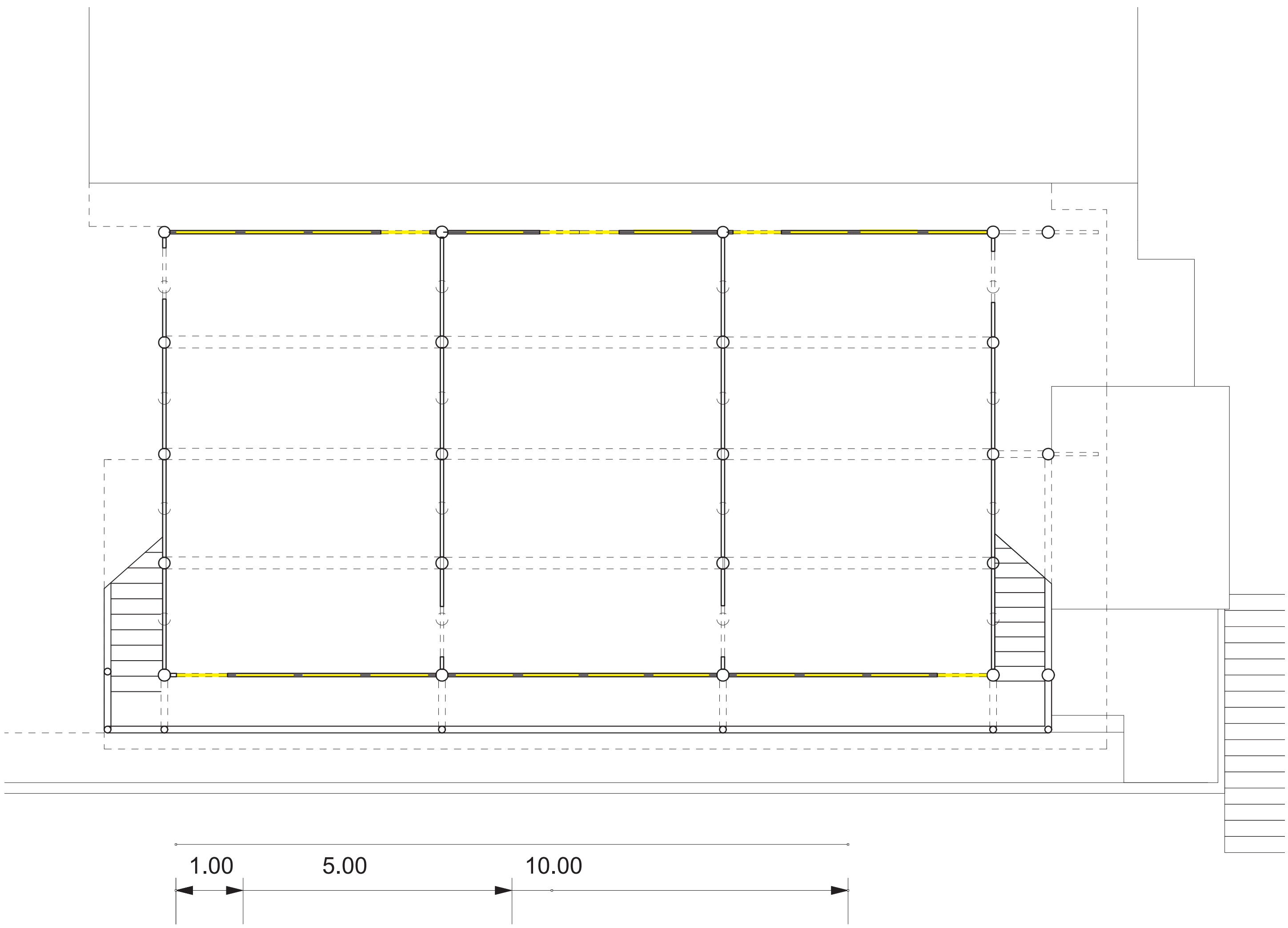


Figure A-44: Case Study Five Light Source Diagram, First Floor

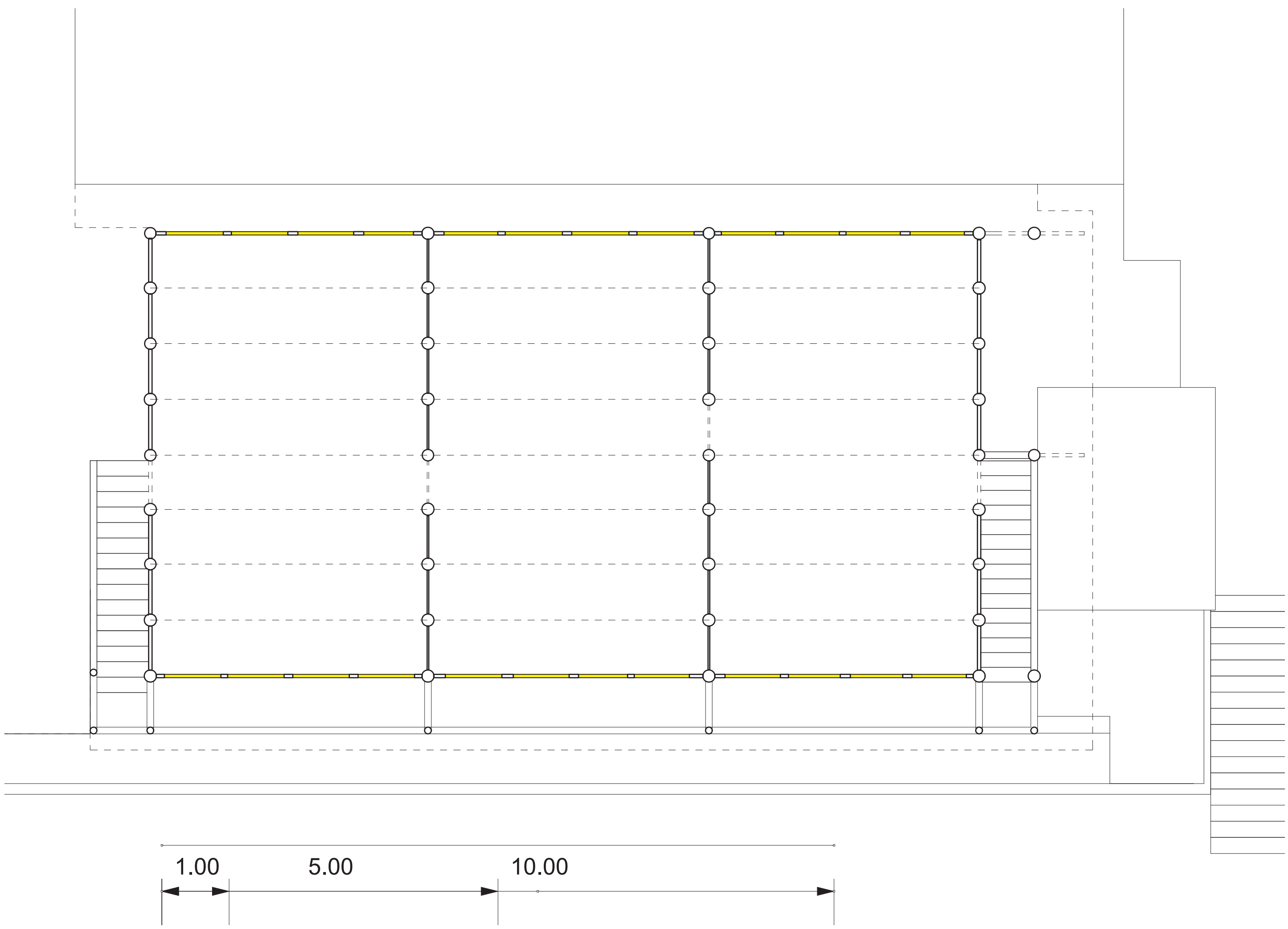


Figure A-45: Case Study Five Light Source Diagram, Second Floor

Figure C-1: Concrete Pile Foundations Used in Gongtan. Photo by Author

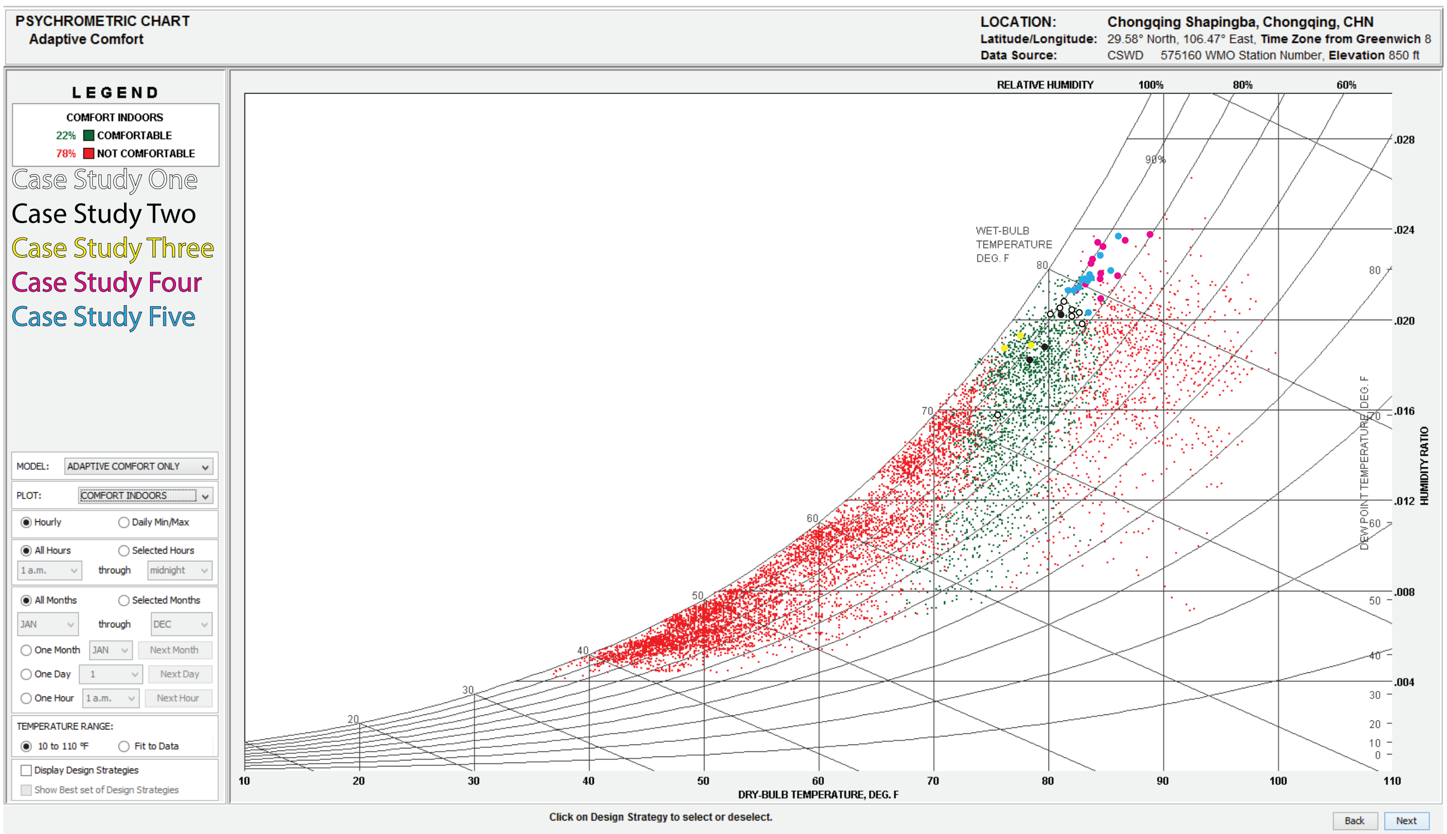


Figure C-2: Psychrometric Chart Plotting all Temperature and Humidity Data from this investigation against the Adaptive Cooling Expanded Comfort Zone from ASHRAE 55-2010

