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Analysis of the Vertical Forest of Milan in Terms of High-Rise Architecture and Biodiversity

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Abstract: With the acceleration of globalization and the development of human civilization, urbanization has led to people living in a space full of industrial materials that create modern icons, while at the same time causing high levels of energy consumption and pollution. Increasing environmental problems have prompted architects to consider the increasingly unbalanced relationship between humans and the natural world and to return to nature. The aim of this research is to discuss how the harmony between architecture and natural ecology has become a key issue in today's environment, trying to find a balance between nature and the city. In this essay, I will discuss the context and 'tree' element of the vertical forest in Milan, Italy, the vertical forest as a living ecosystem, the analysis of architectural structures, the interdisciplinary exploration of sustainability, the non-anthropocentrism embodied in the vertical forest, and the transition from the 'vertical forest' to the 'forest city'. "The transition from the 'vertical forest' to the 'forest city' and the debate on the concept of the 'forest city'. "From 'vertical forest' to 'forest city', a dialectical reflection on the intentions of vertical forest and 'forest', an analysis of the ecological design of vertical forest and the innovative integration of multiple the debate is about the innovative integration of vertical forests and 'forests', and the construction of a truly biodiverse, high-density city.

Keywords: Vertical Forest of Milan; High-Rise Architecture and Biodiversity; Harmony between Architecture and Natural Ecology.

1. Introduction

With the accelerating globalization and the development of human civilization, urbanisation has allowed people to live in a space full of industrial materials, which have created modern icons, as well as high levels of energy consumption and pollution. The growing environmental problems have prompted architects to consider the progressively unbalanced relationship between humanity and the natural world, where the return to nature and the harmonisation of architecture with natural ecology has become a key issue in today's environment. Brundtland suggested that the design of places should be designed by responding to environmental, social and economic imperatives (Robertson, 2018). So how do we get back to ecology? We must confront a number of issues such as ecological diversity. Many architects have tried to find a balance and relationship between nature and the city, for example, in the nineteenth century, Howard proposed the theory of the idyllic city in response to the environmental pollution caused by the rapid urbanization of the industrial revolution in England (Howard, 2008). Thinking about environmental issues has also contributed to the sustainability and ecology of modern urban design.

2. Vertical Forest Background and "Trees" Element

The current course of humanity' s development is briefly summarized as a move from forests to cities (Spence, 2009), with increased urbanization leading to a series of problems such as thermal radiation, atmospheric pollution and water pollution, increasing the energy consumption of human existence, and the modernization of large cities almost separating humans from ecological nature. "Since the Earth Summit, the concept of sustainable development has been widely discussed and flourished (Anna, 2020), and vertical forestry has again been developed on this basis. The design concept of the vertical forest is about the collision and fusion of long-standing Italian schools of thought. The Art & Crafts Movement (Dore, 1992), initiated by William Morris in the 1860s, to Art Nuoveu, which combines craftsmanship and art, through the standard model of 'Stile Liberty', radical futurism in a clash of old and new traditions, and the new. Radical Futurism in the clash of old and new traditions, followed by the modernism of 'order' and the Italian Rational Architecture Movement, Situationism and Radical Architecture, with the 'Super Studio' creating new situational spaces within the city, between the 1970s and the oil crisis and environmental enlightenment. In the 1970s to the oil crisis and the enlightenment of environmental awareness, there was a move towards a different kind of reflection on the relationship between man and nature. Since the 1970s, mainstream Italian architectural practice has continued in a neo-rational style. The fusion of rational logic and aesthetic sensitivity between the 'traditional' and the 'radical' has created a new generation of contemporary Italian style based on the traditional architecture of Milan (Ingersoll, 1990). Boeri, who grew up in the era of the 'radical' and 'neo-rational' debates, inherited this philosophy.

