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The Role in Tall Building Design in Greening the City

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Abstract: *The relationship between tall buildings and urban greening has been one of the most relevant trends of the past few years, with tall buildings developing rapidly around the world in recent years in response to dramatic economic growth, urban population growth, and land use dilemmas. This paper not only describes the significance and impact of urban greening on the design of tall buildings but also explores the positive and negative impacts of tall building design on urban greening. It is easy to see that many factors influence urban greening in the design of tall buildings.As the technology of high-rise buildings is not yet very mature, they will inevitably have some impact on the surrounding environment, so it is necessary to analyze and discuss rationally from a perspective other than that of the high-rise building itself.This paper focuses on the interrelationship between the urban environment and tall buildings, and through this interrelationship, attempts to understand tall buildings from the perspective of the urban environment, and proposes some countermeasures against the negative impact of tall buildings on the urban environment. The contribution of this study is to promote and facilitate the completion of carbon-absorbing green tall buildings to slow down or even reduce global temperature rise and urban pollution.*

Keywords: *tall buildings; urban greening; strengths and weaknesses*

1. Introduction

In this article, the author will research the role of tall buildings in urban greening, mainly by reviewing the literature of Gao (Gao, 2016) on green building in architectural design, where we learn that tall building design not only provides a safe air environment for cities, but also reduces urban noise and improves the urban ecology. In cities where land is at a premium, the construction of high-rise buildings undoubtedly contributes to saving land and opening up more land for urban greening, and vertical greening is an effective way to address air pollution, ecological imbalances, excessive energy consumption in buildings and increased urban disasters.

Green building design concepts and methods have been gradually integrated into the field of high-rise building design(see Fig1), and urban greening is gradually becoming inseparable from the help of high-rise design, but the introduction of the disadvantages of high-rise to urban greening in the literature is scarce. For example, the impact of tall design on local urban climates, the impact of underground urban greenery, and even the negative impact on people's psychological well-being have all been suggested (Xu and Jia, 2013).

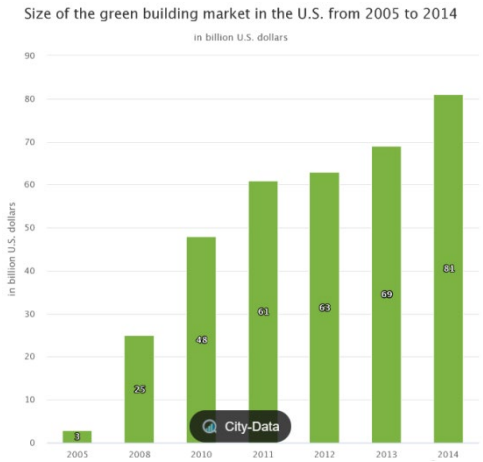

Figure 1: Data graph

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This essay will explore the positive and negative effects of high-rise design on greening cities separately. If the positive effects are greater, this means that high-rise design can be encouraged as it meets the needs of the rising standard of living and is beneficial to urban greening. But if it has more negative effects on the city, then in the future we need to find a solution and think about whether we should build so many high rises and limit the height of buildings. The article will analyse the positive and negative aspects of the case Tao Zhu Yin Yuan (see Fig2) for the urban environment based on the appearance of the building, the green circulation system and the structure of the building. It will be interesting to see what the positive effects are and whether the side effects can be improved in practice.

Figure 2: 3D rendering

2. Literature Review

In this literature review, key findings emerge from the literature around tall buildings and green buildings reviewing high sensitivity, which focuses on the importance and role of green building design in the design of modern high rise buildings. From this article it can be concluded that three-dimensional greening in high-rise design is of great significance to the city, as it can be used to bring convenience to the city, but it also has the characteristic of not being restricted by flat space, and it has a very close relationship with the city and its role is multifaceted, which makes high-rise design play an important role in the future of urban greening (Li, 2021)[1].

However, there are two sides to everything, so whether the positive effects of high-rise design on urban greenery outweigh the negative effects is a subject worthy of further study. As the urbanisation process continues to accelerate, urban buildings, especially high-rise buildings, will continue to increase, whether we want to build so many tall buildings or not is important for the future development of urban greenery, therefore, the study of this issue has certain practical significance(Xu and Jia, 2013) [2].

