TAIWAN RENEWAL DILEMMA:
CHALLENGES IN THE ADOPTION OF SUSTAINABLE DESIGN SOLUTIONS IN TAIWANESE ARCHITECTURAL PRACTICE

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Date of Award: 26-6-2025

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▪ **ABSTRACT**

The paper discusses the climatic, practical, and cultural challenges the adoption of new building design solutions faces in Taiwan's architectural field. The study process involves 1. the Honeybee climatic simulation of building environment, 2. the cross-analysis between historical data, interview with architectural practitioners, and present phenomena in Taiwan's architectural practice and urban landscape. As designing for optimal cooling capability becomes more necessary in Taiwan's increasingly hot summer, the research offers various design criteria that also consider the unique cultual context of the local practice. Passive, low-tech solutions that focus on shading and natural ventilation are favored, while the concept of thermal spatial-temporal zoning is also worth experimenting with.

▪ **KEYWORDS:** *Tropical Regionalism, Low-tech solutions, Bioclimatic Design, Passive design*

I. INTRODUCTION

Taiwan, located on the Northern Tropic in east Asia, constantly experiences extreme heat during summer. As the effect of global warming deteriorates, this vicious climatic condition is expected to only continue to worsen. Regarding the increasingly hot environment, it’s apparent that new building design solutions that promotes better thermal comfort and lower energy consumption should become necessities in Taiwan’s architectural field.

In reflection of such sentiment, official actions are being taken in response to global warming, as Taiwanese government started making legislative efforts to reduce greenhouse gas emission in hope of having it reach net-zero by 2050 across all domestic sectors. In the architectural sector, the policy is mostly based on the EEWH Green Building Evaluation System, which takes into account the embodied carbon and energy consumption (which includes criteria regarding vegetation, waste management, etc.) of the building projects. The ultimate goal is to have 100% of new buildings and over 85% of existing buildings being of nearly-zero emission (National Development Council (Taiwan), 2022).

However, while official demand for greener building has been made, the architectural field in Taiwan still hasn’t seen much innovation in the environmentally-conscious building methods, especially in the more grassroot scene. Glancing over the tectonics of the buildings over the past several decades, it’s apparent that Taiwanese building design as a whole hasn’t advanced much. Meanwhile, it’s also a common tale among the country’s architects that it’s exceptionally difficult to execute design decisions that are outside of the typical building techniques. For a design solution to be viable for the greater part of the architectural sector, it needs to be able to address the obstacles that lie in different aspects of the practice process.

Regarding the circumstances, this research aims to be a comprehensive study of challenges new building solutions may face in Taiwan’s architectural field. The topic is divided into four parts: the identification of both the climatic and practical challenges in a building’s development process, people’s common habits and interactions with the building, and the present/future climatic conditions. The first two present the limiting criteria in architectural practices, while the last two should be regarded as primary targets for design solutions to consciously address.

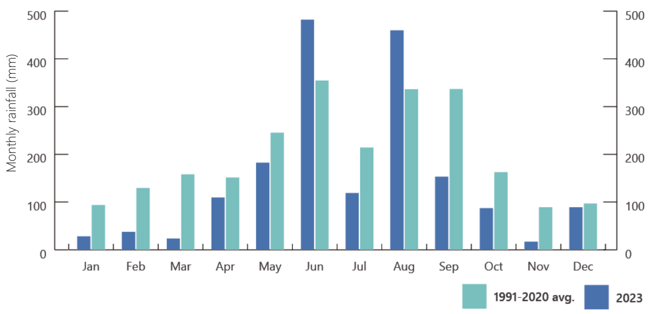
The scope of the research will mostly be on apartment building. As residential buildings consistently making up over half of all new buildings in Taiwan (Ministry of Interior (Taiwan), 2017), with about 50% of them being of the apartment building type (Architecture and Building Research Institute (Taiwan), 2022), it should be an appropriately relevant typology for the research to focus on.

II. THEMATIC RESEARCH

2.1. Taiwan's Architectural Challenges against the Climate

Taiwan's climate profile can be quite briefly described as 'hot and humid', with the relative humidity hovering 80% all year round, moderate winter, and summer temperature that hovers around or beyond 30°C for the most time of the day. In terms of rainfall, it's relatively infrequent in the winter, but otherwise a common occurance between spring to autumn (Figure 1 & 2). Under such climatic condition, the buildings in Taiwan are tasked to meet the requirement for both effective watershedding schemes, as well as means to dispel heat during summer.

This research specifically focuses on Taipei City's climate profile, and for the more in-depth analysis of the physical condition of a building, a high-rise apartment building in Taipei is chosen as the analyzed subject, which features a very typical material and spatial configuration for its typology in Taiwan (Figure 3 & 4).



