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A Case Study for Sustainable Vertical Urbanism
一个垂直可持续城市主义的案例分析

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Richard Mann is a practicing architect with over 30 years' experience and he is the founding director of ECOSYSTEM ARCHITECTURE. Richard has successfully designed environmentally responsive, sustainable medium rise and high-rise residential and commercial buildings in the Middle East, China, Malaysia and Australia.

Richard Mann是一名具有30年从业资历的建筑师，同时也是ECOSYSTEM ARCHITECTURE的创办人。他在中东、中国、马来西亚与澳大利亚等多地成功完成了包括环境响应、可持续的中高层住宅与商业楼等多个项目。

Andrew is a Principal of Arup and structural engineer with a passion for design, integration and innovation. His expertise includes tall buildings, long-term serviceability of structures, seismic analysis and design, and long-span lightweight roof structures.

Andrew是奥雅纳公司 (Arup) 的一名董事，同时也是一名对设计、一体化及创新设计有着强烈兴趣的结构工程师。他擅长高层建筑、建筑长期效应的研究、地震分析与设计以及大跨度轻质屋盖结构设计。

Elke Haege is a registered and award winning landscape architect and qualified consulting arborist who is dedicated to the development and sustainable connection to natural systems. Elke is an executive committee member of the Australian Institute of Landscape Architects (AILA), is part of AILA's National Education Advisory Panel and has lectured at the University of New South Wales.

Elke Haege 是一位获奖注册景观建筑师，也是一名职业树艺师，她致力于景观设计与自然生态系统的发展及可持续性的结合。Elke是澳大利亚景观建筑研究院 (AILA) 执行委员会成员，也是该机构全国教育指导委员会成员之一，同时在新南威尔士大学执教。

Abstract

This paper explores a range of design principles for achieving a socially sustainable residential community in a very tall environmentally responsive building. The goal of this study is the exploration of possibilities for both high-rise and very tall development providing levels of indoor-outdoor amenity usually associated with street level, horizontal housing and in particular focusing on social relationships. Further, the case study demonstrates a strategy for the ecological rehabilitation of degraded, low quality urban land or topographically difficult sites. The case study investigated the design of a building as a platform for supporting healthy ecosystems. The design also demonstrates a significant degree of façade and unit orientation flexibility while maintaining effective structural and spatial planning solutions. The architecture achieves responsiveness for a diverse range of climates without limiting amenity or functional adaptability. The complexity of the brief demanded close collaboration of the diverse disciplines within the design team.

Keywords: Ecosystem, Very Tall, Residential, Sustainable, Urbanism, Innovation

摘要

本文探讨了一系列在响应环境的高层建筑中如何实现可持续性住宅社区的标准设计原则。 本研究目的是为了探索在高层和超高层建筑中提供与通常水平向街道住宅相当的户内外生活便利设施的可能性，特别关注社会关系相关内容。 此外，本案例分析还展示了如何在退化场地或低质量城市地块或地形较差的场地上复原其生态系统的发展策略。 本案例探究了将建筑作为支撑健康生态系统平台的可能性及方法。 本设计展示了建筑立面和单元朝向灵活性的重要性，同时保持有效的结构和空间规划方案。建筑能够在不牺牲舒适性或功能适应性的前提下适用于不同的气候状况。 完成复杂的设计要求设计团队内各专业的紧密合作。

关键词: 生态系统, 高层, 住宅, 可持续发展, 城市主义, 创新

A Case Study for Vertical Sustainable Urbanism

Architectural Strategy

The case study demonstrates principles for achieving a socially sustainable residential community in a very tall building while providing levels of living amenity usually associated with street level, horizontal housing.

Further, the case study design provides a strategy to upgrade and ecologically rehabilitate degraded, low quality urban land or topographically difficult sites.

The research was guided by a key question of what could be the next stage for development of ecologically sustainable development (ESD) principles for very tall residential buildings.

A core theme of the design investigated the building as a platform for supporting healthy ecosystems and flexible architecture (see Figures 1, 2, 3).