Figure 3: London Sky Garden

Figure 4: London Sky Garden

Liu (Liu, 2012) found a positive effect of high-rise sky gardens (see Fig3-Fig5) on improving natural ventilation in the city by selecting Hysan Place in Hong Kong as a case study based on CFD simulations, and the effectiveness of building height restrictions as a policy to limit greenhouse gas (GHG) emissions

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was investigated using model calibration and numerical simulations in Regional Science and Urban Economics (Borck, 2016) [3]. The effectiveness of building height restrictions as a policy to limit GHG emissions was found to lead to urban sprawl and high commuting emissions, but may reduce emissions from residential energy use (Borck, 2016). Moreover, sky gardens can serve to cool and insulate, beautify and purify the air, improve local microclimates and also enrich the three-dimensional landscape of the city, while increasing the green cover of the city opens up new green spaces also requiring more land to be saved. Vertical greening in high-rise design is therefore an important means of beautifying the city(Wu and Li, 2014) [4].

This is why its application in high-rise design is supported and promoted by various countries around the world, and the creation of different types of "sky gardens" in new buildings has become a trend in the development of modern high-rise buildings(Wu and Li, 2014).

(Source: Aedas SustainabilityInterest Group)

Figure 5: Location of Hysan Place

Nonetheless, some people hold the opposite view, Aristodemou (Aristodemou et al., 2018) [5]using the LES flow solver points out that increasing the height will lead to a worsening of pollution levels within the site, with pollutants spreading more widely into previously unpolluted areas, which is very unfriendly to urban greenery(Wu and Li, 2014). The main question is whether to build such a tall skyscraper, as there are also problems of heat radiation, ground-level wind flow and light pollution, which are unfriendly to urban greenery, as well as the reality of spatial oppression of other inhabitants that needs to be urgently addressed(Gao, 2016). At the same time, Xu (Xu and Jia, 2013)also pointed out that high-rise buildings require a large amount of energy for air conditioning, heating and lighting, which generates a large amount of heat, which inevitably exacerbates the urban heat island phenomenon. It is understood that the "heat island" effect is related to the fact that buildings are being built higher and higher and their density is increasing(Dong, 2021) [6]. High-rise buildings and major construction projects are also a cause of ground settlement. In the vicinity of high-rise buildings, urban drainage pipes, water supply pipes, gas supply pipes and buried power supply cables, etc., are all in close proximity to high-rise buildings, which can leave safety hazards(Xu and Jia, 2013).

In the city planning, there are strict regulations on the distance between buildings, but in the prime commercial areas where every inch of land is valuable, they are not strictly enforced, and the external walls of high-rise buildings are generally made of glass materials, which have the role of "reflectors"(Xu and Jia, 2013). The "heat island" effect and its causes The urban heat island effect, also known as "atmospheric heat pollution", is a phenomenon in which urbanization leads to higher temperatures in cities than in the suburbs(Dong, 2021). It is understood that the "heat island" effect is related to the fact that buildings are being built higher and higher, and the density of buildings is increasing. At the same time, high-rise buildings and major construction projects are also one of the causes of ground subsidence(Xu and Jia, 2013). In the vicinity of high-rise buildings, urban drainage pipes, water supply pipes, gas supply pipes and buried power supply cables, etc., are all in close proximity to high-rise buildings, which can leave safety hazards(Xu and Jia, 2013). As a result, permanent damage is caused to the green ecological environment above and below ground within the building. If these conditions are not fundamentally improved, it will be difficult to achieve the city's goal of creating a healthy green city.

Overall, it can be found that high-rise buildings have become an unstoppable trend in urban development, but we cannot simply adopt a fixed pattern of design in the process of designing high-rise buildings, as the negative effects of high-rise buildings on the urban environment are becoming increasingly prominent alongside their beneficial factors(Jiang, 2017). This paper fills a gap in the

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analysis and research on the side effects of tall buildings on urban greenery and confirms the importance of paying attention to the relationship and integration of tall buildings with their surrounding urban environment when designing tall buildings. The future of high-rise design should be integrated with the natural environment so that the building and the ecological environment can be perfectly integrated in order to truly contribute to urban greenery and outweigh the benefits.