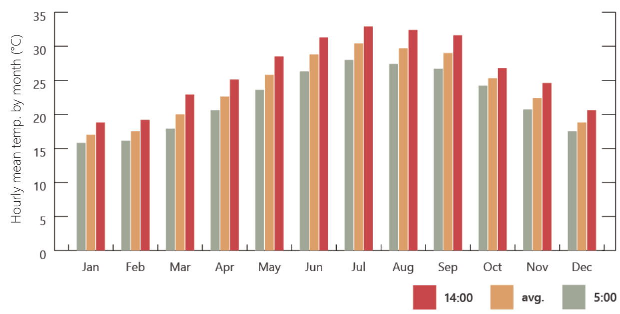


Figure 1 (left) & 2 (right). Monthly rainfall and mean temperature in Taipei, 2023 (data by Taiwan Central Weather Administration, chart created by author)

Figure 3 (left) & 4 (right). Exterior photo and standard floor plan (5F) of the subject apartment building. (project: 正隆官邸 by 正隆（股）公司 , images retrieved from www.myhousing.com.tw)

In Climate Consultant's adaptive comfort model chart, which simulates states of human comfort based on relative humidity and temperature, and the climatic design solutions that are relevant at contributing towards comfort under specific conditions (i.e. the areas covering the chart). This research specifically focuses on Taipei's comfort data. Through the comparison of the monthly readings, the comfort conditions of a whole year can be categorized into 3 types:

1. December to March as the cold months, where cooling means are largely not needed, and comfort can be achieved through appropriate clothing and minimal heating (whose necessity varies among people).
2. April, October, and November as the moderate months. These are the most pleasant times of the year. Appropriate clothing and natural ventilation are usually enough to maintain thermal comfort.
3. May to September as the hot months (Figure 5). Effective building insulation (which buildings in Taiwan generally lack of), shading, and natural/fan-forced ventilation are strongly recommended, and air-conditioning is required in exceedingly hot hours of the months.

In general, while the climatic design in Taiwan shouldn't see much of a demand for heating solutions, the singular focus is on the means to maximize the effect of natural cooling, such as natural stack/cross ventilation and shading, while also accounting for the instances where air-conditioning is necessary, which would benefit from good building insulation and spatial zoning.

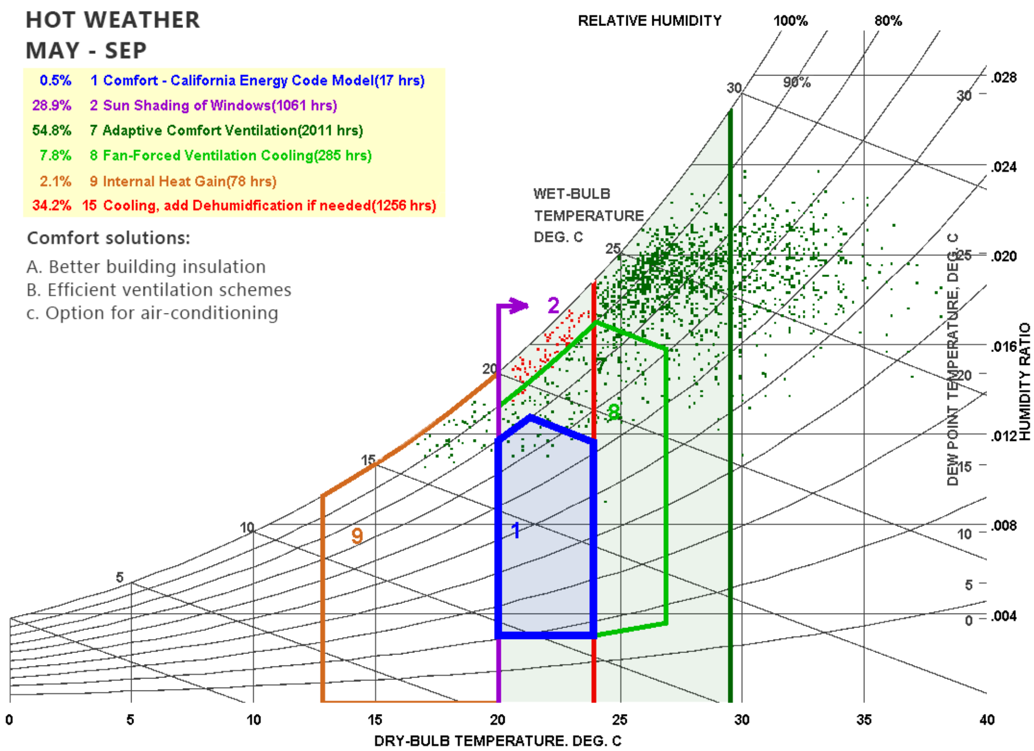


Figure 5. Adaptive comfort chart of Taipei, May. - Sep. (chart generated via Climate Consultant 6.0 by UCLA Energy Design Tools Group, edited by author)

While the analysis on climatic data produces a general climatic design criteria for Taiwanese architecture, in order to further understand the detailed influencing factors of a building's thermal comfort and energy consumption, the research conducted a series of energy model simulation/analysis utilizing Ladybug Tools (mainly Honeybee) for Rhinoceros/Grasshopper CAD software.