一个垂直可持续城市主义的案例分析

建筑策略

本案例分析展示了一栋具备社会可持续性的住宅生态系统的高层建筑，其能够提供如常见的水平街区住宅般舒适的生活空间。

此外，本案例分析也为处于更新和生态复原、低质量的城市土地或者不佳地形提供了解决方案。

这项研究围绕今后高层建筑如何生态可持续发展 (ESD) 该如何进行这一关键问题指明了方向。

本研究的核心主题是建筑是否能够作为一个平台来支持健康的生态系统和灵活的建筑布置。（参见图1，2，3）

国际上，建筑师与工程师通常基于大量模型分析开展ESD工作。而ESD方法也广泛用于目前的城镇规划设计。

一个广为接受的认知是，全球、区域乃至地方的经济基础需要基于健康的生态系统。 (Dasgupta 2001)

Internationally, architects and engineers have adopted ESD methodologies based on various models. Precinct based ESD principles are now widely adopted for town planning.

It is increasingly acknowledged that the basis of global, regional and local economics is underpinned by healthy ecosystems. (Dasgupta, 2001)

The design of healthy ecosystems delivers important benefits, two of which are;

1. Advantage of microclimate design in modifying living environments for residents.
2. Re-connecting people with nature while living in a very tall building.

Architecture as Infrastructure
Architecture has the potential to generate diverse possibilities for infrastructure design.

The apartments of this case study were designed as units to be built within allotments in a very tall building typology. Deep soil gardens are integral to each apartment and this amenity differs from current conventional design in that this integration of amenity contributes to a genuine opportunity for indoor/outdoor life style (see Figures 6, 7, 9, 10).

Accelerated construction processes would become feasible with this separation of building segments through the greatly increased advantage of paralleling construction processes (see Figure 1).

Increased affordability could be achieved through viable, flexible costing models of construction and marketing.

In the long term, the building is designed as a platform for change, so that it is supportive of adaptive re-use.

The case study was designed to be built with current technologies and construction processes.

Decoupling the Apartments from the Structure
Significant opportunities become possible for providing residential units responsive to life cycle changes with the apartments designed as discrete, flexible entities within the structure.

The primary structure is designed for a long life of hundreds of years while the apartments are suited to respond to socially and culturally relevant cycles for intergenerational change.

This design enables apartments to respond to a growing family's needs and financial capacity, as well as changes in social demographics. Enduring social and community relationships benefit thus contributing to sustainable neighborhoods.

The strategy provides significant potential for modifying designs to suit climate and cultural diversity.

Minimizing the Tower Footprint
The building is elevated 32m above ground level in order to maximize ground level landscaping and recreational areas, creating opportunities for urban parkland, forests and orchards .

Climate
The main climatic zones considered in the case study were (see Figures 9, 10):

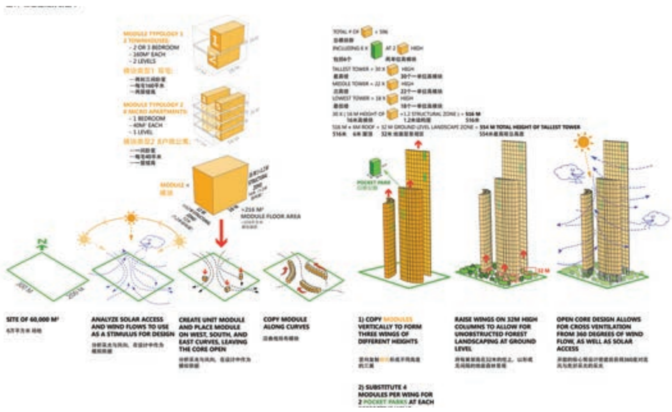

Figure 1. Form Making Diagram (Source: Ecosystem Architecture)
图1. 建筑形体形成示意图

Figure 2. Form Making Diagram (Source: Ecosystem Architecture)
图2. 建筑形体形成示意图

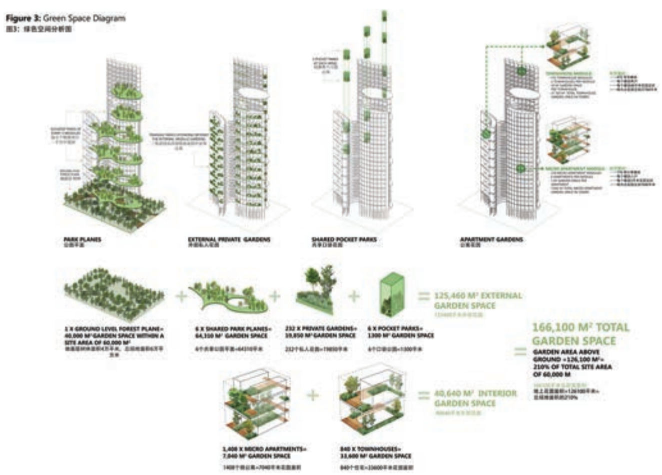

Figure 3. Green Space Diagram (Source: Elke Haege Landscape Architect & Ecosystem Architecture)
图3. 绿植景观空间(来源: Elke Haege Landscape Architect & Ecosystem Architecture)