The Austrian artist Friedens Reich Hundertwasser proposed a new architectural concept, building buildings around trees (Stratonova, 2021). In combination with this, the relationship between trees and humanity is also contemplated, with ecology and the environment as human culture, and they also envisage a future city in which trees will permeate the buildings (Stratonova, 2021). Previously, it seemed somewhat unlikely that trees would be planted on buildings; in earlier architectural styles, trees had served as inspiration for Classical and Gothic architecture, where branches and stone made perfect partners, and in Greek temples, the earliest

marble columns were decorated with branches. But today, in modernist design elements, simple geometric forms and curves have replaced the previous use of nature as an inspiration. However, there are still architects who combine trees with architecture to create a range of architectural works. For example, the Vertical Forest in Milan, which Boeri says was inspired by a tree-planting event, contemplates the creation of a home for man and nature by standing up a flat forest (Basilico, 2000). The trees here are not just green, they are not just 'green', but each tree here has a sense of preservation of memory.

Figure 1. Aerial view of the Vertical Forest
(Source: https://mr. baidu. com/ r/12pDTtmD7 Wg? f= cp&u =c09e55a5fd02d654)

3. The Vertical Forest is a Living Ecosystem

Stefano Boeri believes that the vertical forest represents a different concept of sustainability (Boeri, 2012), bringing a new kind of biodiversity into urban architecture. The current demographic, economic, environmental and urbanization processes are changing the way we conceive of the future city, and the architects have made energy strategies and environmental sustainability issues one of their design goals (Lyubomirsky, 2005), building on the new technological revolution to expand the materials and structures of architectural design, where vegetation is part of the project's conception. Following this design approach, the vertical forest brings in vegetation on top of the two buildings, forming a new ecosystem 'medium'. The vegetation in the vertical forest is not just decorative, but is intended to create a rich micro-ecosystem that grows within the artificial environment of the high-rise buildings to enrich biodiversity, provide habitat and support natural resources, and create an artificial natural biosphere in the city. The two buildings act as a meeting point for urban 'greenery', surrounded by suburbs, fields and urban green belts. The vegetation that grows in the man-made high-rise buildings is artificially grafted into the green development process of the city. The vertical forest spreads the biodiversity into the city, thus creating an urban ecosystem that is more attractive, where the city's creatures spontaneously inhabit and provide a common ecological environment. For the vertical forest, the architecture itself is secondary to the flora and fauna, returning to its essence by preserving biodiversity. The Vertical Forest is a living ecosystem that records the city's archives, changing its landscape with the seasons, witnessing the slow and continuous growth of a rich ecosystem in the heart of the city. Abandoning the absolute dominance of man as a vehicle for human co-habitation with flora and fauna, the vertical forest encapsulates the characteristics of biodiverse architecture, while building a new ethical and cultural ideology of human presence in the natural world, with the natural environment as part of the original composition of the architecture.

Figure 2. Vegetation Detail of the Vertical Forest

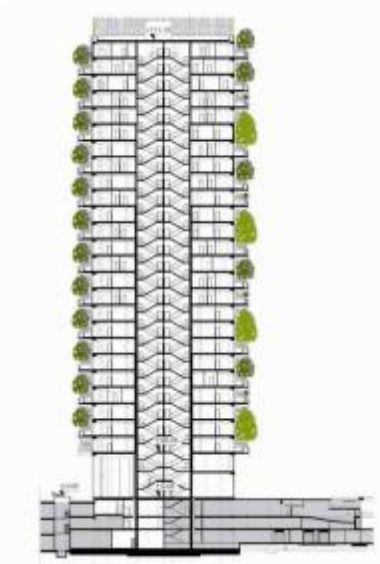

Figure 3. Section of the "Vertical Forest"
(source: Cowen, T. (2019) Bosco Verticale, Marginal Revolution. Fairfax: Newstex.)

4. Structural Analysis of Architecture in the Vertical Forest

The Vertical Forest considers the overall facade of the building and the partial inter-unit facade of each unit in an integrated manner in terms of functional composition, morphological requirements and technical specifications. A superimposed approach to the building's structure, which integrates the garden flats, has some similarities to the Villa Apartments designed by Le Corbusier in 1922, but differs in that the Villa Apartments were conceived experimentally and its focus was on the architectural form itself rather than the plants (Difford 2009). To a certain extent, the vertical forest can be used as a counter-urban sprawl, as the condominiums in the vertical forest are based on a number of different systems that maintain a continuous interaction with each other and are in a dynamic and changing environment, with the