The subject of analysis is a typical apartment building home in Taipei with the following simulation parameters, which are balanced to approximately match the official household energy consumption statistics:

1. The apartment is built with 24cm RC walls + openable double-glazed window; it's not on ground nor roof level.
2. The apartment is occupied by a family of 4, between 18:00 to 7:00.
3. For the bedrooms and living room, the air-conditioning is turned on at 29°C.

The simulation takes into account the physical environment of the apartment building throughout the year under the set parameters, which produced the statistics of the general energy load balanece (Figure 6).

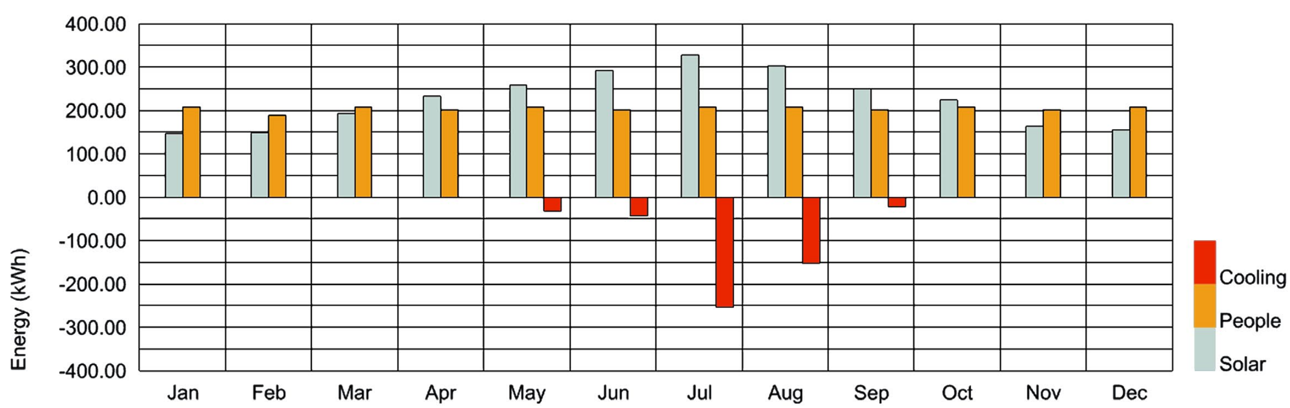


Figure 6. Monthly energy loads balance chart

The energy balance simulation indicates that while a baseline of positive energy loads from inhabitants' body heat and solar heat falls within the range of thermal comfort without mechanical cooling, excessive solar heat in the summer does require air-conditioning to be offset.

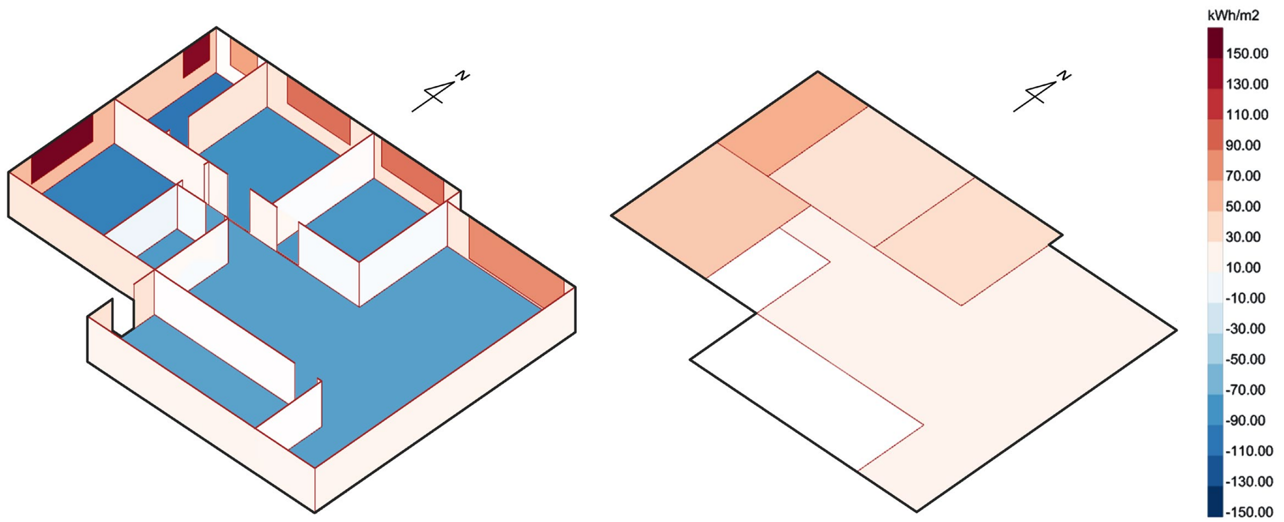


Figure 7 (left) & 8 (right). Annual surface conduction and window transmitted radiation energy intensity