- Temperate: Operable screens to provide wind shielding and or solar load management.
- Hot Arid: Solar shading screens; dust storm blocking screens.
- Tropical: Solar shading screens providing enhance breeze flow as well as wind shielding.
- Cold & Cool Temperate: Screens for solar heat gain retention (standard double glazed louvers) and wind and snow protection; hydronic heating of the unit module would act as a potential outdoor recreational area during the long winter months as well as assisting with heating the apartment.

Design Flexibility to Suit Different Building Heights, Fire Escapes and Lift Capacities

The open core design accommodates different lift and fire escape capacities depending on the project height and unit numbers (see Figure 8).

Single Apartment Depth & Open Core

Cross flow ventilation is provided for all apartments by opening the core to create an atrium. Air flow is facilitated through the tower from all directions (see Figures 6, 7).

The porous building involves and reflects the progress of daily and seasonal cycles. Weather protection is provided by overhead walkways, screens and enclosing porous diaphragm bracing walls (see Figure 11).

A sense of enclosure is added by solid balustrades and high level glazed screens shielding communal parks.

The Reconnection of Residents with Nature

Soil based gardens are incorporated throughout the design. The advantage of soil based gardens provides carbon capture interface with the atmosphere as well as creating sustainable ecosystems, microclimates and opportunities for indoor – outdoor living in a high-rise building (see Figures 9, 10, 11).

The 32m high pocket parks are also fitted with dedicated BMU's for tall tree landscaping maintenance and glazed weather screen cleaning (see Figure 1).

Apartment Adaptability Over Time and Design for Disassembly (DfD)

Inherent in the design is the ability of apartments to be changed, added onto or upgraded over their life. Building Maintenance Units (BMU) suitable for constructing and ongoing maintenance of the apartments are integral components of the tower, with each wing having its own dedicated BMU.

The vertical lift capability and allotment design generates the feasibility for residents to build their apartment incrementally to suit their needs and level of affordability. The flexibility of the design supports the differing financial and social needs of the residents.

As residents age in place they may wish to downsize their home. The design allows for apartment disassembly of excess space and residents are able to remain at their original address with their social links intact.

Should residents develop mobility impairment through illness, accidents or aging, the design facilitates installation of prefabricated residential lifts to provide full accessibility throughout a two level apartment. The case study also provides for single level living design options.

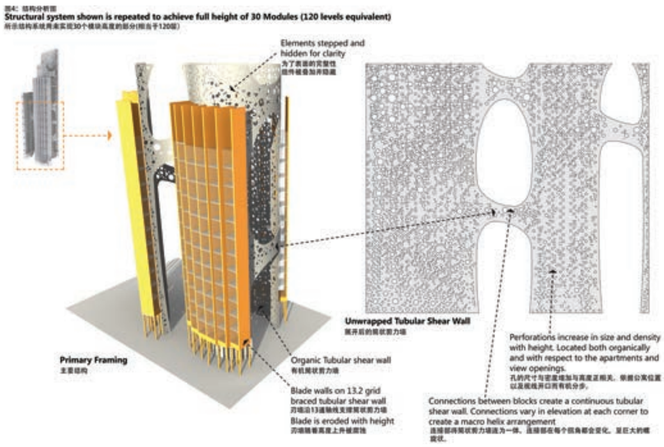

Figure 4. Structural Diagram (Source: ARUP)
图4. 结构示意图 (来源: ARUP)

Figure 5. Urban Context View – Docklands, Melbourne Australia (Source: Ecosystem Architecture)
图5. 城市背景效果图- Docklands, 墨尔本，澳大利亚 (来源: Ecosystem Architecture)

健康的生态系统能带来非常多的好处，以下是其中两项:

1. 利用微气候来调整居民的生活环境。
2. 通过高层建筑促进人与自然的和谐融入

建筑作为基础设施

建筑为基础设施提供多种有创造力的设计方案。

本案例中的公寓间作为建筑单元分布在一栋高层建筑内。与常规设计不同，其中每间公寓都带有具有覆土的花园，这种整体性的设计能让住户体验到舒适的户内外生活 (参见图6，7，9，10) 。

建筑构件模块化以及并行施工的施工工艺能够加快施工速度。(参见图1)

而通过多样且灵活的建筑费用模型和营销策略可以提高其购买力。

长远来看，建筑将被设计为一种能为各种不同的实用功能提供支持的平台。

本案例是基于现有的技术及施工流程来进行设计的。

Aging in place with on-site flexibility of accommodation encourages strengthening of social relationships and neighborhood cohesiveness.