3. Case Study

3.1 Background

Located in Taipei, Taiwan Province of China, this project was designed by French architect Vincent Callebaut with the main objective of promoting and facilitating the completion of carbon-absorbing buildings to slow down or even reduce the rising global temperatures(Tian, 2017). The Tao Zhu Yin Yuan residential flats are named after Tao Zhu Gong (Fan Li) of the Spring and Autumn period in China, in order to carry on his philosophy of benefiting oneself, one's neighbour and the world(Callebaut, 2021). I chose this case study because it is a high-rise design that contributes to greening the city and is of great relevance in promoting energy-efficient design for high-rise buildings and enhancing the rapid development of urban greening (As shown in Fig6).

Figure 6: 3D rendering

3.2 Findings and discussions

The shape of Tao Zhu Yin Garden is derived from the double helix structure of DNA (deoxyribonucleic acid), signifying the source of life, vitality and pairs, a biomimetic approach in Vincent Callebaut's futuristic study of architecture(ÇAKMAKLI, MUTLU AVİNÇ and ARSLAN SELÇUK, 2022) [7].

3.3 Appearance

Each floor of the apartment building is rotated 4.5° clockwise, giving the building a different appearance from all angles including V, X, Oval, and Cone (see Fig7) . With this 90° rotated shape, the architects wanted to achieve four main goals(Callebaut, 2021) [8].

1) Incorporate tapered areas on the north and south sides of the building to comply with urban appearance regulations set by the Taipei City Government. 2) Maximize the outdoor garden as much as the usable area ratio allows to allow the patio to be planted with vegetation well in excess of the 10% required. 3) Give residents the widest possible view, especially of the Taipei 101 Tower and the Central Business District.4) To provide the occupants with the necessary visual coverage and privacy by using special standard planes made from a twisted shape(Callebaut, 2021).

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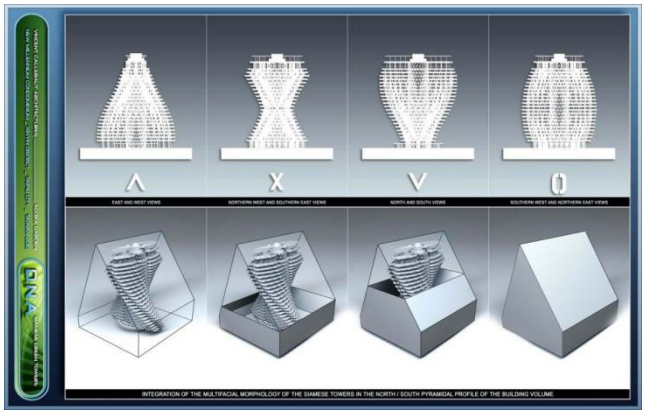

Figure 7: Morphological analysis

However, this is also a controversial aspect of the building, as the large, short, fat, spiralling mass standing on a street corner in Taipei is a practice that undermines the city's image and has been labelled as a 'genetic mutation', 'architectural art' and 'too existential'.Sari and Chiou (Sari and Chiou, 2019) [9]mentioned some designers are bound by the image of a green building and forget the main function of the facade.It makes people think about what good architecture should look like and what the true aesthetics of architecture is. This relates to Gao Min (2016) point, In the design of high-rise buildings, design methods and technical means should be used wisely to integrate the building into the ecological environment system, and on this basis to establish a greening of the building where people and the ecological environment live in harmony(Gao, 2016). I personally feel that the exterior of the building could have been handled more fluidly, and that the manipulation of the layers rotating and subtly staggering, as in the case of MAD Architects' The Absolute Towers, is different, changing and fascinating when viewed from different angles(Liu, 2012). Because the diversity of the building's appearance does not necessarily bring people better visual enjoyment, designers should pay attention to the laws of formal beauty in the design of the building's exterior, so that the design can reach a certain artistic height (As shown in Fig8) [10].