addition of the ecological and natural environment that makes each system closely and intricately related to each other. The Vertical Forest is equipped with scientifically sustainable energy devices, including wind turbines on the roof, photovoltaic panels on the roof and facade, and solar panels for heat generation, creating a natural ecology in the high-rise building using renewable energy sources. The interplay between the mineral skin and vegetation in the building materials of the vertical forest offers further possibilities for architectural design forms and materials to create a powerful form impact, and the shade and protection created by the plants planted on each level can significantly reduce the energy consumption generated by the system. From an architectural analysis, the balcony is one of the more unique design elements of the vertical forest. The integrated planting of the balcony provides space for the micro-ecology, and the balcony acts as a meeting point between the space for human habitation and the micro-ecology, extending the space for human activity and interaction with the ecology. The staggered balcony design scheme allows each balcony to maintain a different form and linear disposition along the façade, creating a height space between the balconies, expressing the aesthetics of the façade form while reflecting the sense of boundary between each.

Figure 4. Vegetation Details

Figure 5. Vertical Forest Establishment
(Source: Cowen, T. (2019) Bosco Verticale, Marginal Revolution. Fairfax: Newstex.)

In terms of the vertical forest building itself, it is a presentation of the uncertainty of traditional architecture, using vegetation as a design language to express the internal structure and architectural aspirations of the building. It itself uses the language of obscurity to set off the growth and reproduction of flora and fauna. Balcony From an architectural point of view, the balcony is the most important element in the vertical forest. Integrated with planting pots, the balcony with its plants provides the ideal environment for micro-ecological generation. Balconies also create an extension of indoor living spaces, blurring the boundaries between them and providing areas for human, animal and plant contact.

5. Interdisciplinary and Sustainable Exploration in the Vertical Forest

During the construction of the vertical forest, scientific and safe project assurance was particularly important. The diverse forms of structure and system design are unified in the vertical forest, where this success is due to a stable and excellent interdisciplinary team. A group of accomplished the vertical forest is part of a complex of 25 buildings with LEED pre-certification (Giacomello, 2015), the most important international certification for energy and environmental design and implementation (Kubba, 2010). The drip irrigation system, for example, is a system of precise drip irrigation controlled remotely by computerized equipment according to the actual needs of each individual plant, its distribution, its actual light conditions and its growth height requirements. Other water is cycled and the water supply system can be flexibly switched on and off according to the data. In terms of structural testing, the structural design of the 'vertical forest' is essential to demonstrate the feasibility of the 'vertical forest' concept. The extreme geometric and scaling characteristics of the plants within the tolerable range need to be considered (Woodman, 2015).

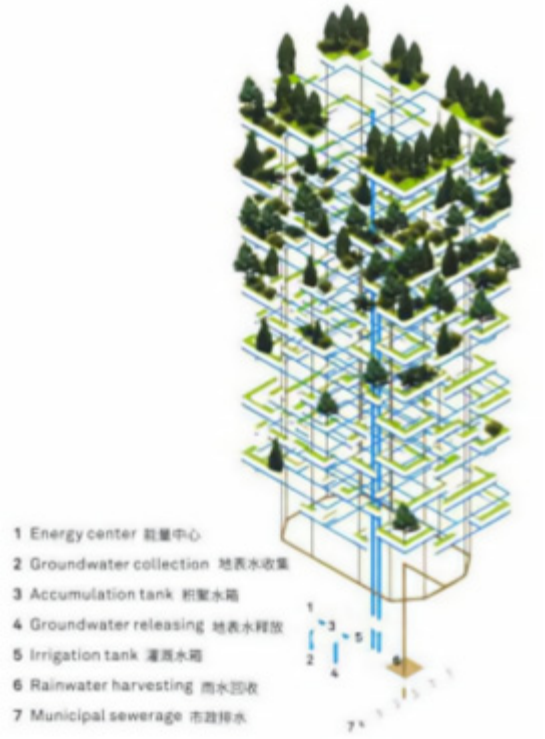

Figure 6. Intelligent Drip Irrigation System
(Source: https:// mr. baidu. com/r/ 12pEtrw ZIKQ? f=cp&u = 54faee22e8cce293)

Figure 7. Wind Tunnel Experiment
(Source:https://ishare.ifeng.com/c/s/7pMK66tkeaT)

How to protect the life of trees from being jeopardized by the personal choices of home owners. Energy sustainability criteria are only part of the basic principles of vertical forestry, followed by the need to consider biodiversity, including the soil for the vegetation. The formulation of the soil needs to take into account the weight of the planting pots and balcony sections and secondly to find a load minimization solution to ensure the safety of the vegetation planting and the load bearing of the building.