Stability of social relationships and neighborhoods would therefore be strengthened.

Numerous prefabricated construction systems are now available in the market for providing high quality, high levels of sustainability and amenity. A number of these systems are incorporated in the design.

Fire Safety
The recently published CTBUH study, "Roadmap on the Future Research Needs of Tall Buildings" highlighted the acknowledged prominence of safety as an issue in tall building design.

The Case Study has adopted a number of robust strategies to provide a high level of occupant safety as follows:

1. Fire compartment design with apartments forming separate fire compartments within each module with each 16M x 12M x 18M module performing as a separate fire compartment.
2. High density of fire escapes providing rapid alternative egress for residents. Fire escape travel is highly visible and easily navigable.
3. Multiple hose reels per wing at each level.
4. Gravity fed water storage tanks (in services zones).
5. Sprinkler system.
6. Designated fire resistant level construction for apartments and claddings.
7. Rapid smoke exhaust.

Services
Location of services within the atrium junction of the modular party walls ensures that duct risers are fully accessible without the privacy of apartments or allotments being intruded upon for maintenance or upgrades. The services risers and branches remain clear of structural zones (see Figures 6, 7).

Finance Models
Separation of superstructure and apartment construction systems provides the possibility for different financial methods being useful for:

1. The superstructure funding using very long term private investment, government and local authority sources of finance.
2. The apartments may be financed by conventional market home loan products or consumer credit.

Affordability can be facilitated by the combination of different financial instruments.

The design presents opportunities for different financial instruments being used for home finance.

Passive Design Principles
Passive design principles have been adopted to optimize the provision of thermal comfort for residents without the need for air-conditioning. The design achieves solar access and protection, natural light and ventilation, large thermal mass values, microclimate design as well as a high level of insulation. Building envelopes are layered within the enclosing structure providing active climate modification design opportunities to suit various latitudes and orientations.

与主体结构分离的公寓单元
公寓单元与主体结构的分离，使得它可以根据生命周期内居民的需求来改变成为可能。

主体结构按照数百年的设计使用年限来设计，而其中的公寓则将基于社会、文化相关的周期来考虑。

这种设计使公寓能够应对不断增长的家庭需求、经济能力以及社会人口结构的变化。持久的社会与社区关系同样能够促进邻里关系的可持续性发展。

本设计方案可以根据不同的气候状况及文化习俗做相应调整与之适应。

最小化塔楼占地
建筑首层高于地面32米，因此可以充分利用首层空间作为景观及休闲区域。此区域也可以设置为城市公园、森林或果园。

气候
主要考虑了如下几个主要气候带: (见图9 、图10)

- 温带: 可操控的挡风遮挡及太阳能管理系统
- 炎热干旱地区: 遮阳板; 防尘板
- 热带: 遮阳板以提高空气对流，挡风板

Figure 6. 3 Bedroom Apartment Plans & Section (Source: Ecosystem Architecture)
图6. 3卧室公寓平面及剖面 (来源: Ecosystem Architecture)

Figure 7. 1 Bedroom Micro Apartment Plans & Section (Source: Ecosystem Architecture)
图7. 1卧室公寓平面及剖面 (来源: Ecosystem Architecture)

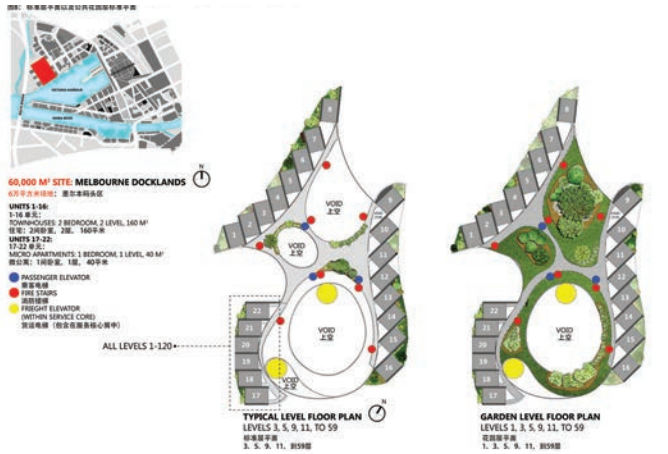

Figure 8. Typical Tower Floor Plan & Typical Tower Communal Garden Level Floor Plan (Source: Ecosystem Architecture)
图8. 典型塔楼平面图及典型公共花园层平面图 (来源: Ecosystem Architecture)