Figure 8: 3D rendering

3.4 Anti-global warming and low carbon ecosystems

The iconic balcony of the apartment building epitomises the building's green organic ecosystem, providing ample natural light and bringing sufficient vegetation and greenery to the occupants. To better reflect the building's symbiosis with nature, more than 23,000 trees and shrubs will be planted to provide a green cover of 246%, resulting in an annual carbon sequestration of 130 tonnes. This figure is also five times the local incentive scheme standard. Thanks to the extensive planting of shrubs and trees, Tao Zhu Hidden Garden will have different natural colours throughout the year, making it a veritable vertical forest. To better ensure the building's carbon sequestration, numerous botanical experts were consulted during the advancement phase of the project to determine the final planting schedule for the trees and shrubs. The greenery on the balconies provides oxygen and moisture while absorbing ambient noise. The vertical forest also allows the building to be warm in winter and cool in summer.

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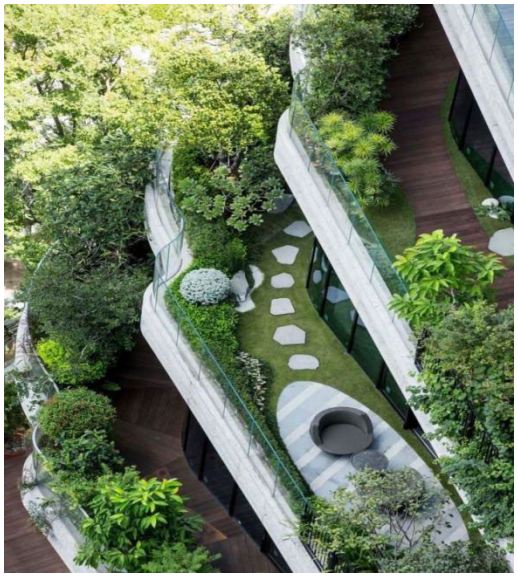

Figure 9: Greenery on the balcony

Tao Zhu Yin Yuan also makes use of various natural energy sources (e.g. natural ventilation and lighting in the basement, solar energy, wind power), new building materials (e.g. buoyant ventilation towers that effectively block heat radiation, Low-E laminated glass) and energy recycling facilities (e.g. rainwater recycling, electricity recycling, food waste recycling into compost), which are expected to reduce carbon emissions by 75% (see Fig9-10) , in addition to the estimated In addition to reducing carbon emissions by 75%, the building is estimated to absorb over 130 tonnes of CO2 per year(Tian, 2017) [11].

Figure 10: Environmental analysis

The building is also earthquake-proof, with seismic isolation devices that block damage, caused by vibrations caused by seismic forces.In addition, each house has a large terrace that is not shaded by the land plate and is planted with six or seven trees about 3 meters long, which allows for unlimited tree growth and absorbs 2.92 times more carbon per unit area than Taipei's famous one Daan Forest Park(Callebaut, 2021).

Despite the ideal greenery coverage and additional energy-saving features, the special structure and the all-round greenery make it much more difficult to maintain later; the roots of some plants can damage the building facade and too many plants can "compete" with people for air and sunlight; the local climate is hot and humid and dense plants can easily breed mosquitoes. ..... also tests the wisdom of the architects and the property management at a later stage. Structural design optimisation is a process of screwing up and accumulation, and when the quantity accumulates to a certain level, a qualitative change will occur, so the accumulation of experience in structural design and the breakthrough of new methods are quite important. The growth of plant roots can lead to the destruction of a wall, but as long as a substrate is

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provided on the surface of the wall to hold the plant roots in place and the plants are regularly supplied with water and nutrients, the plant roots will only be distributed on the outer surface of the building wall, thus leaving the interior of the wall unaffected.

3.5 High strength seismic and column-free structure

The main columns used in the steel structure of Tao Zhu Yin Yuan are of the same strength as those used in Japan's Skytree. The truss structure of the main body of the building resembles two arms of the human body, while the giant structural columns on either side are ski poles held in the hands. The special Vierendeel Truss design allows the weight of the building to be perfectly transferred to the foundation piles in the ground, achieving a functional and aesthetic unity.

The building's special 90° twisted shape also makes some reference to the traditional Tai Chi concept. The structure of the building, which rotates 4.5° on each floor, allows the interior occupants to enjoy a 270° panoramic view. The special structural design of Tao Zhu Yin Yuan allows for column-free open spaces within each residential unit. This allows residents to enjoy views of the vegetation on the outdoor terraces to their heart's content (see Fig 11-12).