Appendix

Appendix A: Field Observations of the Five Case Studies

Appendix A.1: Case Study One

Located at 28 degrees, 50.360 minutes North, 106 degrees, 19.381 minutes East, Case Study One is a shop/house style building and belonged to an elderly member of a family that had a second *diaojiaolou* home for the second and third generations. Figures A-1 and A-2 show the first and second floors respectively, and Figure A-3 shows the section of Case Study One. The building is oriented west to east. The west face forms the street façade with the neighboring buildings, and the east end extends over the sloping river bank. Case Study One is about 4.5[1] meters wide and 10.5 meters deep with a 6.5-meter extension on the eastern end into a stone kitchen, garden and shed area.

Case Study One is structurally divided into three *jian* that are connected along the south wall via a hallway. The entrance into the home is on the first floor and opens into a front public room intended for business dealings. The front room has a single electric light in the middle of the ceiling, a window into the bedroom, and a window and door into a hallway on the south side of the east wall.

Through the door in the south end of the west wall, a hallway opens into the middle room with a staircase ascending to the second floor and a door into the rear room. The hallway leads into the third structural section: the living room. Adorned with simple desks and a couch, this room is used for private relaxation and gathering. On the north side of the living room, the first or western door leads to the bedroom (not made accessible for documentation); and the second or eastern door leads out to the exterior

[1] All dimensions noted in this Appendix are rounded to the nearest quarter meter.

kitchen. The living room's ceiling follows the descending roofline, giving a trapezoidal section.

The second floor only occupies the front two *jian* of the house, with a bamboo screen wall dividing the two. The first accessible room on the second floor sits over the bedroom. This room's height reaches up to the clay tile roof, sloping from 1.5 meters at the east end of the room to 3.25 meters at the west. The clay roof tiles are interspersed with glass tiles that allow natural lighting into the upper floor and to the hallway at the bottom of the staircase. The second room is up a short .75 meter high staircase and covers the front *jian*. This room has a low wood plank ceiling, giving the room a more enclosed feeling as well as providing storage space above. A central window opens onto the street. The roof of the Case Study extends 1 meter into the middle of the street and blends into the roofs from the surrounding buildings.

The house has an additional external area behind the east wall on the riverbank. Described to us as a "temporary" kitchen and storage area, it was built over 30 years ago. A set of stone slab stairs leads down to the first external *jian*, the kitchen area, which extends 3.25 meters eastward and 2.25 meters south, about half the width of the building and rests on solid stone. Immediately next to the kitchen area is slight drop to a kitchen pantry. Filling out the remainder of the first *jian* this pantry and the kitchen are both covered by a continuation of the roof. Beyond the roof, a stone staircase descends gently on the kitchen side along the woven bamboo wall. Six steps down to the north is a stone clearing area that extends out 2.75 meters north and 1.75 meters east. Four steps further, the stairs come to an end with a square landing to a room on the south side. This room extends back to a rock face that is about even with extension of the uppermost level and is used as a storage room. A plaster partition on the eastern edge provides a modest amount of privacy for the floor toilet that opens directly to the riverbank slop below. This area is covered by an extension of the roof but the stone based garden area to the north is uncovered.

The first internal *jian* is 3.25 meters deep, 4.5 meters wide, and 3 meters high. The connecting hallway is 2 meters wide and 4.25 meters deep with a .75-meter wide staircase. The third *jian* is 3 meters deep, with a sloping roof. The second floor's rooms are off set by a .75-meter staircase running down the center of the front room. The front room's ceiling is 2.5 meters high covering the 4.5 by 3.25 meter room area.

Case Study One uses a *chuandou* timber frame, with its columns supporting horizontal bracing members and extending up to the roof purlins. The first *jian* is three *kaijian* deep, the second is four, and the third is three again. The timber *chuandou* frame's primary structural beams run north-south, connecting into the first, fourth, eighth, and eleventh columns delineating the *diaojiaolou's jian* sections. The north, south, and east exterior walls are all infilled with panels of woven bamboo plastered with a limestone mixture. The street-facing west wall is clad in wood panels that can be removed on the first floor to create the entrance. The wood facade continues up to the roof, interrupted on the second floor by a bay of windows.

The ground floor appears to be a rammed-earth floor, but one that was so compacted as to be indistinguishable from stone. The rear extension is constructed with stone and the second floor is wood plank flooring. The upper floors are wood planks supported on cross beams that run north-south between the walls. The stairs are also wood, open in the back and connected by an angled wood plank. The central walls are infilled with woven bamboo screen covered with a white plaster.

The western half of Case Study One is very dark with little external light. The front room is the darkest and the single incandescent bulb in the middle of its ceiling is scarcely used. The second floor windows open onto the street, which itself is covered and dark throughout the day. The only other window to the exterior looks into the back area, which is still covered and a private part of the home. The bedroom has windows into both the front room and the back living area. The front room has additional windows into the hallway. The hallway is one of the best-lit rooms in the house because the roof over the central section of the building has scattered skylight windows made possible by glass tiles in the roof. This feature is consistently seen in the other case studies.

Appendix A.2: Case Study Two

Case Study Two is up-stream, at 28 degrees 50.335 minutes North, 106 degrees, 19.344 minutes East. The home has been inhabited by a single elderly man for the past 20 years. He does not know who originally built the house or lived there. Figure A-4 shows the layout of the first floor and Figure A-5 the two basement rooms. The second floor was not available for measuring. The entire home is 5 meters wide and 13.5 meters long with at porch that wraps around the back room. The main floor has 4 distinct *jian*: a business or public room meeting the street; followed by a kitchen and corner stair to the second floor; next, and down two steps, a bedroom and living area sit parallel to a second (not recorded) room, possibly a bedroom; and finally a fourth *jian* with two parallel storage rooms, the southern most containing a trap-door staircase leading to the basement. Although the second floor was not accessible for measurement, the double height spaces in the kitchen and living room revealed that there are only rooms over the front three *jian*. The basement is comprised of two rooms identical to the rooms above them.

The front room is 3.25 meters deep with two windows into the kitchen behind it. Filled with tables and variously sized wood panels and signs, the front room's south wall is only plastered on the upper half. The lower half reveals CMU infill between the wood beams. The west end of the front room is covered in a newly applied wood ceiling. Facing the street, the west wall is made of wood planks supported by a strip of concrete about .25 meters high. The front door lies in the center of the west wall, on a concrete beam running across the floor about .1 meters high.

The kitchen runs the width of the home and is 2.5 meters deep. A half-meter linoleum-covered counter wraps along the south and west walls up to the door. The kitchen walls are tiled from the top of the counter to the height of the windows into the front room (about 1 m). In the northeast corner of the kitchen, the staircase to the second floor uses a recess in the north wall to make the turn. Starting with two stone stairs and a large stone landing, it shifts to wood after turning from west to south to continue up. The wooden stairs are supported by both the main wall and a brick wall one course thick, creating a small storage area under the stairs by the living room door. In addition to the staircase, the kitchen ceiling has two openings, the fume hood over the stove and a central one. The central opening in the ceiling looks all the way to roof and the structure's roof peak along the rear edge of this aperture. Missing tiles in the drop ceiling structure reveal the second story to be supported upon large timbers running the width of the home.

Down two steps from the kitchen, the living room is 2.75 meters wide by 4.75 meters deep. The second story extends for 3.75 meters with the room, leaving the far end of the room open to the roof above, where glass tiles in the roof let natural light through to the lower story. A bed sits in the southwest corner, running along the south wall to face a TV sitting on a dresser next to the door into the back rooms. The north wall, noticeably thinner than the others, opens into a darkened bedroom (not measured) with a bed running against the west wall.

The final two rooms of the first floor sit partially on the stone floor, and partially on a wood floor where the structure extends over the edge of the hill. The first room is a roughly square 2.75 by 2.75 room, with the floor changing to wood after a meter of stone. Parallel portals on the west ends of the north and south walls open to the second room and the wrap-around balcony. Windows along the south and east walls open onto the covered exterior. The north room sits at 3 meters by 2.75 and has its thin, plastered walls showing the wood columns and cross beams. The balcony is .75 meters wide along the exterior south wall and .5 meters along west exterior wall of the house. In the center of the floor in the wooden section, an open trap door reveals a staircase down to the two basement rooms.

The stairs to the basement run along the stonewall of the cliff face, turning into concrete stairs after a 90 degree turn to the east for the final 3 descending steps. The two basement rooms sit entirely under the east most rooms of the main floor, clearly illustrating the continuity of the structural system between the two floors. The south room is subdivided with a concrete clad toilet room tucked under the stairs against the dividing wall. Unlike the south room, the north basement room has a tiled drop ceiling and its walls are plastered with old newsprint. Both basement rooms have windows in line with those above along the east wall.

Case Study Two uses a timber frame structural system on a stone foundation. The exterior walls that border the neighboring homes are CMU infill covered in plaster. The interior walls running north to south, separating the *jian*, are noticeably thick, most likely a masonry infill that was then plastered over. The other interior and eastward wall has a lighter infill, as the cross-timbers are easily visible.