Figure 9. Internal View of 3 Bedroom 2 Level Apartment Module (Source: Ecosystem Architecture and Elke Haege Landscape Architect)
图9. 3卧室公寓单元二楼内景 (来源: Ecosystem Architecture and Elke Haege Landscape Architect)

All apartments enjoy complete cross flow ventilation conditions that can be modified in their intensity with integrated perimeter screens in response to height, orientation and climate.

Embodied Energy:
The design of the structure provides for a long life cycle which, coupled with the apartment prefabricated construction systems, contribute to a significant lowering of the embodied energy of the building.

For example, apartments constructed from Cross Laminated Timber (CLT) and other appropriate systems would contribute to a significant reservoir of carbon storage. The gardens similarly contribute significantly to the carbon storage cycle.

Water:
Water supply, treatment, storage and recycling have been embedded in the design parameters. Capacities for fresh water, fire services and irrigation for the landscaped microclimates have been incorporated in the design.

Transport & Urban Regeneration
The design achieves a high residential density while providing a recreational amenity usually associated with street level housing. This design approach could be utilized for brownfield and degraded sites and other appropriate urban locations. Public transport efficiencies could be increased with the higher urban densities generated.

A density of approximately 1000 people per hectare has been achieved on a selected site of six hectares, or 60,000m^2. This compares with established inner city suburbs in say Sydney that extend for approximately 50 hectares providing an equivalent population and level of amenity as the case study.

Social Sustainability
The design adopts the principle of creating opportunities for meaningful social interactions as one proceeds through the building. The porous structural diaphragm sheer wall provides a transition between the private and public domains for each apartment.

Six communal recreational parks are interspersed through the tower as well as pocket parks for more contemplative and quiet recreation.

- 寒带与冷温带: 太阳能 (标准双层玻璃百叶) 及风雪遮挡; 可在长达数月的冬季为户外休闲区域提供供暖的热水系统，该系统同时也可作为公寓的辅助供暖。

不同建筑高度、消防逃生及电梯容量需求情况下的设计灵活性
开放式的核心筒设计能够适应不同建筑高度及住宅单元数量的情况下所需要电梯和消防逃生的需求。 (参见图8)

公寓单元及开放式核心筒
开放式核心筒设计形成了中庭空间，而来自各个方向的穿堂风穿过这里并使所有公寓都能保持良好的空气对流。 (参见图6，7)

这种通透的建筑形式能够适应日常及季节性的周期变化。而人行天桥、各种遮挡及内部通透的结构墙体系则可应对不同的天气状况。 (参见图11)

公园区域将会安装结实的扶手并在高位安装玻璃遮挡。

人与自然的再融合
本方案中设计的花园都带有覆土，这样的设计为大气中的碳提供了固碳界面，同时也创造了可持续性的生态系统、微气候并使在高层建筑中进行室内外生活成为可能。 (参见图9，10，11)

层高为32米高的小公园也同样可以使用原为维护大树景观及清洁玻璃遮挡所使用的建筑维护系统 (BMU) 。 (参见图1)

公寓适时设计及其可拆卸式设计 (DfD)
本设计的核心是公寓能够随着时间的推移而进行相应的改变、增加或更新。建筑维护单元 (BMU) 作为塔楼整体的部件，适用于寓单元施工及不断的维护工作，同时每栋配楼都设有其专用的建筑维护系统。

足够的垂直功能和可灵活分配的设计方法使居民可以根据其自身需求及消费水平逐步完善他们的公寓。设计的灵活性可以根据居民不同的经济和社会状况来进行调整。

随着居民年龄的增长，他们可能希望减小房间的面积。本设计允许公寓拆除多余的空间但却能保留原有的地址与完整的社交联系。

如果居民因疾病、事故或年龄原因造成行动不便，可以安装预制的电梯以方便进出一栋两层的公寓单元。本案例中同时也提供了单层居住空间的方案。

Figure 10. External View of 1 Bedroom Apartments (Source: Ecosystem Architecture and Elke Haege Landscape Architect)
图10. 1卧室公寓外观 (来源: Ecosystem Architecture and Elke Haege Landscape Architect)

Structural Strategy

The structural system systematically combines the planning and functional characteristics of the spaces with structural efficiency, modularity, and flexibility – whether 100m or 1000m tall.