The sources of heat gain are then simulated (Figure 7 & 8), which directly correlate to the indoor air temperature of the apartment (Figure 9). The analysis considers the condition of the summer afternoon, which is the hottest segment of time in a year. Comparing the simulation to the comfort zone based on ASHRAE 55-2023 Standard (Figure 11 & 12), which ranges between 24~28°C for summer in Taipei, it shows that the whole apartment is well over the comfort thredhold without air conditioning. Note that the analysed time of the day (14:00-17:00) is excluded from the occupancy schedule of the energy simulation, but nonetheless the design of the building should still take the climate extremes as such into consideration.

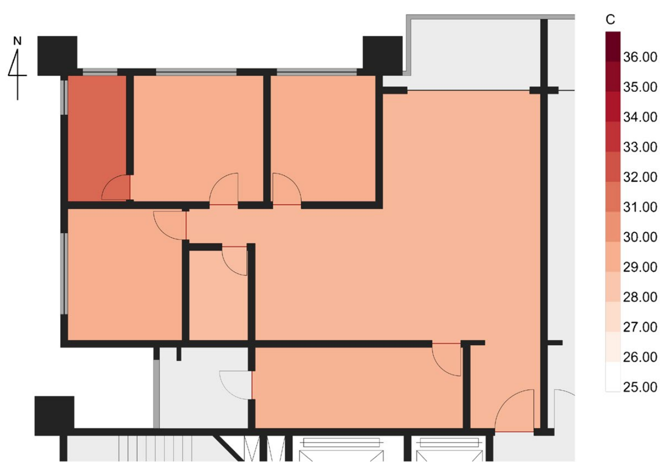


Figure 9. Mean zone air temperature in summer afternoon (14:00-17:00)

Figure 10. Summer ideal cooling load supply intensity

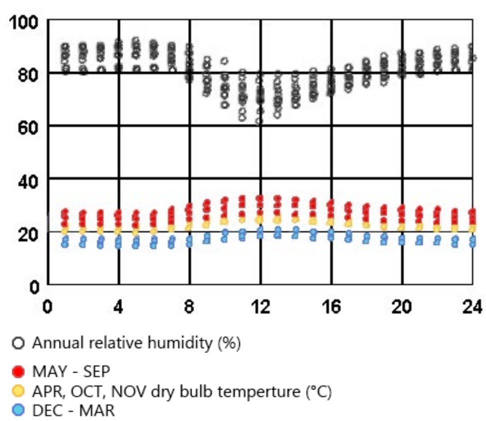


Figure 11. Taipei annual relative humidity and temperature per hour (data set generated via Climate Consultant 6.0, edited by author)

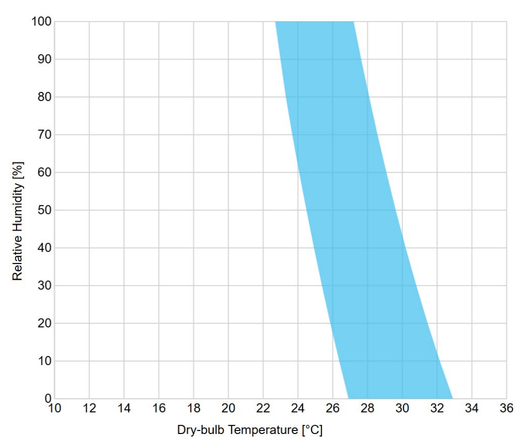


Figure 12. ASHRAE 55-2023 compliant thermal comfort zone with summer clothing (Tartarini, F., Schiavon, S., Cheung, T., Hoyt, T., 2020)

Lastly, the annual simulation of energy intensity of cooling air supply in the ideal comfort scenario as the result of offsetting the heat gain (Figure 10). In the simulation excludes rooms that are typically not air-conditioned in a Taiwanese home, namely the bathrooms and the kitchen.

Figure 13. Summer ideal cooling load supply intensity with inversed building orientation

Additionally, in order to test the effect building orientation has on the solar heat gain, another simulation is carried out with the apartment unit rotated 180°, where it now faces south/east instead of north/west. Taiwan being situated between 22-24°N latitude, it's as expected that the result shows an increase in solar load (+15% solar load between May and September, +27% annual cooling load). While a southern orientation adds cooling demand to the building in the summer, it also allows for solar heating during the winter (Figure 13 & 14).