Appendix A.3: Case Study Three

Case Study Three, the smallest of the Zhongshan case studies measured at only 9 meters long and 4.25 meters wide, also housed the most people. Located further up the road at 28 degrees 50.386 minutes North, 106 degrees and 19.379 minutes East, Case Study Three has been home to four individuals, a man, woman, and two children, for the last twenty years. The home's builder is unknown, but according to the elders in the town the home is about 100 years old. Given the home's state of disrepair, this was not hard to believe. The home's brick-masonry interior walls were but are detached from the exterior walls and timber structural system, which itself leans about 30 degrees west.

Figures A-6, A-7, and A-8 show Case Study Three's main floor, second floor, and basement, respectively. Case Study Three is divided into three *jian* on the main floor. The front room is the business and public room, just as in the two previous case studies. The second section holds a hallway along the north wall and a bedroom accessible only from the third *jian*, which is the kitchen. The kitchen has four distinct entrances. In addition to the hall door, a portal on the east wall opens to a balcony and stairs to the basement. The west wall has a staircase leading up to the second floor running along the southern wall, and a doorway back into the bedroom in the second *jian*. On the second floor a rise in the floor height clearly divides two areas. These rooms are open to each other and are filled with 2 beds and lots of stored items. The basement is a single room with a toilet enclosure, and is open to the north as the floor gives way to cliff face.

The front room of Case Study Three sits on a rammed-earth floor. Four meters deep, it displays a wide array of materials and wall systems. On the street side, the west wall is a system of wooden doors, 2 meters tall, which fold back from the center exposing the entire face to the street. The half *chuandou* timber frame of the whole home is readably identifiable. The south wall is a masonry brick infill for the first meter off the ground, transitioning into a plastered-over woven-bamboo wall system that is reflected on the entirety of the north wall. The interior east wall is a bare woven-bamboo panel system against the first floor bedroom, and a masonry system along the wall of the hallway. Brick masonry columns are immediately apparent at the north and southwest corners, and at the entrance and exit to the hallway.

The second *jian's* hallway is 2.25 meters long by 1.25 meters wide, but two shelving units a meter thick on the south wall make the entire space cramped and tight. The north wall maintains the plastered-over woven bamboo, but the first meter and a half from the wall is made of vertically running wood planks. The hall way immediately opens into the kitchen. The kitchen is 2.5 meters long and runs the full width of the home, and uses wood floorboards. The north, east, and south walls are the same timber structure with plaster covered woven bamboo panels. The interior west wall, however, is a brick masonry wall with an opening to a bedroom and a hole for a wood-burning fireplace. Unlike the previous rooms whose ceiling is delineated by the floor of the roof above, the kitchen is open to the roof. The roof is disjointed, dropping down a meter in height .75 meters into the room. This drop in the ceiling creates an opening equivalent to a clerestory window.

The door in the east wall of the kitchen opens to a .75 meter wide deck covered by the roof eves. The south of half of the deck comprises a set of stairs down to the basement area. Including the staircase, the basement area is 3 meters deep, running back into the hillside. Immediately to the west of the stairs is a 1-meter square bathroom enclosed in a brick masonry wall. This brick wall continues across the south wall out to the stairs where the wall becomes woven bamboo and wraps around the stairs and up the east wall. The basement has no north wall. It is open to the hillside and the objects stored in the basement area stretch out under the next-door building.

The building's second floor is divided into two sections by way of a change in floor height. The first level sits on the height of the ninth step, over the middle *jian,* and the section over the front room sits a meter higher at the top of the stairs. The lower room is only 3.5 meters wide due to the stairs along the southern wall. The wood in this section is charred, and the walls are missing some of the bamboo panels where the south wall meets the roof. The roof peaks at 3.641 meters above the top of the stairs, slanting down to the front and rear of the house.

Case Study Three's main structural system is a *chuandou* timber frame, with columns again directly supporting the roof and outlining the footprint of the building. The internal secondary structural system in Case Study Three, delineating the three *jian* from each other and providing the support for the cross beams that supported the second floor, is detached from the timber frame. Similarly the basement sits on a set of masonry walls on the north and south ends that supports a beam holding up the upper floor's joists. The detached structural systems are not that surprising however given that the structural beams of the home tilt fully 10 degrees in the westward direction.

Appendix A.4: Case Study Four

The first case study in Gongtan, Case Study Four, at North 28 degrees 55.583 minutes, East 108 degrees 20.866 minutes, is located on the third terrace row in the historic "Ancient Town" area. Removed from the main commercial street, the house faces west toward the river with the next terraced level coming up to its eastern wall. Figures A-9 and A-10 show the floor plans for the 3 *jian* building, set at what appears to be Knapp's first stage of home expansion of southern forms from Figure 2-6. It should be noted first that Case Study Four does not sit over a topographic change, and it was therefore originally discounted from our survey. However, the home's owner is a local *diaijiaolou* builder and one of the workers involved in the rebuilding efforts for the entire historic area. He boasts of having built his own home -- he is still working on it -- and insists it is a *diaojiaolou*. So, proceeding on the authority of a traditional *diaojiaolou* builder, Case Study Four is included.

Case Study Four is 11.75 meters by 7.75 meters with the long axis running north-south in parallel with the street and river. The structure shares its north wall with a neighboring house and the East wall runs against the earthwork for the terrace behind it.

The building has two floors, the first being 3 meters tall and the second peaking at 3.5 meters in the center under a center pitched roof. Each floor is divided into three *jian*, running east to west. The bottom floor has a main double door entrance in the center bay living room flanked by a door on either side. This living room has doors into two bedrooms on the south wall, and an entrance into the kitchen in the east wall's south corner;. The north wall opens into a hallway connecting two bedrooms and a rear bathroom. The southwest bedroom is the master bedroom. It has a second door on the south leading outside which was kept open during our visit. The northwest bedroom and the central north bedroom are for their children, leaving the southeast bedroom, which also contained a small bathroom, for extended family. The kitchen has a double height area running along the east wall up to the roof above the counter.

The second floor is accessed via a staircase in center bay that runs from the kitchen to the attic. There is also a door into the second floor on the south end of the east wall leading out to the terrace behind the home, but it was blocked off by stored materials such as wood scraps. The second floor is also divided into three *jian* bays, still under construction by the homeowner. The north and central *jian* are mostly empty, predominantly being used for storage. The north room is down a .25-meter step from the rest of the second floor and runs the full length of the house. The center room is one meter shorter, closed off by the double height space above the kitchen. The southern bay is subdivided into two rooms separated by a hallway running down the center north-south axis. Each room is entirely enclosed, having an internal 2.25 meter high ceiling that becomes parallel to the roof slope when it runs into it. The southwest room has a second door that open onto a small, .75 meter wide balcony meant to evoke the traditional *diaojiaolou* balconies that would run around the entire structure. The southeast room has a door that opens into the storage area the is also reachable by the exterior second floor door. This door was closed to us in our study.

Like many of the buildings in Gongtan, Case Study 4 uses the structural timbers from the previous site's structures. There is a stark contrast between the old timbers and wall façade and the new timbers and wood that have replaced lost or damaged members. The exterior wall boards and timber columns and beams were original from the previous house, and the windows and interior walls are the new additions. Case Study Four used the traditional center peaked *chuandou* timber, but the interior first floor walls and floor have been replaced with concrete infill. The west wall, running into the earth of the abutting terrace, is a concrete wall up to the roof. The bathrooms are internally tiled and situated on a raised floor. The second story is floored with wood beams, and only has a thin, almost paper-like, wood veneer between the columns in the main walls. The new rooms on the second floor have additional wood paneling along the walls and ceiling. On the first floor only the center north room on the first floor mirrors this material pallet; all other rooms are open to the floor supports and the underside of the floor above. The north and center rooms on the second floor are both are open to the roof, which is terra cotta tiles supported on wood beam purlins running up at a 60 degree angle.

Case Study Four is 11.75 meters long along the north-south axis and 7.75 meters deep, running 10 *kaijian,* with only 5 extending to the floor. There is a 2.5-meter wide front sitting area on the west side of the building between it and the edge of its terrace. The first meter of this area is shaded by the roof's own extension. The central bay is recessed .75 meters into the rest of the house, falling half way between the columns that run the height of the building. The transverse bays are 3.75, 4, and 3.75 meters wide running from north to south. The front room is 4.25 meters deep with the kitchen taking up the remaining 2.75 meters to the back wall. The south *jian* is divided into the 3.25 meters deep master bedroom and the 4.5-meter deep guest bedroom with 1 meter dedicated to the bathroom in the back corner. The north *jian* has a 3.25 meters deep bedroom in the front that runs into the meter wide hallway that runs along the side of the central bed room for it's length of 2.75 meters whereupon it runs into the bathroom taking up the final 1.5 meters of the house.

The second floor has the same *jian* widths, with the north bay running the full 7.75 meters of the house and the center bay running 6.75 meters, stopping short for the 1 meter wide double high space in the kitchen running along the east wall. The south bay is divided into a 3-meter deep bedroom and a 2.5 meter bed room separated by a .75 meter hallway. The southwest room has a .75 meter balcony that runs the length of the room and is covered by its own roof. The roof's eves extend out 1.5 meters beyond the south wall.

As previously mentioned the building's structural system is a *chuandou* timber frame system with interior, non-loadbearing masonry walls[2]. The timber columns are spaced every 1.75 meters running east – west. These columns run from the concrete floor to the roof purlins. Running along with these columns at 2 meters off the ground are beams running on top of the plastered concrete walls. These beams notch into the columns and support a second set of columns that runs up to the roof system. These beams also mark a material change as the infill between the columns changes to wood

[2] While it is most likely plaster or concrete covered CMU walls due to their cost efficiency, the owner simply referred to them as "concrete walls" so their true cross section is unfortunately unknown.

paneling. Another meter up wood timber joists notched into the columns run north south across the bays laying down the second floors support system. The second floor's floor is comprised of wood planks that run along these joists.

The roof's structural system is a simple set of wood timber roof joists running north south, parallel to the floor boards of the second floor. These roof joists support purlins spaced every .25 meters on center, holding up the roof tiles. The second floor walls running east-west are wood veneer infill with support beams running up between the columns. The inserted south bedrooms on the second floor have a simple wood framing wall system to create the enclosures.

One of the most notable things about Case Study Four is that the building is very well lit. This is accomplished by having windows in every room, save the rear bathrooms, and once again making use of skylights on the second floor. The clay roof tiles are interspersed with glass tiles that act as small skylights letting a large amount light into the second floor. Windows dominate the west facing façade of the building, and run along the southern wall, larger on the second floor than the first. Additionally the constant opening of the doors lets light in through these main apertures. Even the center north bedroom on the first floor has a clerestory window that looks into the hall. This was however, the only non-bathroom that required an electric light to bring the illumination to a useable level. Because none of these windows are sealed, Case Study Four is also nicely ventilated. A consistent movement of air could be felt throughout the home.