To suit a variety of geographic, social, financial, risk and safety variables, the structure is able to be constructed from a variety of materials.

The structural solution comprises:

Primary Frame with Design Life >100 and up to 500+ years.
The primary framing, (see Figure 4) is intended to be fixed for the life of the building.

- Plan form structural grid 13.2m x 18m;
- Fixed diaphragms at 16m vertical spacing;
- Shear walls as necessary located on the 13.2m grid of each block, exchanging with columns/frames as required for function. Where shear walls are unnecessary or can be eroded with height, these revert to a column and beam system with non-structural infill walls pending construction efficiency;
- Continuous, perforated tube shear walls are located at the inside face of the apartments in each tower wing. Perforation is graded increasing bottom to top aligning with structural performance. Large openings can be provided at the ground plane;
- The shear wall tube links across the garden levels between selected blocks. These connections are achieved within 32m (double module) heights. The connections vary in elevation on each of the three corners, forming a macro-helix arrangement and a continuous vertically braced tube;
- A concrete design is the base scheme materiality. Reinforced, pre-stressed/post-tensioned, insitu, precast, or other permanent formwork systems could be all feasible for the design. Benefits of concrete include thermal mass, acoustics, fire resistance, robustness, geometric flexibility, materials handling capability, reduced trade complexity (geographic flexibility), high recycled industrial waste content, and inherent durability;
- Clad steel or steel/concrete composite frame alternatives are feasible, particularly in regions of poor foundation and/or

为就地老龄居民提供的弹性居住方案增强了社会关系及邻里凝聚力。

稳定的社会关系和邻里关系因此得到了增强。

目前市场市场上已有大量高质量、高可持续性、高舒适性的预制构件供应。本设计中将大量采用此类产品。

消防安全
最近在CTBUH发表的研究"未来高层建筑需求研究路径图"强调了高层建筑设计中安全的重要性。

本案例分析采取了如下一系列稳健的策略以确保高等级的居民防火安全:

1. 公寓防火分区由数个独立的防火分区组成，其中每个独立防火分区为16米x12米x18米
2. 高密度的消防楼梯作为居民快速逃生的替代通道。消防疏散路径明显，逃生路径指示清晰。
3. 每层楼的每侧设置消防水喉。
4. 重力式水箱 (服务区内) 。
5. 喷淋系统。
6. 为公寓及外饰面指定防火等级。
7. 设置快速排烟系统。

机电空间
位于中庭与公寓单元隔墙连接处的机电空间需要确保机电管线能有足够的操作空间来维护和更新而不需要进入公寓或已分配地块的私人空间。机电管线及其支管需要避开结构区域。 (参见图6，7)

财务模型
分别建立上部主体结构与公寓的施工系统用于下列不同的财务用途:

1. 上部主结构用于长期的私人投资以及政府与地方政府的资金来源。
2. 公寓用于一般性的住房贷款产品或消费信用贷款。

不同金融工具的组合可以改善其负担能力。

这样的设计也为家庭财务提供了不同的金融工具可使用。

被动式设计原则
采用被动式设计原则可以无需空调时优化居民的热舒适度。其中，利用了太阳能及遮阳，自然光与通风，大蓄热热容量值材料，微气候设计以及高效能的保温隔热。建筑的围护结构置于结构层内部及内部结构的组成使得建筑能够积极应对气候变化，适应不同地区的经纬度的气候。

在不同的气候状况下，所有公寓都能够通过调节外围遮挡的高度、方向来享受舒适的空气对流。

隐含能耗
结构设计考虑了很长的设计使用年限，再加上公寓的预制结构系统，这意味着建筑的隐含能耗将大为减少。

比如，公寓可以采用交叉复合木材 (CLT) 以及其他适合的能显著提高碳储存量的体系建造。同样地，花园也可以为碳储存周期做出重大贡献。

水
设计过程中已经考虑了水的供应、处理、储存已及再利用过程。

Figure 11. Typical Atrium View from one level above Communal Garden Level (Source: Ecosystem Architecture and Elke Haege Landscape Architect)
图11. 从公共花园一楼楼上俯视中庭图 (来源: Ecosystem Architecture and Elke Haege Landscape Architect)

high seismicity where mass reduction is critical. High recycled material content is preferable;

- Clad timber or hybrid concrete/timber or steel/timber alternatives such as CLT bearing walls are also feasible at lower building heights. Durability is of greater consideration.