The soil is therefore a mixture of organic and inorganic substances, which is light and drains well, and has a high nutrient content to ensure the best growth solution for the vegetation. In addition to this, wind tunnels need to be considered, both for the impact on the vegetation and for the increased load-bearing of the building itself due to the forces that will be applied to it. There are also different microclimates between each different flat and differences in the action of the vegetation in different spaces, which filters dust, reduces noise and produces an abundance of oxygen and moisture. The Vertical Forest has developed a centralised "smart, safe and scientific" facility with an interdisciplinary team of professional elites.

6. "After- Morden" Thinking in Vertical Forests

In early societies, human life was closely linked to nature in a pre-modern way, with a stable relationship to nature and a dependence on the virtuous cycle of natural ecology, a traditional and stable way of life, such as the settlements of Anasezi (Anne Kerr, 2015). Within the socio-cultural 'Progress' process, the architectural approach and form of buildings has also been influenced, and there is still a continuous exchange and connection between architecture and nature, which is influenced by society's definition of nature and changes in architectural form and settlement patterns. Amongst other things this encompasses the process of urbanization and today's environmental and ecological issues. Relationships are complex and fluid (Macy, 2003). At a time when mankind wishes to claim nature as an inspiration and material for more possibilities of shaping architecture, urbanization has brought industrial materials to replace traditional grasses and grottoes, and society continues to evolve, with architecture's original function of protection changing to one of heritage, development and the forging of new worlds, with architecture inheriting the pre-modern, modifying the modern urban process, and anticipating the after-modern. Architecture is inseparable from ecology, taking it as an inspiration to progress and explore on the basis of its compatibility with the laws of nature. The bionic inspiration of architecture for the natural world is not only aesthetically meaningful, but also a spiritual aspiration.

7. Non-Anthropocentrism Embodied in the Vertical Forest

The Vertical Forest reconstructs a new relationship between humans and nature, establishing an ecological world view, while experimenting with the development of ecological and green architecture concepts, which have become known as Ecological Postmodernism. From the previous reliance on non-renewable resources to the rational use of renewable energy, the concept of architecture also takes into account the use of natural resources. Some scholars argue that the vertical forest has its origins in an environmental ethic, non-anthropocentrism. In the vertical forest, the previous perspective of starting and thinking in terms of human interests is changed to treat every living thing equally, no longer only considering the interests of humans (Gansmo Jakobsen, 2017), but to treat architecture as a piece of home shared by all humans and other plants and animals, and to build more vertical forest systems by superimposing and replicating them, so that plants and animals can preserve biodiversity in this case, humans share living space with plants and animals, thus limiting excessive human intrusion into nature. Here non-anthropocentrism is a change from the idea that humans are central, no longer as a separate factor to be considered, but in a larger relationship with each other. is the issue of the human-ecological relationship (Valera, 2019). In the field of architecture, deep ecology argues that society needs a shift in consciousness, which entails finding a balance between humans and nature so that humans are no longer overly dependent on modernity (Valera, 2019). An important manifestation of non-anthropocentrism is biodiversity, which balances the quantitative relationship and status between humans and plants and animals, while biodiversity emphasises the special significance of each species and the search for a balanced, symbiotic relationship between humans and ecology in the natural world. Increasingly, architects are developing non-anthropocentric architectural thinking, introducing the exploration of the relationship between humans and living things into new forms of architectural exploration, while it has been found that it is not enough to consider the vested interests of humans, but that humans need to extend their values to a larger sphere, which will stem from a new ethical perspective that will link from urbanization to non-human justice.