The material choice of plastered concrete walls and concrete floor helps cool the base level of the home, even if the humidity and ambient temperature are roughly equivalent. (Figures A-17 and A-18 clearly show how far outside the comfort zone the home lies.) Most important for comfort, it seems, is the pattern of use obtaining in Case Study Four. The occupants who were home while we visited spent most of their time outside in the front porch area, smoking, talking, and relaxing in the shaded front area. They did not vacate the house to make room for us, but came and went freely to get things or clean. As the day, and our measuring, went on and the sun came around, the occupants slowly moved away from the encroaching sun. This use pattern reinforces the idea that the Chinese home is more than just an enclosed, built environment. Similar patterns were noted at the other Case Studies as well.

Appendix A.5: Case Study Five

The final case study, Case Study Five, is located at 28 degrees, 55.803 minutes North and 108 degrees, 20.947 minutes East at an elevation of 1132ft at its main entrance, on the 3rd and 4th terraces up stream from Case Study Four. The house is home to seven people: grandparents, their son and daughter-in-law, and 3 grandchildren. During the visit the son and daughter-in-law were away working in the city and we were able to interview the grandfather of the house. Like the rest of the newly relocated Gongtan, Case Study Five was built in 2007 by the local craftsmen in Gongtan's reconstruction, but the family's previous home was over a hundred years old. The grandfather of the family noted that he was a Mandarin Chinese teacher at a local school over the mountain on the far side of the river. At his suggestion, we later visited the Miao village on the top and were able to see the other home he referred to, but time precluded us from documenting it.

The three-story structure of Case Study Five, drawn out in Figures A-11, 12, and 13, was built into the grade change of the terraces, giving a ground entrance to the basement and first floor levels, very similar to Case Study Four. The home is organized on a three *jian* using a *chuandou* timber frame structure. There is an addition connecting to the north side of the home that was in progress of being built. Made with concrete and CMU blocks, the addition is intended to be a bed-and-breakfast for tourists who come to Gongtan. It was not covered in this survey due to its incomplete status and because it was felt it deviated too much from the idea of *diaojiaolou*. The basement has a single door entrance on its south wall, a double door entrance into the second *jian* (blocked off), and a third doorway in the north wall that lead into a CMU room with stairs to the next level of the addition. The southern *jian* in the basement is the kitchen, and the center and north *jian* are used as storage rooms. There are bathrooms connecting off the southern and northern *jian,* as well as the staircase landing room. The main floor entranceway is a double door in the east wall of the center *jian*. This room is the main gathering space and living room and while we were there it was occupied by the grandchildren watching television. The doors to the north and south rooms are in the west corner of the center bay's walls. The north and south rooms also have doors on their west and east walls which were closed and blocked. The north *jian* was the son and daughter-in-law's bedroom while the south room was the bedroom for the grandchildren and the grandfather. The top floor was reached through staircases that were connected to a wrap-around balcony walkway along the east wall of the main story. With stairs on both the north and south walls the top floor can be accessed from either side. The top three rooms are empty and unused, intended to be bedrooms when the addition is finished. The north addition connects to, and provides the landing for, the north staircases. While we did not thoroughly study the addition it should be noted that each floor has three rooms arranged linearly, mimicking the rhythm of a traditional Chinese house. The finished product will be formally similar to an L-style formed *diaojiaolou* but employ a shift in the material palette.

Case Study Five's major dimensions measure 12.25 meters north to south and 7.5 meters east to west including the balcony. The basement level has a .75 meter wide concrete slab running the length of the old building and the addition, with at .25 meter step down to another .75 meter wide area before reaching the wall of the terrace level. The basement rooms are all 6.5 meters by 4 meters. The south basement room, the kitchen, is connected to a bathroom that is 2.75 by 1.5 meters big, not including the privacy wall, off its south-west corner. There is also a temporary shed extending 3 meters from the south wall and 2.75 meters wide. The north staircase landing room is 4 meters wide and only 2.25 meters deep, with concrete stairs running up its south wall.

On the main floor, a 2.75-meter patio area to the east runs into the wall of the next terrace. The northern and southern rooms on the main level are each 4 meters wide, while the center room is 4.25 meters wide due to the walls transitioning from a cement foundation to wood panel infill. The .75 meter wide balcony runs along the western façade under a roof overhang of 1 meter to the west, 1.75 meters to the south, and 1 meter to the north. The top floor has the same dimensions as the main floor, the center bay measuring 4.25 meters and the other two 4 meters with all running 6.5 meters wide. The east and west walls are only 1.5 meters high, but the rooms peak at 3.5 meters in the center of the pitched roof. Nine roof joists are spaced equidistantly across the roof, holding up wood purlins and a terra cotta tiled roof.

Except for the roof tiles, the main and top floors use wood, almost exclusively, in their construction and detailing. Wood panels fill in between the timber posts running east to west and the exterior beams around the exterior. The floors on both levels are wood panels supported on the joists below. The walls on the top floor have bamboo reeds woven together. These are highly permeable for both light and air. The basement's material palette is dominated by cement. Cement internal walls as well as the cement east wall abutting the earth create the main floor's patio area. The north stairs down to the basement are concrete, as is the room that they run down into, despite also having a finished wood floor. The south and west walls, however continue the timber and wood style from the above floors.

The timber frame skeleton once again dominates the structural form in Case Study Five. Five timber posts, spaced every 1.5 meters on center, run the entire height of the building, imbedded into the concrete walls of the basement. These timbers are joined at the top of the walls on the main floor by 4 more timber posts that rest on beams notched into the main skeleton. All these timbers support the floor beams for the top floor that run north-south. All timbers also support the roof system similar to Case Study Four. The floorboards for the main floor rest on top of timber beams that run between the timbers in the north and south exterior walls and are imbedded in the concrete of the two interior basement walls. The east and west walls are made up of one-meter-on-center wood planks interspersed with wood panels that run the length of the floor. On the top floor these panels are only .75 meters tall and topped with a jali-screen window.

This house is exceptionally well lit on the main and top floors, even without the use of glass tile skylights. Jali window screens, or patterned wood screens in the windows, and woven bamboo walls allow light to penetrate the entire top floor, as well as let breezes in and heated air out. The main floor was similarly well-lit by windows running along the east and west walls and light reflected off the warm wood. The only floor that was not well lit and needed electrical assistance was the basement along the east wall. The west wall had windows similar to the upper two levels that let light in, but without an additional light source the concrete walls ate up any light that might otherwise have been reflected.

Appendix B: Case Study Temperature and Humidity Data

Case Study One

Room	Surface	Material	Temperature	Humidity
Front Room	Ambient	(air)	71.5	83
Front Room	North Wall	Wood	73	
Front Room	South Wall Support	Wood Timber	73.3	
Hallway	Ambient	(air)	78	82
Hallway	Floor	Stone	72	
Living Room	Ambient	(air)	78.4	84
Living Room	South Wall Support	Wood Timber	73.5	
Living Room	South Wall Panel	Plaster over bamboo	74	
Back Porch Kitchen	Floor	Stone	72.5	
Back Porch Kitchen	Stove Wall	Stone	72	
Back Porch Pantry	Ambient	(air)	78.5	81
Back Porch Pantry	Floor	stone	72	
Back Porch Pantry	South Wall	Plaster over bamboo	73	
Back Porch Pantry	South Wall Support	Wood Timber	74	
Back Porch Open	Ambient	(air)	79.5	86
Back Porch Open	Upper Floor	Stone	73.5	
Back Porch Open	West Wall	Stone	73	
Back Porch Open	Lower Floor	Stone	72	
Back Porch Lower Storage	Ambient	(air)	78.2	85
Back Porch Lower Storage	Floor	Stone	71.5	
Back Porch Lower Storage	West Wall	Stone	71.5	
Back Porch Lower Storage	South Wall	Stone	72	
Back Porch Lower Storage	Center Support Post	Wood Timber	73	
Back Porch Lower Storage	Roof Tile	Ceramic	74.5	
Second Floor Front Room	Ambient	(air)	78.3	90
Second Floor Front Room	Floor	Wood	75	
Second Floor Center Room	Ambient	(air)	78.7	90
Second Floor Center Room	Floor	Wood	75.5	
Second Floor Center Room	North Wall Support Column	Wood Timber	76	
Second Floor Center Room	North Wall Panel	Plaster over bamboo	77.5	
Second Floor Center Room Back	Ambient	(air)	77.9	91
Second Floor Center Room Back	floor	Wood	75.5	
Roof	Tiles	Ceramic	82	

Roof	Cross Beams	Wood Timber	78.5	
Roof	Light Holes	Glass	81	

Case Study Two

Room	Surface	Material	Temperature	Humidity
Exterior	Ambient	(air)		87
Front Room	Floor	Rammed Earth	74.5	
Kitchen	Ceiling	Wood	72.5	
Kitchen	Floor	Stone	80.3	
Living Room	Floor (center)	Stone	73	
Living Room	North Wall	Plaster	73	
Living Room	Ambient	(air)	80.9	
Living Room	North East corner floor	Stone	78	
Living Room	South Wall	Plaster	75.5	
Living Room	South Easter Corner floor	Stone	76	
Living Room	Celing	Wood	76.5	
North Bedroom	Floor	Stone	73	
South Storage Room	Floor	Stone	75	
South Storage Room	Floor	Wood	76.5	
South Storage Room	Porch Floor	Stone	74.5	
North Storage Room	Floor	Stone	74.5	
North Storage Room	Floor	Wood	75.5	
South Basement	West Wall by Stair	Stone	74	
South Basement	Bathroom Wall	Ceramic Tile	75.5	
South Basement	Ceiling	Wood	77	
South Basement	Ambient	(air)	76	86
South Basement	Floor by Bathroom	Wood	78.2	
South Basement Bathroom	Ambient	(air)		88
North Basement	North Wall	Papered	78.5	
North Basement	Ambient	(air)	78	