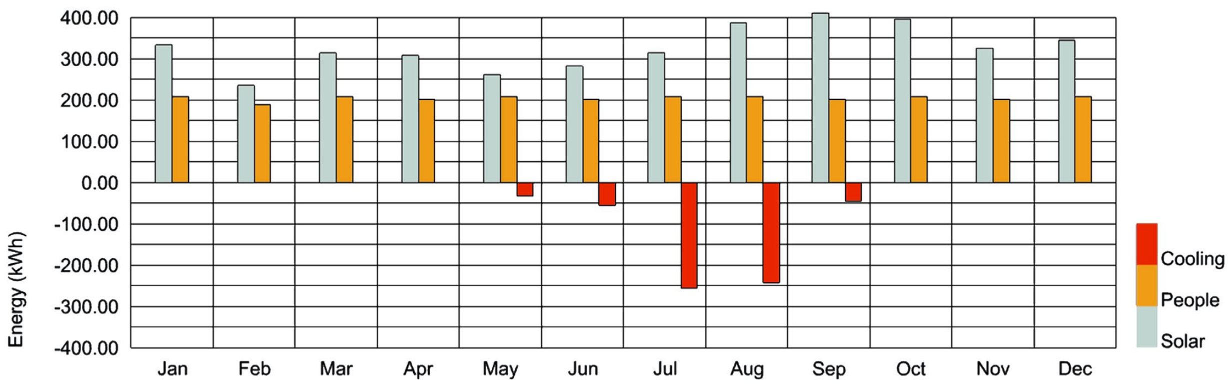


Figure 14. Monthly energy loads balance chart with inversed building orientation

To summarize the climate analysis, several points of climatic design principles can be extracted from the series of findings:

1. Windows/facade openings are the main sources of the conduction and solar radiation heat gain in a building, as seen if Figure 7-10, and thus an effective shading scheme and smart configuration of openings is recommended.
2. Orientation a has profound impact on the building's solar heat gain. Particularly, east/west facade in the summer, and east/west/south facade in the winter receives the more significant amount of illumination, which comes in the form of heat, lighting, and potential glare. This could be both a design obstacle and an opportunity. A controllable exterior shading scheme, for example, could be a way to selectively filter or allow in the southern solar heat in different seasons.
3. The corner of the building absorbs much more heat simply because of the increased surface area, as evident in Figure 7-10 and 13. One must be wary of this fact during the design.
4. Continuing from the above, the combination of thermal zoning and programming can be a very effective method at reducing energy consumption. This is evident by comparing the result of Figure 9 and 10, where the bathroom would've added to the cooling demand if it were air-conditioned. By assigning secondary programmes such as bathroom or storage to hotter areas of the house, it can negate the extra cooling needs that'd otherwise be required with living spaces.

2.2. The Cultural and Practical State and Challenges of Taiwanese Architecture

The goal of this theoretical analysis is not only to identify the specific challenges the architecture practitioners and users in Taiwan faces, the mechanism of their responses, but also produce a theoretical framework as a way to observe and interpret the phenomena of how people interact with the built environment in the region.

This research adopts a Critical Regionalist approach, which identifies elements within the architectural and urban fabric that act as "agents of contact and community"—the fundamental forces linking the geographical environment with tangible cultural activities and products (Lefaivre, Tzonis, 2001, pp. 8-9). By examining these agents of cultural consciousness, which serve as catalysts for Taiwan's architectural practices, the study offers a lens for understanding the historical evolution of building tectonics and the current state of the architectural sector.

The Rainfall, Sunlight, and Tropical Mentality

First and foremost, the research explores the way the hot and humid tropical/subtropical climate influences inhabitants' physical responses to their surroundings. Architect Bruno Stagno theorized that the vibrant and often chaotic climatic environment fosters the mode of thinking that doesn't rely on rigorous systematic thinking, but instead emphasizes the 'relationships' between self and other subjects in life – a tropical mentality.

On a physical level, it's logical that this mindset comes as the response to the limitations imposed by the climate; it's a state where the culture accumulates over people's constant solutions to the demanding physical environment. In essence, the tropical mentality is of relation and reaction to nature (Stagno, 2001, pp. 66-72).

This unique awareness of the environment also manifested itself as the fundamental logic upon which the tropical architecture and cities are built: The construction of **shading is effectively the act of space/activity-making**, and the material that can withstand the harsh weathering condition becomes the aesthetic baseline.

In Taiwan's case, the low technical threshold to climatize spaces also presented itself as a path of design principles by which the evolution of modern architectural practice would follow. The absence of the need for robust thermal insulation in a building means that it has the privilege to take up a more simplistic composition – where a shading is, functionally speaking, a shelter. And thus, for the development of a modern tropical city, the next defining step lies in gaining widespread access to the types of material and construction method that excels at performing such tasks.

The Perfect Building Solutions Leading to the Stagnation of Architectural Practice

During the first half of the 20th century, the Japanese Colonial Period introduced modern building materials and climate-responsive design methods to Taiwan. Solutions like reinforced concrete, terracotta or ceramic façade tiles, and flat-tile waterproofing with asphalt, prized for their low-tech, low-maintenance, and water-shedding qualities, quickly became ideal responses to Taiwan's climatic challenges. These innovations established a lasting foundation for the local building industry (Lin, 2006, pp. 5.7-5.10, 5.18-5.25).