8. From " Vertical Forest " to " Forest City "

As the environmental problems of urbanization become increasingly serious, there are claims that high-rise buildings can achieve carbon neutral solutions in spatial transformation (Zuo, 2012). With urbanization causing every inch of land resources to become precious, more architects are considering designing buildings with sufficient density in an attempt to change the previous horizontal expansion at ground level and instead consider space in the sky for answers. The landing of

the vertical forest provides more confidence and guidance on the feasibility of the sky space concept. If one were to create a 'forest city' on a global scale, this would be difficult to implement on a large scale due to the irreversible process of urbanization in many areas, for example. The vertical forest is a replicable model that can provide the basis for a number of interrelated behaviors. It can also be used as a model for the transformation of different types of buildings in the public realm, commercial and residential, providing value and meaning to them. In different specific contexts, buildings will show different functions, cycles and meanings, bringing ecology and thinking about the relationship between humans and ecology into architectural design (Giacomello, 2015), which is a great start for the after-modern. Stefano Boeri and his partners then took the Vertical Forest project around the world, extending the Vertical Forest into the Forest City, a summation and an evolution. The "Forest City" will be a combination of systems of vertical forests, forming an integrated and complex ecosystem that will bring together sustainability, biodiversity, urban innovation and development, social and cultural values in a vibrant city, applying this beneficial balance to all areas of daily life, creating New values.

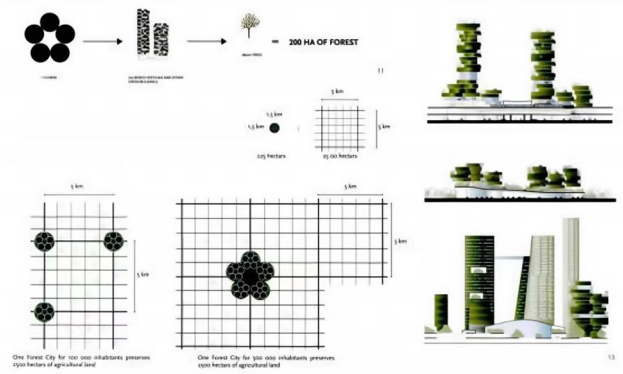

Figure 8. Vertical Forest Urban Planning
(Source: http://www.a-green.cn/ document/ 201812/ article 172500.htm)

9. Dialectical Thinking about Vertical Forests and the Intention of 'Forests'

From an architectural point of view, the vertical forest is to some extent a safety hazard, the most questionable of which is the trees. Unlike traditional building materials, trees have stable physical properties and will continue to grow after being planted in the soil, especially in the case of large trees in a vertical forest. The second is that the later maintenance of intelligent equipment such as intelligent drip irrigation systems is going to be a huge expense. The regular pruning and maintenance of the vegetation becomes an ongoing construction cost. The high cost and maintenance fees make the 'vertical forest' difficult to replicate on a large scale, and it is mostly used as a pilot project. Architecture has historically served power and wealth (Arnold, 2002), and the idea of a 'garden in the sky', as seen in the Babylonian sky gardens, has been perceived, and whether vertical forests have become somewhat of a service for the upper classes. In additional to this, are the words 'green' and 'sustainable' becoming the new vocabulary of the consumerist market, with its unique aesthetic shapes, rare resources and intriguing 'advertising slogans'? has become a new kind of consumerism (Akhtar, 2021).

10. Conclusion

The Vertical Forest is not only a construction, but also a manifesto. The architects of the Boeri Studio have come together to produce a "Vertical Forest Manifesto", which explains the significance of the vertical forest for the city, emphasizing the idea of new architecture, sustainable living and ecological diversity. In contrast to a series of Italian architectural movements such as Super studio in the last century, Vertical Forest has succeeded in bringing more experimental ideas to the ground and has gradually moved from the 'vertical forest' to the 'forest city', using new sustainable ideas, advanced interdisciplinary thinking and design, and Biodiversity is used as a way to improve the environment, changing the interconnectedness and balance between flat systems and organisms. Although more details of the vertical forest will need to be tested to prove its feasibility and safety, the vertical forest has become a reference for a new bio-facade for high city buildings, which will be a new expectation for after-modern and a bold exploration of the architects' creative ideas on the relationship between human and ecological models.

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