Case Study Three

Room	Surface	Material	Temperature	% Humidity
Basement	Ambient	(air)	75	96
Basement	Porch and Stairwall	Woven Wood	74.5	
Basement	Floor	Wood	72	
Basement	South Wall	Stone	73.5	
Basement	North Floor	Rubble	73	
Basement	Bathroom Wall	Tile	72.5	
Basement	Bathroom Ambient	(air)	71.5	
Basement	Exterior Support Post	wood	83.5	
Front Room	Ambient	(Air)	76	94
Front Room	Floor	Rammed Earth	73.5	
Front Room	Ceiling	wood	74.5	
Front Room	North Wall	Plaster	74.5	
Front Room	South Wall	Plaster Covered Brick	73.5	
Hall way	Floor	Rammed Earth	72.5	
kitchen	Floor	Wood	74	
Bed Room	North Wall	Brick	74	
Attic	Ambient	(air)	75.8	89
Attic	Floor (South End)	Wood	74	
Attic	Floor (North End)	Wood	74	
Attic	South Wall, Main Support	Wood	74.5	

Case Study Four

Room	Surface	Material	Temperature	% Humidity
Exterior	Floor	Stone	78	
Main/Living Room	Ambient	(air)	80.1	87
Main/Living Room	Floor	Concrete	73.5	
Main/Living Room	Floor At Center of East Wall	Concrete	73	
Main/Living Room	North, West Wall	Wood	77	
Main/Living Room	South, West Wall	Wood	77.5	
Main/Living Room	East Wall	Concrete	75	
Main/Living Room	South Wall	Concrete	75.5	
Main/Living Room	North Wall Support Post	Wood	76	
Main/Living Room	Ceiling	Wood	76.5	
South Front Room	Ambient	(air)	79.6	89
South Front Room	Floor	Concrete	74	
South Front Room	Ceiling	Wood	76.5	
South Front Room	South Wall	Wood	78	
South Front Room	West Wall	Wood	79	
South Front Room	North Wall	Concrete	75	
South Front Room	East Wall	Concrete	75	
South Back Room	Ambient	(air)	81.8	83
South Back Room	Floor	Concrete	72	
South Back Room	Bathroom Floor	Concrete Tile	71	
South Back Room	South Wall	Wood	74.5	
South Back Room	West Wall	Concrete	75	
South Back Room	North Wall	Concrete	74	
South Back Room	East Wall	Concrete	73.5	
South Back Room	Bathroom Wall	concrete/plaster	74	
South Back Room	Bathroom East Wall	Concrete	72	
South Back Room	Ceiling	Wood	74.5	
North Front Room	Ambient	(air)	80.9	89
North Front Room	Floor	Concrete	72	
North Front Room	South Wall	Concrete	75	
North Front Room	West Wall	Wood	77.5	
North Front Room	North Wall	Concrete	75	
North Front Room	North Wall	Concrete	75	
North Front Room	North Wall support post	Wood	75.5	
North Front Room	Ceiling	Wood	76	
North Mid Room	Ambient	(air)	81.8	92
North Mid Room	Floor	Concrete	72.5	
North Mid Room	South Wall	Concrete	75	
North Mid Room	West Wall	Concrete	75	

North Mid Room	North Wall	Concrete	75	
North Mid Room	East Wall	Wood	75	
North Mid Room	Drop Ceiling	Wood Panels	75	
North Back Bathroom	Ambient	(air)	81.2	89
North Back Bathroom	Floor	Ceramic Tile	72.5	
North Back Bathroom	South Wall	Ceramic Tile	75	
North BackmBathroon	West Wall	Ceramic Tile	75	
North Back Bathroom	North Wall	Ceramic Tile	75	
North BackmBathroon	East Wall	Ceramic Tile	73.5	
Kitchen	Ambient	(air)	80.6	85
Kitchen	Floor	Concrete	72	
Kitchen	South Wall	Concrete	74	
Kitchen	West Wall	Concrete	74.5	
Kitchen	North Wall	Concrete	75	
Kitchen	East Wall	Concrete	73.5	
Second Floor				
Center Room	Ambient	(air)	80.8	86
Center Room	Floor	Wood	76.5	
Center Room	South Wall, West	Wood Thatch	77	
Center Room	South Wall, East	Wood Thatch	76.5	
Center Room	West Wall	Wood	79.5	
Center Room	North Wall, West	Wood	77	
Center Room	North Wall, East	Wood	77	
Center Room	East Wall	Wood	76.5	
Center Room	Roof	Ceramic Tile	79	
Center Room	Cross Beam	Wood Timber	77	
North Room	Ambient	(air)	82.6	84
North Room	Floor	Wood	76.5	
North Room	West Wall	Wood	76.5	
North Room	North Wall	Wood	76.5	
North Room	East Wall	Masonry	76.5	
North Room	Roof	Glass Tile	85	
South, west room	Ambient	(air)	79.8	82
South, west room	Floor	Wood	76.5	
South, west room	South Wall	Wood	77.5	
South, west room	West Wall	Wood	77	
South, west room	North Wall	Wood	77	
South, west room	East Wall	Wood	77.5	
South, west room	Drop Ceiling	Wood	78	
Second floor, balcony	Ambient	(air)	83.1	81

Second floor, balcony	Floor Center	Wood	80	
Second floor, balcony	Floor East	Wood	80	
Second floor, balcony	Floor West	Wood	80	
South Hall Way	South Wall	Wood	79	
South Hall Way	West Wall	Wood	77.5	
South Hall Way	East Wall	Wood	77.5	
South Hall Way	Floor	Wood	76.5	
South, east room	Ambient	(air)	81	82
South, east room	West Wall	Wood	76.5	
South, east room	North Wall	Wood	76.5	
South, east room	East Wall	Wood	77	

Case Study Five

Room	Surface	Material	Temperature	% Humidity
Second Floor, South room	Ambient	(air)	80.3	88
Second Floor, South room	Floor, center	Wood	76	
Second Floor, South room	Floor, east	Wood	76	
Second Floor, South room	Floor, west	Wood	76	
Second Floor, South room	East Wall, north	Wood	76.5	
Second Floor, South room	East Wall, Mid	Wood	76.5	
Second Floor, South room	East Wall, south	Wood	76.5	
Second Floor, South room	South Wall, east	Wood	76.5	
Second Floor, South room	South Wall, West	Wood	76.5	
Second Floor, South room	West Wall, North	Wood	76	
Second Floor, South room	West wall, mid	Wood	76	
Second Floor, South room	West Wall, south	Wood	76	
Second Floor, South room	North wall, West	Wood	76	
Second Floor, South room	North Wall,East	Wood	76	
Second Floor, middle room	Ambient	(air)	80.4	87
Second Floor, middle room	Floor, center	Wood	77	
Second Floor, middle room	Floor, East	Wood	76.5	
Second Floor, middle room	Floor, West	Wood	76.5	
Second Floor, middle room	East Wall, North	Wood	76.5	
Second Floor, middle room	East Wall, Mid	Wood	76.5	
Second Floor, middle room	East Wall, South	Wood	76.5	

Second Floor, middle room	West Wall, North	Wood	76.5	
Second Floor, middle room	West wall, mid	Wood	76.5	
Second Floor, middle room	West Wall, South	Wood	76.5	
Second Floor, North room	Ambient	(air)	79.5	88
Second Floor, North room	Floor, center	Wood	76	
Second Floor, North room	Floor, East	Wood	76	
Second Floor, North room	Floor, West	Wood	76	
Second Floor, North room	East Wall	Wood	76	
Second Floor, North room	South Wall, East	Wood	77.5	
Second Floor, North room	South Wall, West	Wood	75.5	
Second Floor, North room	West Wall	Wood	76	
Second Floor, North room	North wall, West	Wood	75.5	
Second Floor, North room	Web in North West corner	Spider Silk	86.9	
Second Floor	Roof Tiles	Clay Tiles	78.5	
Second Floor	Roof Cross beams	Wood	77	
Second Floor	Panels	Wood	76.5	
Second Floor	Columns	Wood Timber	76	
Second Floor	East Beams	Wood Timber	77	
Second Floor	West Beams	Wood Timber	76.5	
First Floor, Exterior	Stone wall facing west/front wall	Stone	79	
First Floor, Exterior	East wall, South section	Wood	85	
First Floor, Exterior	Exterior East Floor	Stone	80	
First Floor, Exterior	East wall, Mid section,	Wood	84.5	
First Floor, Exterior	East Wall, North section	Wood	82.5	
First Floor, Exterior	North Wall	Wood	76	
First Floor, Exterior	West Wall, South section	Wood	84	
First Floor, Exterior	West Wall, Mid Section	Wood	84.5	
First Floor, Exterior	West Wall, North section	Wood	84	
Exterior Walk way	Ambient, south end	(air)	80.5	87
Exterior Walk way	Ambient, North End	(air)	78.7	83
Exterior Walk way	Floor, south end	Wood	83.5	

Exterior Walk way	Floor, south mid end	Wood	83.5	
Exterior Walk way	Floor, mid	Wood	83.5	
Exterior Walk way	Floor, north	Wood	83	
North Room	Ambient	(air)	80.4	87
North Room	North Wall panels, from west	Wood	77	
North Room		Wood	76.5	
North Room		Wood	76.5	
North Room		Wood	76.5	
North Room	East wall panels, from North	Wood	78	
North Room		Wood	78.5	
North Room		Wood	79	
North Room		Wood	79	
North Room	South Wall panels	Wood	77	
North Room	West wall, From North	Wood	78.5	
North Room		Wood	79	
North Room		Wood	79	
North Room	Floor, West end	Wood	76.5	
North Room	Floor, Center	Wood	75.5	
North Room	Floor, East End	Wood	75.5	
Center Room	Ambient	(Air)	82.7	86
Center Room	Floor, West end	Wood	77	
Center Room	Floor, Center	Wood	77.5	
Center Room	Floor, East End	Wood	78.5	
Center Room	West Wall Panels, From North	Wood	79	
Center Room		Wood	80	
Center Room		Wood	79.5	
Center Room		Wood	79.5	
Center Room	East Wall, South Half	Wood	80.5	
Center Room	East Wall, North Half	Wood	80.5	
Center Room	South Wall Columns from West	Wood Timber	78	
Center Room		Wood Timber	77.5	
Center Room		Wood Timber	77.5	
Center Room	South Wall Panels from West	Wood	78	
Center Room		Wood	78.5	
Center Room		Wood	78.5	
South Room	Ambient	(air)	81.4	88
South Room	Floor, West end	Wood	77.5	
South Room	Floor, Center	Wood	77	
South Room	Floor, East End	Wood	77	