While these advancements enabled the modernization of Taiwanese architecture and urban development, they also shaped public expectations for buildings to be simple, durable, and cost-effective shelters. As the buildings are able to be designed, constructed, and maintained inexpensively, **architects and contractors had little incentive to pursue advanced technical knowledge or innovative design approaches**. By the 1970s, this mindset, coupled with growing demand for higher profit margin in real estate development, led to poorly designed buildings with inadequate programming and climate adaptation. As a result, residents often addressed these shortcomings through makeshift additions, which have since become a defining feature of Taiwan's urban landscape (Hu, 2010, pp. 30-48).

In 1995, Taiwan introduced its first green building regulations, followed by the EEWH Green Building Evaluation System in 1999. While these policies aimed to improve energy performance and encourage better building practices, they merely set a low baseline for eco-friendly standards (Ministry of Interior (Taiwan), 2021, Chapter 17) (Wang et al., 2023). Consequently, the architectural industry has largely continued its reliance on the same stagnant building methods established over the past eight decades.

To further examine this phenomenon, interviews were conducted with Taiwanese architects, focusing on two key questions:

1. *What common challenges arise in detailing and design production, particularly in communication with various stakeholders?*
2. *How do existing green building regulations influence design decisions?*

The interviewees included architects and assistant designers from three architecture firms in Taiwan: one from a typical local office, another specializing in high-end projects with strong collaboration with top contractors, and a third being a specialist in timber architecture. Despite their varying contexts, the responses revealed consistent experiences regarding the topics:

1. Budget constraints and contractors' scheduling were cited as the primary limitations on design decisions, particularly for elements requiring customization or unconventional construction techniques. To mitigate these challenges, architects and contractors often simplify techniques to reduce costs and technical demands.
2. Climate control is usually addressed at a basic level during the design process, with subsequent adjustments to meet legal building performance standards. This is typically achieved through common, higher-performing materials (e.g., glazing with higher R-values or low-density cement). Since these solutions generally suffice to meet regulations, they rarely prompt revisions to detailing or spatial layouts.

The interviews highlight the resistance of Taiwan's architectural field to technical innovation but also shed light on practical challenges that need to be addressed. In order to realistically introduce a more proactive approach to climate-responsive design in a practical setting, the building solutions should not only fit to the typical tropical climatic design criteria, but also be economical, easy to produce, and maintain. These solutions should encompass not only the detailing but also broader spatial strategies. As previously discussed, tropical architectural design hinges on shading, water-shedding, and maximizing natural ventilation—characteristics that offer opportunities for innovation at both material and spatial scales.

2.3. Challenges in Development - Global Warming and Urban Heat Island

Aside from some of the persistent issues in architectural practice discussed earlier, the pressing challenge Taiwan's built environment faces is undoubtedly the effects of global warming. In urban areas, the rising temperature is amplified by the urban heat island (UHI) effect. The combined effort of global warming and UHI has resulted in increasing more days of extreme heat, most notably in Taipei City. On top of that, the people in the area subjected to the most intense UHI effect in Taipei is experiencing 20.6% of the total annual time in thermal discomfort and 2.5% in severe thermal discomfort, and it is estimated that the percentages will rise to 22.4% and 5.3% respectively by mid-century (TCCIP, 2024, pp. 45).

With the wide prevalence of mechanical ventilation and air-conditioning solutions in today's buildings, the extreme indoor heat can be mitigated with additional energy consumption. As the UHI intensifies, so will the cooling energy demand increase, and the waste heat emission in the process creates a reciprocal effect, which further aggravates the UHI. With the combined conditions, the cooling energy demand is projected to double in Taiwan by 2085 (Hwang et al, 2017, pp. 809-810).

It's apparent that the heating impact of UHI must be addressed not only to alleviate the comfort and safety concerns of the urban areas, but also reduce the cooling energy required to offset the indoor heat. On an architectural level, the contributors of UHI can be offset with various design decisions: 1. Using facade elements/materials with higher albedo/solar reflectance, 2. utilizing vegetation for shading and plant transpiration cooling, and 3. adopting passive design schemes in general to lower the mechanical cooling needs, and therefore minimizing the waste operational heat (Hulley, 2012, pp. 82–83).

2.4. The Physical and Habitual Living Conditions of Taiwanese Apartment Housing

Thus far, the research delved into the conditions in which the production of building takes place in Taiwan, both physically and culturally; however, in order to paint a complete picture of Taiwan's architectural field, it's equally as important to understand the experience of the buildings' end users. This part of the research documents and presents how the common apartment building typology produce the respective indoor climatic conditions with specific building configurations/elements, and how the certain level of thermal comfort is reached through the common household activities and habits of the residents (Figure 15).