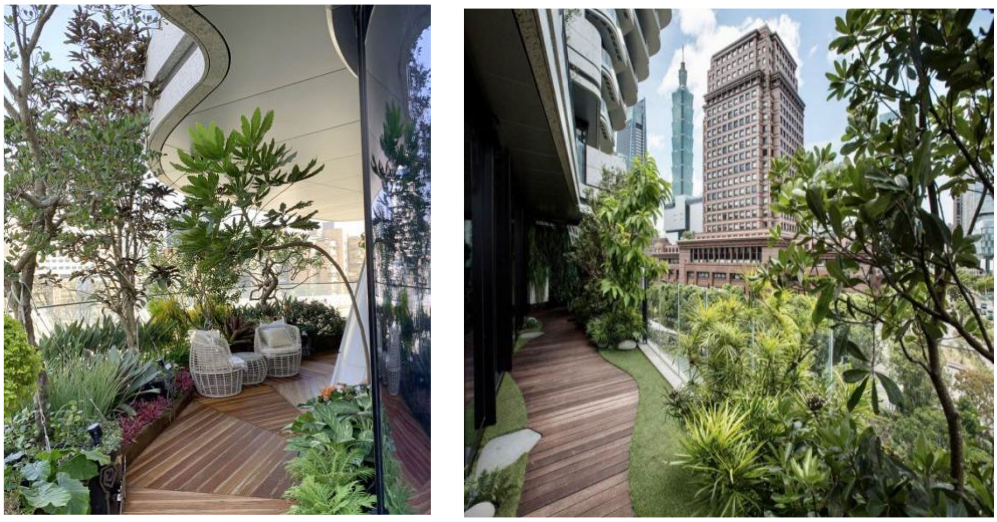

Figure 11-12: Iconic balcony

But how long will it take for the adverse effects of the mulch and the weight of the plants themselves, the weight absorbed by the mulch on rainy days, the materials required to carry this weight and the pollution caused by these materials during construction, to be offset by the beneficial effects the building can have on the environment, and how long will it take to contribute to the environment(Cai, 2015). But all this requires aspects such as the presentation of experience of advanced green, ecological buildings, and some of the actual engineering practice models, computer simulations, and testing and analysis of environmental effects mentioned earlier in the literature(Aristodemou et al., 2018).

3.6 Case Study Summary

Overall, even though the Tao Zhu Hidden Garden has issues with its clumsy appearance, the plant life blocking off the mild of citizens and the issue of construction, the tremendous results on city greenery outweigh the bad ones. As a vertical city wooded area with carbon absorption is surely the destiny course of city improvement, Tao Zhu Yin Yuan displays the care and difficulty for inexperienced flora and an honest preference to broaden a sustainable inexperienced city. It is hoping that destiny high-upward push designs will unfold the idea of inexperienced constructing layout, whilst constantly enhancing technological manner and rational layout strategies to sell the improvement of towns with inside the course of strength saving, inexperienced and environmental protection.

4. Conclusion

This paper discusses the positive and side effects of high rise design on urban greenery and whether high rise should continue to be built in the future.

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In the first part of the paper, the literature review discusses the factors that can affect the urban greenery in the design of tall buildings. One good design tool is the sky garden. In this section, the advantages of sky gardens are discussed and the implications of their being promoted in high-rise design. On the other side of the coin, one of the most important features for thousand-storey buildings is the high level of energy consumption and pollution, which, despite the high level of technological development, still leads to the heat island effect in some high-rise buildings. This section focuses on the side effects of the heat island effect on urban greenery and the factors. It calls for more energy-efficient and low-carbon materials to be used in modern tall building design in the future, which is of great relevance in promoting the rapid development of energy-efficient tall building design.

The second part of this paper is a case study of Tao Zhu Yin Yuan. At the beginning, the significance of this case study for urban greening is presented. The main issues discussed are the mixed reviews of the building's appearance, the fact that the ecosystem is idealised but faces construction difficulties, and the novelty of the structure but whether it is really friendly to urban greenery.

The aim of this paper is to discuss the role of tall buildings in urban greening in order to promote sustainable urban development. It is believed that in the future, with the continuous improvement of technology, more energy-saving and low-carbon materials will be applied to the design of modern high-rise buildings, which is of great practical significance in promoting the rapid development of energy-saving design for high-rise buildings.

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