South Room	West Wall Panels, From North	Wood	80	
South Room		Wood	79.5	
South Room		Wood	79.5	
South Room		Wood	80	
South Room	East wall panels, from north	Wood	79.5	
South Room		Wood	79.5	
South Room		Wood	80	
South Room		Wood	80	
South Room	South Wall Panels from West	Wood	78	
South Room		Wood	78	
South Room		Wood	78.5	
South Room		Wood	79	
Basement Exterior	Ambient, south end	(air)	80.3	87
Basement Exterior	South End	Concrete	81.5	
Basement Exterior	Exterior Floor, South Room, south	Concrete	79.5	
Basement Exterior	Exterior Floor, South Room, Center	Concrete	79.5	
Basement Exterior	Exterior Floor, South Room, North	Concrete	79.5	
Basement Exterior	Exterior Floor, Center Room	Concrete	78.5	
Basement Exterior	Exterior Floor, North Room	Concrete	77.5	
Basement Exterior	Exterior Floor, Addition	Concrete	80.5	
Basement Exterior	South Room, Exterior wall, south	Wood	82.5	
Basement Exterior	South Room, Exterior wall, Center	Wood	82.5	
Basement Exterior	South Room, Exterior wall, North	Wood	83	
Basement Exterior	Center Room, Exterior wall, south	Wood	79.5	
Basement Exterior	Center Room, Exterior wall, Center	Wood	79.5	
Basement Exterior	Center Room, Exterior wall, North	Wood	79.5	
Basement Exterior	North Room, Exterior wall	Wood	78	
Basement Exterior	Stair well Room, Exterior wall	Wood	78	
Basement, South Room	Ambient	(air)	81	83
Basement, South Room	Floor, North West	Concrete	75.5	

Basement, South Room	Floor, North Center	Concrete	73.6	
Basement, South Room	Floor, North East	Concrete	72.5	
Basement, South Room	Floor, Center West	Concrete	75.5	
Basement, South Room	Floor Center	Concrete	74	
Basement, South Room	Floor Center East	Concrete	73	
Basement, South Room	Floor, South West	Concrete	76	
Basement, South Room	Floor, South Center	Concrete	73.5	
Basement, South Room	Floor, South East	Concrete	73	
Basement, South Room	East Wall, North	Concrete	75	
Basement, South Room	East Wall, Center	Concrete	75	
Basement, South Room	East Wall, South	Concrete	75	
Basement, South Room	South Wall, East	Concrete	76.5	
Basement, South Room	South Wall, Center	Concrete	76	
Basement, South Room	South Wall, West	Concrete	77	
Basement, South Room	West Wall, North	Wood	83	
Basement, South Room	West Wall, Center	Wood	82.5	
Basement, South Room	West Wall, South	Wood	82.5	
Basement, South Room	North Wall, West	Concrete	76.5	
Basement, South Room	North Wall, Center	Concrete	76	
Basement, South Room	North Wall, East	Concrete	76	
Basement, Mid Room	Ambient	(air)	79.5	91
Basement, Mid Room	Floor, North West	Concrete	74	
Basement, Mid Room	Floor, North Center	Concrete	73	
Basement, Mid Room	Floor, North East	Concrete	72	
Basement, Mid Room	Floor, Center West	Concrete	74	
Basement, Mid Room	Floor Center	Concrete	73.5	
Basement, Mid Room	Floor Center East	Concrete	72	
Basement, Mid Room	Floor, South West	Concrete	74	

Basement, Mid Room	Floor, South Center	Concrete	73.5	
Basement, Mid Room	Floor, South East	Concrete	72.5	
Basement, Mid Room	East Wall, North	Concrete	77	
Basement, Mid Room	East Wall, Center	Concrete	76	
Basement, Mid Room	East Wall, South	Concrete	76.5	
Basement, Mid Room	South Wall, East	Concrete	75	
Basement, Mid Room	South Wall, Center	Concrete	75.5	
Basement, Mid Room	South Wall, West	Concrete	76	
Basement, Mid Room	South Wall, West	Concrete	76.5	
Basement, Mid Room	West Wall, North	Wood	76.5	
Basement, Mid Room	West Wall, Center	Wood	76	
Basement, Mid Room	West Wall, South	Wood	77	
Basement, Mid Room	North Wall, West	Concrete	75.5	
Basement, Mid Room	North Wall, Center west	Concrete	73	
Basement, Mid Room	North Wall, Center	Concrete	75	
Basement, Mid Room	North Wall, Center east	Concrete	74.5	
Basement, Mid Room	North Wall, East	Concrete	74.5	
Basement, North Room	Ambient	(air)	79.9	88
Basement, North Room	Floor, North West	Concrete	74	
Basement, North Room	Floor, North Center	Concrete	72	
Basement, North Room	Floor, North East	Concrete	75.5	
Basement, North Room	Floor, Center West	Concrete	73.5	
Basement, North Room	Floor Center	Concrete	72.5	
Basement, North Room	Floor Center East	Concrete	72	
Basement, North Room	Floor, South West	Concrete	73	
Basement, North Room	Floor, South Center	Concrete	72	
Basement, North Room	Floor, South East	Concrete	72	
Basement, North Room	East Wall, North	Concrete	74	
Basement, North Room	East Wall, Center	Concrete	73.5	
Basement, North Room	East Wall, South	Concrete	74	
Basement, North Room	South Wall, West	Concrete	75.5	
Basement, North Room	South Wall, Center west	Concrete	74.5	

Basement, North Room	South Wall, Center east	Concrete	74.5	
Basement, North Room	South Wall, East	Concrete	74.5	
Basement, North Room	West Wall, North	Wood	76	
Basement, North Room	West Wall, Center	Wood	76.5	
Basement, North Room	West Wall, South	Wood	75.5	
Basement, North Room	North Wall, West	Concrete	75	
Basement, North Room	North Wall, Center	Concrete	74.5	
Basement, North Room	North Wall, East	Concrete	74.5	
Basement, Addition	Floor, Base of the Stairs	Concrete	74	
Basement, Addition	Floor, next to the stairs	Concrete	76	
Basement, Addition	Floor, extra room	Concrete	74.5	
Basement, South Bathroom	floor	Concrete	73.5	

Appendix C: IRB Materials

Protocol Form

Required Instruments

Introductory Script (Chinese)

Oral Consent Script

Homeowners Interview Template

Institutional Review Board for Social & Behavioral Sciences
University of Virginia

Protocol Form

Using this document:

- The purpose of this document is to provide you with a guide for providing the information that the IRB-SBS needs in order to review your protocol. Each question provides instructions as well as suggestions for completing the question. After every **Instruction** section, there is a **Response** area; please provide your answer in **Response** area.
- In addition, any blue underlined text is linked to related areas in our Researcher's Guide on our website. If you have questions about how to respond to a question, start with the Researcher's Guide and then contact our office for additional help.

Submitting a protocol:

- This document has three parts: **Section A "Investigator's Agreement**," **Section B "Protocol Information,"** and **Section C "Description of the Research Study."** To submit a protocol, complete this document and email it and any accompanying materials (i.e. consent forms, recruitment materials, instruments) to irbsbs@virginia.edu. For more information on what to submit and how, please see Submitting a Protocol.
- **Please note that we can only accept forms in Microsoft Word format and in this form only. Do not submit your responses in a separate document.** We do not accept hand-written documents (with the exception of the signature on the Investigator's Agreement). Please submit the electronic form in its entirety; do not remove the signature pages from the document even though you will submit these pages as a pdf/hard copy. Do not alter this form; simply provide your responses in the **Response** area. **Forms that are not completed correctly will be returned to you and you will be required to complete them correctly before they are accepted. No exceptions!** If you need help using our form, please contact our office. For tips and suggestions for completing the protocol, please see Protocol and Informed Consent Tips.
- **Section A "Investigator's Agreement"** must also be submitted with signatures. Signed materials can be submitted by mail, fax (434-924-1992), or email (scanned document to irbsbs@virginia.edu). Signed materials can also be submitted in person to our office. **Your study will not be approved until we receive this document.**
- In order to not delay your review, make sure that you (and any researcher listed on the protocol) have completed the CITI training in human subjects research.
- You will be contacted within 3-7 business days regarding your submission (depending on the protocol queue). Please see Protocol Review Process for more information.

Institutional Review Board for Social & Behavioral Sciences
University of Virginia

A. Investigator Agreement

BY SIGNING THIS DOCUMENT, THE INVESTIGATOR AGREES:

1. That **no participants will be recruited** or data accessed under the protocol **until** the Investigator has received the **final approval or exemption letter** signed by the Chair of the Institutional Review Board for the Social and Behavioral Sciences (IRB-SBS) or designee.
2. That **no participants will be recruited** or entered under the protocol **until** all researchers for the project including the Faculty Advisor have completed their **human investigation research ethics educational requirement** (CITI training is required every **3** years for UVA researchers).
3. That any **modifications of the protocol or consent form** will not be implemented without prior **written approval** from the IRB-SBS Chair or designee except when necessary to eliminate immediate hazards to the participants.
4. That any **deviation from the protocol and/or consent form** that is serious, unexpected and related to the study or a **death** occurring during the study **will be reported promptly to the SBS Review Board** in writing.
5. That all protocol forms for **continuations of this protocol** will be **completed** and returned **within the time limit stated** on the renewal notification letter.
6. That **all participants will be recruited and consented as stated in the protocol approved or exempted** by the IRB-SBS board. If written consent is required, all participants will be consented by signing a copy of the consent form that has a non-expired IRB approval stamp.
7. That the IRB-SBS office will be notified within **30 days** of a **change in the Principal Investigator** for the study.
8. That the IRB-SBS office will be notified when **the active study is complete**.

Peter Kempson	**May 5, 2014**
Principal Investigator (print)	**Date**
Architectural History and Design DiaojiaoLou Thesis	
Protocol Title	**Protocol Number (SBS office only)**

Principal Investigator's Signature

FOR STUDENT AND STAFF PROPOSALS ONLY
BY SIGNING THIS DOCUMENT, THE FACULTY ADVISOR HAS READ THE PROPOSAL FOR RESEARCH AND AGREES:

1. To **assume overall responsibility** for the conduct of this research and investigator.
2. To **work with the investigator**, and with the SBS Review Board, as needed, in **maintaining compliance with this agreement**.
3. That the **Principal Investigator is qualified to perform this study**.

Shiqiao Li	**May 5, 2014**
Faculty Advisor (print)	**Date**

Faculty Advisor's Signature

The SBS Review Board reserves the right to terminate this study at any time if, in its opinion, (1) the risks of further research are prohibitive, or (2) the above agreement is breached.