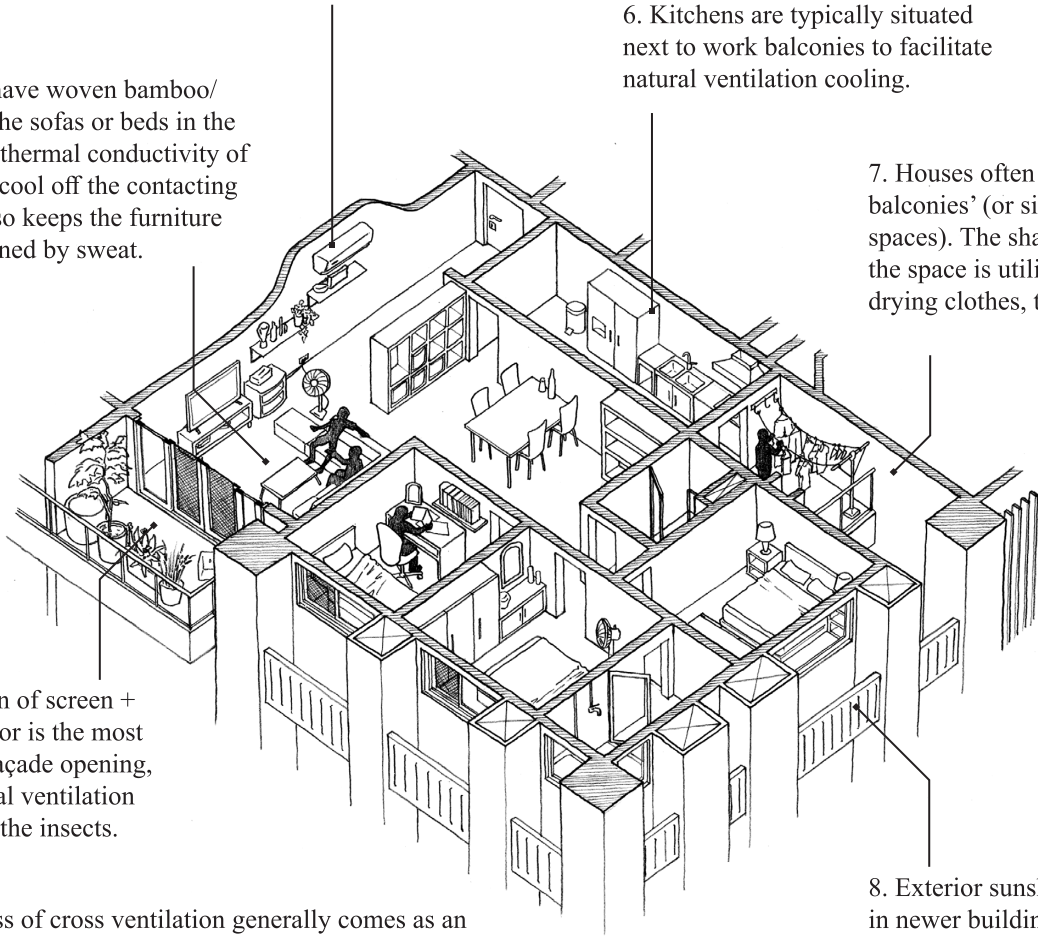


Figure 15. Mapping of common living condition in a Taiwanese apartment building unit (based on project 正隆官邸 , drawn by author)

Understandably, many facets of the residential environment are closely connected to thermal comfort, which is achieved with the minimum possible energy consumption (and therefore smaller energy bill) not just with building design but also user habits, amenities such as electric fans, and the attitude of enduring moderate degree of heat. This unique adaptation to hot climate provides more flexibility compared to the likes of ASHRAE standards in terms of the building climatization. However, despite this cultural advantage, effective passive (and mechanical) building design solutions will still be critical in further improving the quality and energy consumption of the household living.

On the topic of cooling via building elements, apart from an appropriate shading scheme, another key element that helps cool the indoor temperature is natural ventilation.

As stated above, the effectiveness of cross ventilation varies heavily from different projects. While the subject building of this research doesn't have the most ideal configuration for cross ventilation, it's also common for an apartment unit (and townhouse) to have clear front and rear façades with large openings that facilitates strong air circulation. Nonetheless, a more flexible and universal cross ventilation solution could benefit a building regardless of its pre-determined floor plan. In the meantime, the nature of the repetitive stacking floor plan in a generic apartment building means stack ventilation typically isn't utilized much as a climatic design feature, which also could be a potential feature for dissipating hot interior air.