Institutional Review Board for SOCIAL & BEHAVIORAL SCIENCES
UNIVERSITY of VIRGINIA

Protocol Form

B. Protocol Information

IRB-SBS Protocol Number (assigned by SBS office, leave blank):	
Submission Type (delete all those that don't apply):	**New Protocol**
Protocol Title:	Architectural History and Design DiaojiaoLou Thesis
Principal Investigator:	Peter Kempson
Professional Title:	
School (Curry, Medical, Arts & Sciences, etc.):	School of Architecture
Department (CISE, Family Medicine, Psychology, etc.):	Department of Architecture, Department of Architecture History
Campus Box Number:	
Mailing Address (only if campus box number is not available):	611 Rugby Road, Apt 103, Charlottesville, VA 22903
Telephone:	203 273-1492
UVA e mail address (no aliases, please): *Your computing ID is used for tracking your IRB CITI training.*	Prk2c@virginia.edu
Preferred e-mail address for correspondence (if applicable):	
You are (delete all those that don't apply):	**Graduate Student**
This research is for (delete all those that don't apply):	**Master's Thesis**
Primary contact for the protocol (if other than the principal investigator):	
Contact's Email:	
Contact's Phone:	
Faculty Advisor:	Shiqiao Li

School (Curry, Medical, Arts & Sciences, etc.):	School of Architecture
Department (CISE, Family Medicine, Psychology, etc.):	Department of Architecture, Department of Architecture History
Campus Box Number:	400122
Telephone:	(434) 924 -6444
UVA e mail address (no aliases, please): *Your computing ID is used for tracking on-line human subjects training.*	sl2fa@Virginia.EDU

Other Researchers*:

Please list all other researchers in this study that are associated with UVA.* Please provide the following information for each researcher: Name, UVA email address (no aliases, please.)	
Please list all other researchers not associated with UVA.* Please provide the following information for each researcher: Name, Institution, Phone Number, Mailing Address, Email Address.	

IRB-SBS Library Instruments:

Funding Source: **If research is funded, please provide the following:**

grant name (or name of the funding source):	
funding period (month/year):	
grant number:	

Paying Participants: If you are paying participants who are US citizens or US residents and you are using State or UVa funds (including grants), you are required to

I am paying participants using State or UVa funds (including grants) and will include the UVa or State		I am not paying participants or I am not using State or UVa funds (including grants).	X

complete the **UVa or State Funds Study Payment Procedures Form**. (Please describe your payment process in question 3-b in the next section.) **Please mark an "x" in the appropriate box (to the right):**	Funds Study Payment Procedures Form.
Anticipated start and completion dates for collecting and analyzing data: (please note that the start date should be after anticipated IRB approval)	**June 14, 2014 – July 2, 2014**

*** Please only list researchers that are working directly with human subjects and/or their data. All researchers listed on the protocol must complete the IRB-SBS CITI Training or provide proof of completing IRB training at their institution. If you have any questions about whether a researcher should be listed on the protocol or if a researcher has completed training, please contact our office (irbsbshelp@virginia.edu). Proof of training can be submitted to our office via fax (434-924-1992), by mail (PO Box 800392 Charlottesville, VA 22908-0392) or by email (irbsbs@virginia.edu).**

C. Description of the Research Study

1. **Study Overview:** Give a brief overview of your project. Consider the following when framing your response:
    - What is your purpose in conducting this research? How does the project contribute to the advancement of knowledge and why is it worth doing? What is the general benefit of the knowledge you expect to gain?
    - Include information about the study's logistics (where and when it will be conducted, what instruments and/or methods you will use, etc). What will you be asking participants to do, and what do you hope to learn from these activities?
    - Will participants be compensated for taking part in your study? If so, how much will they receive?
    - If your study has more than one phase, please clearly map out the different phases.

Response 1: (enter response below this header)

This research is being done in conjunction with a combined Architecture and Architectural History Masters Thesis that is studying the traditional Chinese stilt house found in Chongqing, China called diaojiaolou. The purpose of the thesis is to study the factors that effected the creation of this house style and then use these factors in designing a modern form of housing for the area. The Design Thesis component intends to show the importance of knowing and understanding local culture, history, and construction techniques in designing a new structure. The Historical Thesis Component aims to discuss the impact that cultural, climatic, and material forces have on the construction and use of these structures. Because most of the research on this subject is in Chinese, and there has been little fieldwork done in this area of Chinese vernacular architectural history this investigation will provide important material in the form of case study drawings, climatic measurements, and occupant interviews.

This research project will be carried out over the second half of the month of June 2014 in Chongqing China, and the greater outlying areas. For house documentation, a GPS will be used to identify each buildings location, and a laser tape measure, pencil, pen, and paper will be used to make onsite field drawings of the structure. Photos of the Building's interior and exterior will also be taken for further analysis. To collect climatic data, a kestrel weather tool will be used to gather humidity, ambient temperature, and wind speed data onsite; a laser temperature gun will be used to measure the surface temperature of the walls and floors. This data will be recorded in an onsite notebook. The occupant interviews will be recorded audibly or visually to ensure accuracy in the record and the primary investigator's UVA student ID will be used to prove his affiliation claim. Occupants will be asked about the function and use of their house, its history, and their physical comfort in it throughout the year. Participants will not be compensated monetarily for their involvement with this project.

2. **Participants: Please describe as best you can the population(s) you plan to work with.** Please describe them in the terms that are most pertinent to your project. We need to understand how working with them will further your research objectives and what steps need to be taken in order to minimize risk to them. **Please respond to questions a-e in this section.**
    a. Please fill in the following blanks below. If you are working with more than one population, please provide information for each group.

Response 2-a: (enter response below this header)

Age: 18 and above
Gender: Male and Female
Race: Chinese

Estimated number of participants: 15

b. Describe how participants will be identified and selected to participate in the study. Are there specific populations that you will be targeting and if so, why? Are there potential participants that you will exclude from the study and if so, why?

Response 2-b: (enter response below this header)

This research will involve non-exclusive voluntary participation from household occupants. Households will be selected on the exterior appearance, structure, and location of the house. The research will only target households that live in buildings of the visually and structurally distinct diaojiaolou style. This research will exclude those not of majority age and those unable to give consent.

c. Will you deceive and/or withhold information from the participants about the study? If so, please justify why deception and/or withholding information from the participants is necessary and describe the deception. Using deception requires specific consent forms and processes; please describe this process in the **Consent section** under **Response 3-a** and **3-b**.

Response 2-c: (enter response below this header)

There will be no deception or withholding of information from the participants of the study.

d. What special experience or knowledge do you, your faculty advisor, and the members of your research team (where appropriate) have that will allow you to work productively and respectfully with your participants?

Response 2-d: (enter response below this header)

The principal investigator has language skills to carry out these interviews, as well as will be joined by an interpreter to make sure that everything is understood. The principal investigator also has experience taking field measurements and using the equipment to take physical measurements of the building. The faculty advisor is fluent in Chinese and will be checking language the consent cards use. I am working with Professors and Students at Chongqing University's School of Architecture to identify specific locations to go perform the interview, but none of them will be participating in the interviewing, or the data analysis.

3. **Consent:** Consent is an on-going process that starts when you first inform your participant about the study through your recruitment/advertising efforts and ends when the participant's data are no longer needed. The federal regulations require a formal consent process takes place where you provide participants with specific information about the study (usually provided in the consent form, see General Consent Template) and the participants are required to sign the form. Not every study will fit this mold and there are some alternative methods for conducting the formal consent procedure. **In general, the Board needs to understand how participants will be recruited and consented to participate in the study.** Please note that if your study qualifies for exemption, you will not be required to follow the federal regulations for consent, but the Board may require that you provide information about the study to the participant. **Please respond to questions a-d in this section.**

   a. How will you approach/recruit participants to participate in your research? **Please provide all materials used to contact participants in this study. These materials could include letters, emails, flyers, advertisements, etc. If you will contact participants verbally, please provide a script that outlines what you will say to participants.**

Response 3-a: (enter response below this header)

Upon reaching the project site the researcher will spend a day familiarizing himself with the site by traversing the area and identifying households for further inquiry. Those households identified will be approached via door-to-door visitation and will be introduced to the study, its methods, and intent by the researcher reading a script. The investigator will present his UVA Student ID to prove his identity and status as a student. The participant will be asked if he or she would like to participate. If they agree, a time will be set for the researcher to return to carry out the consent process, interview, and house documentation. An English translation of the script is below, the Chinese language script is as follows;

Hello. My name Peter Kempson. I am an American Graduate Student at the University of Virginia studying Chinese architecture for my Masters Thesis. (WHILE HOLDING UVA STUDENT ID OUT FOR THE SUBJECT TO VIE) This is my Student ID. I am interested in diaojiaolou. At your convenience I would like to talk to you about your house and record it. I want to know how people use diaojiaolou and what they think about diaojiaolou and understand the building's history. I also want to record the building with photos and drawings. I would like to interview a member of the household who is over 18 years old and ask this person questions about the house and take photographs and take measurements of the house and record the humidity and temperature inside and outside.

I must tell you that you do not have to participate, and that you may change your mind at any point in this process. I will be using what I learn in my report as well as publish it in the US and cannot guarantee confidentiality but I will try to do so. If you change your mind at any point you can contact me and all information you provide will be removed from the study. There are no risks in your participation and no benefit to you other than providing up with information about your house's history and letting me document it.

The questions should take no more than an hour and the drawings should take no more than 5 hours to complete. If you would like to participate and now is not a good time, I can set up a time to come back later. You may feel more than free to say no. May I interview you and be told about your home?

b. What is your consent process? Who will present the consent information and how will it be presented? How will you document consent? Are your participants able to sign a form, and if not, how will you document consent? Will you use more than one form (if you use more than one version of the consent form, each form needs to have a unique title in order for our staff to keep track of the different forms)? When and where will participants receive the consent form? Who will give them the consent form? Will you pay participants?

Response 3-b: (enter response below this header)

Consent will be documented orally by the primary investigator and recorded along with the interview, and the participants will get copies of the oral consent script. The primary investigator will give participants written copies of the introduction at the first inquiry and another copy with contact information at the beginning of the interview. The English translation of the oral consent is as follows;

As you know, I am an architecture student from the University of Virginia, in the United States. I am conducting a study on diaojiaolou and their owners, and I would like to ask you some questions about that. I would like to tape-record our conversation, so that I can record your words accurately. If at any time during our talk you feel uncomfortable answering a question please let me know, and you don't have to answer it. Or, if you want to answer a question but do not want it tape recorded, please let me know and I will turn off the machine. If at any time you want to withdraw from this study, please tell me and I will erase the tape of our conversation. I will not reveal the content of our conversation beyond myself and people helping me whom I trust to maintain your confidentiality. I will do everything I can to protect your privacy, but there is always a slight chance that someone could find out about our conversation. Now I would like to ask you if you agree to participate in this study, and to talk to me about your house. Do you agree to participate, and to allow me to record our conversation?

c. Are any of your participants unable to consent (i.e. vulnerable population)? These populations include (but are not limited to): minors (participants under the legal age of consent), prisoners, and participants with diminished mental capacity. These participants generally need a parent (or surrogate) consent form and a participant assent form (prisoners being the likely exception unless they are minors too).

Response 3-c: (enter response below this header)

None of the participants will be members of a vulnerable population or unable to consent.

d. What is your relationship to your participants? Do you know them personally or hold any position of authority over them? Do any of the researchers (including the faculty advisor) have positions of authority over the participants, such as grading authority, professional authority, etc.? Are there any relevant financial relationships?

Response 3-d: (enter response below this header)

There is no relationship between the participants and the principal investigator.

e. Do any of the researchers and/or the faculty sponsor have significant financial interests in the study's financial sponsor(s) or in any other entity whose financial interests could be affected by the research?

Response 3-e: (enter response below this header)

The researcher and faculty sponsor of this study have no financial interests that will be affected by the research.

4. **Materials/Data collected**: For most SBS studies, the risk to participants often lies in the information that is collected from them. Thus the manner in which the data are collected, how they are stored, and how the data are reported in your research is an important part of determining the risk to participants. When you develop your procedures, consider **minimizing or eliminating the collection of identifying information** where possible and **provide justification** as to why it needs to be collected. **Please respond to questions a-d in this section.**

a. Are any of the data already collected? (If you are only using archival data, please use the Archival Data protocol form instead of this form.) Are the data publicly available or part of a private collection? Please describe the data set(s) and provide a list of data fields you will use (when applicable). What will you do to protect the confidentiality of the pre-existing data? (If the data are anonymous but it is possible to deduce identities, please state that you will not attempt to deduce identities.)

Response 4-a: (enter response below this header)

None of the data that will be taken in this fieldwork research will have previously existed.

b. What will you do to protect the privacy and confidentiality of your participants? Describe the process for collecting data from your participants, focusing on the kinds of information you will gather and the material forms it will take. Describe the level to which participants will be identifiable, why this information is necessary for you to collect, and how the identifying information will be linked with the participant's data. If you don't intend to collect identifying information, describe your process for keeping the data anonymous (if the data are anonymous but it is possible to deduce identities, please state that you will not attempt to deduce identities).

Response 4-b: (enter response below this header)

There will be 4 types of data taken in this project, and they will be stored in three ways. Interview data will be documented audibly or visually and stored on drives. Notes will be taken digitally at the end of the day and the audio or video files will be transferred from the device to computer storage at the end of each day. The climate, environmental, and geographic location data will be documented in a field notebook and transferred to a digital document at the end of each day. Measurements and sketches of the building will made in a second field note and sketch book. Digital copies of the pages will be made at the end of each day. Photos of the buildings will be taken and stored digitally, transferred to a computer at the end of each day. A GPS location for each building's front door will be recorded as per standard fieldwork practice. The building's location will be used for later analytical mapping of the sites. The GPS location will recorded in the field journal with the climate data and with the date, neighborhood, and a numeric identifier for the case study. Photos, audio and visual recordings and notes, and field drawings will be dated and Identified by a numeric identifier corresponding to the case study. The numeric identifier will be the only link between the climate and location data and the visual and audio data.

c. Will you use audio recordings, photographs, video recordings or other similar data recording devices? Please justify why it is necessary to use these devices, how you will use them, and what you will do with the data after they are collected.

Response 4-c: (enter response below this header)

Photographs and fieldwork drawings of the houses will be taken. This data is essential and crucial for the research project to allow for recording and analyzing of the forms to deduce similarities and differences between the case studies. Photos will also be used to construct a 3D digital model of the structures. An audio/video recorder will be used to record audio of the interviews to ensure data retention and to allow the project advisor to verify the data and translations made for accuracy. The digital data will all be transferred to a computer, organized and labeled in a filing system and backed up on an external password protected device.

d. How will your materials be stored? Discuss both how you plan to store it while you are collecting and actively analyzing it, and your long-term plan for maintaining it when the active research phase is finished. How will your data be reported in your study? Will you report the results in aggregate or will individual data be discussed? If you are storing electronic files, make sure that your data storage plan complies with UVa IT policies.

Response 4-d: (enter response below this header)

Material will be stored in two field notebooks, a digital camera, a digital audio recorder, an external drive, and the principal investigator's computer. The field notebooks, digital camera, and digital audio recorder will be used to recorder and store the data during collection. Data will be moved to the computer and backed up on an external drive. Data on the computer will be used for analysis and backed up on the external device. The data will remain on these two electronic devices after the active research phase for analysis. The data will be reported in the study in tables, comparison graphs, building plan and sections, 3D model renders, and textual analysis. The results will be reported both in aggregate and as individual case studies as illustrative examples of the larger principles discovered.

5. **Risks**: Almost any intervention into other people's lives carries with it the potential to cause them social, psychological, physical, or legal harm. However, not every interaction will put a participant at risk beyond what is considered minimal. **Please describe to the Board the potential risks and the probability of harm to the**

participants in your study. In this section, consider the following when framing your response:

- Describe the risks to the participants in your study. Does your study include "risk-sensitive" participants (as identified in the Participants section)? What is the probability that harm could occur?
- Describe what you will do to minimize those risks. Describe what you will do if a harmful situation occurs.
- Would a loss of confidentiality of any of your materials put participants at risk? If so, how will you prevent this from happening?

Response 5: (enter response below this header)

There is minimal risk in this project. The study will not include risk-sensitive participants. Data separation from identifiers will even further minimize any potential unforeseen risks, but a loss of confidentiality will not put the participants at risk.

6. **Benefits**: Benefits help to outweigh the risks to the participants, though not every study will have direct benefits to the participants. Will there be any direct benefits to the participants in your study? If so, what are they? (The Board also considers the general benefits of the study, as described in section 1).

Response 6: (enter response below this header)

This study will not have any direct benefits to the participants.

Project Title: Architectural History and Design DiaojiaoLou Thesis:
Required Instruments for Investigation

Data Collection and Recording Instruments

Temperature Measurement tool: Kestrel 3000 Weather Tool
Laser Temperature Gun: Raytek MiniTemp
Laser Tape Measurer: Stabila Messgeräte D-76855
Digital audio and video recorder: Samsung HMX-W300 (camera and audio recorder)
GPS Location Device: Garmin Oregon 550T 3-Inch Handheld GPS Navigator with 3.2MP Digital Camera
Digital Camera: Fujifilm FinePix S4000
Field Notebooks: Moleskine notebooks (one ruled, one plain) and graph paper pad
Manual Recording Devices: Micron Pens (various brush sizes) and Derwent Graphic Pencils (various weights)
Computer Recording Device: Microsoft Surface
Proof of Identification: UVA Student ID

Introductory Script for Talking to Home Owners (Chinese Language Card to be presented when talking)

您好，我的名字是 Peter Kempson，您可以叫我彼得。我在美国弗吉尼亚大学就读建筑研究生，我的毕业论文是关于中国传统建筑“吊脚楼”的。这是我的学生证。如果可以的话，我希望可以问问您关于您家里的一些问题，比如您如何使用您家里的房子，房子的历史，房子的湿度和温度等等。

为了采访资料的准确性，我将用录音，拍照和画图的方式记录我们的谈话。美国研究机构规定我必须告诉您，您不一定需要协助我的研究。如果我有任何问题冒犯到了您，请立刻告诉我，您不必回答。或者，如果您愿意回答某个问题却不愿意被录音，也请告诉我，我会立刻关掉录音设备。如果任何时候您不愿意参与我的研究课题，我会立刻销毁我们的谈话记录。我的研究将在美国出版——在这个过程中，我会尽量保护您的隐私。您不会承担任何风险，也不会得到任何商业利益。

我提问的时间不会超过一个小时，画图时间不会超过五个小时。如果现在您的时间不合适，我们可以安排别的时间。请您告诉我是否愿意参与——我可以开始记录我们的谈话吗？

Oral Consent Text

As you know, I am an architecture student from the University of Virginia, in the United States. I am conducting a study on diaojiaolou and their owners , and I would like to ask you some questions about that. I would like to tape record our conversation, so that I can get your words accurately. If at any time during our talk you feel uncomfortable answering a question please let me know, and you don't have to answer it. Or, if you want to answer a question but do not want it tape recorded, please let me know and I will turn off the machine. If at any time you want to withdraw from this study please tell me and I will erase the tape of our conversation. I will not reveal the content of our conversation beyond myself and people helping me whom I trust to maintain your confidentiality. I will do everything I can to protect your privacy, but there is always a slight chance that someone could find out about our conversation. Now I would like to ask you if you agree to participate in this study, and to talk to me about your house. Do you agree to participate, and to allow me to record our conversation?

我的名字是 Peter Kempson，我在美国弗吉尼亚大学就读建筑研究生。我这次在中国进行一项关于中国传统建筑“吊脚楼”的研究。我希望可以问问您关于您房子的一些问题。为了采访资料的准确性，我将用录音的方式记录我们的谈话。美国研究机构规定我必须告诉您，您不一定需要协助我的研究。如果我有任何问题冒犯到了您，请立刻告诉我，您不必回答。或者，如果您愿意回答某个问题却不愿意被录音，也请告诉我，我会立刻关掉录音设备。如果任何时候您不愿意参与我的研究课题，我会立刻销毁我们的谈话记录。这个研究项目将以论文的形式在美国出版。我会尽量保护您的隐私——我们详细的谈话内容，您的身份以及联系方式将不会泄漏给任何人。您不会承担任何风险，也不会得到任何商业利益。

请您告诉我是否愿意参与——我可以开始记录我们的谈话吗？

Diaojiaolou Interview Questions Template (English Translation)
Diaojiaolou Homeowner Interview Template:
(Go through Oral Consent Script)

How many people live in this house?
您的房子里有多少人？

How long has your family lived here?
您家在您的房子里住了多久了？

Can you tell me how your house was built?
您的房子是什么时候建造的？

Who built your house?
是谁造您的房子？

What do you like about the house?
您比较满意这座房子的哪些方面？

What do you dislike about the house?
有哪些地方您不太满意的？

Is the house too hot? Too cold?
你的房子热不热？冷不冷？

Is the house too windy?
你的房子风大不大?

Is the house too humid?
你的房子潮湿吗?

Do you keep the windows open or closed?
你平时一般是把窗户打开还是关上？

What you use this room for?
这个房间的用途是什么？

Who uses this room?
一般是谁用这个房间?

What rooms do you like?
您比较喜欢这个房子里的哪些房间?

What would you change about the house?
如果可以的话，您会如何改建您家的房子?