III. CONCLUSION

The research has aimed to identify different facets of challenges in Taiwan's architectural sector, and understanding the reasoning and mechanism behind such challenges. With the findings, a critical set of design parameters/principles for new building solutions to refer to is produced:

1. The design solutions should not merely comply to the regulations, but to future-proof the new or existing buildings.
2. Designers should invest in the concept of climatic and passive design. While Taiwanese architecture is privileged to only need much simpler insulation schemes compared to the colder areas, reduction of solar heat gain and the adoption of natural ventilation should be the primary objectives. Sun orientation, façade surface area, shading coverage, thermal zoning, and different types of natural ventilation should be carefully considered in strategizing the optimal building solution(s) in pursuit of the indoor thermal comfort.
3. A simplistic architectural solution in terms of the construction and maintenance is much preferred. The compromise in its complexity is necessary for it to be relevant and viable to the general practical field. Simplify the components/techniques or utilize pre-fabrication are among the potential options to reach the criteria.
4. Combining the climatic and practical concerns, it'll also be beneficial for the building components to have high tolerance, and be heat/water-resistant.
5. The cultural attitude and habits in managing the indoor thermal comfort can be seen as an opportunity. Taking advantage of the flexibility in Taiwan's acceptable level of comfort, as well as critically arranging 'thermal discomfort' in a spatial-temporal scheme (i.e. zoning and scheduling) can be effective at further reducing the cooling energy use, and could be experimented with.

Follow-up Design Direction

This paper serves as a preliminary research for part of my design project, which will comprise of a catalogue of climatic/passive building solutions that cover the range of scales from detailing to spatial scheme, which will then be utilized in an adaptive reuse project of an old apartment building in Taipei. The design will take inspirations from existing building solutions that addresses Taiwan's climatic challenges, while evolving them in a way to meet the practical limitation and cultural needs of Taiwan's unique context. The catalogue and the research combined would serve as a reference material of climatic design methods for Taiwan's architectural design practices.

FINAL REFLECTION (RESEARCH + DESIGN)

1. What is the relation between your graduation project topic, your master track (Architecture), and your master programme (MSc AUBS)?

The aim of the course is to discuss a design topic with the emphasis on technical and physical properties/ functions of the design decisions. My design project's focus is on purposeful reprogramming, effective sunshading, and passive ventilation schemes that also facilitates community engagement in dwellings, and therefore reflects the objective of the course.

2. How did your research influence your design/recommendations and how did the design/ recommendations influence your research?

My thematic research directly provided a set of design criteria for my project, as well as the study on climatic design context in Taiwanese living culture and habits, which became a key part of my design process.

3. How do you assess the value of your way of working (your approach, your used methods, used methodology)?

I consider my approach of identifying and developing social implications of a climatic design elements to be an effective one, as it is essential in bridging the gap between the discussion of physical building technologies and the spatial and social quality of the building. However, my method also presents challenges. Organizing a wide range of building solutions along with their interconnected physical and social impacts requires a clear and structured process. Effectively executing and communicating the order of my design decisions remains challenging, and is an area where my methodology and workflow could be improved.

4. How do you assess the academic and societal value, scope and implication of your graduation project, including ethical aspects?

My project is a pragmatic proposal to the subject of sustainable architectural design in Taiwan, which is also based on the value of Taiwanese urban and community culture. The solutions and method I developed may serve as a reference and inspiration for future architectural or urban project of such topic, which is becoming more relevant over the years.

5. How do you assess the value of the transferability of your project results?

The product of the design process is a series of climate design elements, as well as the design methodology of connecting generic design solutions with personal and social purposes. This pair of design output is thus relevant to sustainable architectural practices in Taiwan beyond the scope of the project's situation.

6. Self-question: what might be the potential gaps between the theoretical impacts of your project and the practical field, and how can it reflect on the real world?

The project encourages the construction of minor building additions outside of the standard architectural practice from the residents, which has always been a legislative gray area in Taiwan. Meanwhile, the project facilitates but also depends on active community participation in the neighborhood. In reality the activation of community and controlled vernacular construction will also require a consistent communication and collaboration between different stakeholders of the building, on top of the architect's programming and tectonic design decisions. Nonetheless, the operation system for the community and the building solutions in the design project, and the methodology behind it could be a valuable inspiration or starting point for a community development project in practice.

7. Self-question: is there any aspect of your research + design project that you'd like to develop further if given more time and opportunity?

- Digital simulation analysis of the ventilation design scheme.

While my climate design decision regarding ventilation elements and façade openings are based on the general rule of thumb of air under/over-pressure, I'd wish to take a more precise design approach by utilizing airflow simulation tools such as Forma or Honeybee in Rhino Grasshopper. It'd also be an essential knowhow in the practical field for climatic design.

- Potential schemes for vernacular building intervention on both the public and private spaces.

As my design project consists of spaces and structural elements that encourage the involvement of the residents to modify their living space with furniture or structural additions, a broader process of theorizing and testing what potential modifications might be made would've been very valuable in refining the form of the basic structure, as well as the configuration and programming of the communal areas.

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