Secondary Framing with Design Life > 50 to 100+ years.
Secondary framing does not contribute to overall lateral stability or gravity support framing.

- Mid-height floors between fixed diaphragms;
- Bottom "false" floor in each module for services reticulation and planting;
- Egress, plant, and public floor areas between fixed diaphragms;
- Service pods/risers, lift shafts, and egress stairs;

Tertiary Systems with Design Life of 30 to 50+ years.
Tertiary framing is associated with the residential dwellings and support spaces wholly within primary structural and fire compartments. These structures can be modified or changed at will with no adverse impact on the building stability or gravity load carrying capacity.

Preferable systems are light-weight, fire resistant, dry trade sub-assembly and prefabricated systems to suit future modification or disassembly such as:

- Cross-Laminated-Timber (CLT) construction for materials handling, trade skills, carbon capture, and renewables; &
- Structural insulated compressed strand board panels coupled with CFC, terracotta, phenolic resin and other claddings.

Wind Effects
The building plan form and vertical perforation reduces susceptibility to dynamic structural response due to vortex shedding.

Landscape Strategy

The landscape functions in many roles within, upon and underneath the ground. There are 3 main and multifunctional landscape elements.

而包括净水、消防系统用水以及景观用水等的水容量大小也都已经过仔细考虑。

交通与城市更新
本设计的居住密度很高，但同时又提供了与街面住宅相类似的舒适环境。这样的设计能够利用闲置区域、退化的场地以及其他合适的城市区域。有效率的公共交通系统能够进一步提高该地区的居住密度。

在目前选定的6公顷或60,000平方米场地上，我们设计的居住密度约为每公顷1000人。相较现存的城市中心近郊，比如说悉尼，大约需要50公顷的场地才能达到如本案例分析同样规模的人口和设施水平。

社会可持续性
设计采取的原则希望能够通过建筑来创造更多有意义的社交互动机会。而多孔结构墙正好为每间公寓在私人与公共空间之间提供了一个过渡。

六个公共休闲公园分布在塔楼周边，除此之外还有许多的小公园也能作为休憩娱乐的空间使用。

结构策略

不管是100米还是1000米的高楼，结构体系都需要系统地考虑空间规划和功能特点，以实现空间结构的经济性、模块化和灵活性。

为适应不同的地理、社会、财务、安全及风险等多种变量因素的影响，需要采用不同的材料构建空间结构。

结构方案包括:

主体结构框架，设计使用寿命应为100至500年。
主体结构框架 (参见图4) 与建筑的设计使用寿命相同。

- 计划结构网格为13.2米X18米
- 竖向每16米设置一层连接楼板
- 每个单元在13.2米轴线的位置需要设置剪力墙，必要时可根据功能的需要替换为立柱或框架。对于不需要设置剪力墙或影响高度的地方，可使用梁柱体系并采用非结构填充墙以提高施工效率。
- 公寓单元塔翼内侧设置连续的多孔剪力墙。开孔等级自下而上根据结构需要逐渐增大。大尺寸的洞孔可设置在

Environmental

Typical modelled calculations demonstrate that the landscape component in surface area alone equals 2.75 times of a landscape with the same site area (6Ha). These calculations are based on a vegetated site, however it is likely the site would be a brownfield site to start with.

- The increased surface area provides approximately 3 times the active carbon storage in the soil than on a 'Greenfield' 6Ha site.
- Carbon will also be stored in the trees on all levels. Calculating just the ground level (3399 proposed native hardwood trees at approximately 20 years old); 92 Tons of carbon will be stored which is 336T of Co2 equivalent[1].
- Carbon storage in soil and trees is dynamic with carbon being taken out of the atmosphere and converted into the soil or vegetation. Some carbon and CO2 will be released through transpiration, photosynthesis and breakdown. The calculations are a net balance for ground level planting only, modelled for a temperate - subtropical zone.
- The above ground landscapes will provide almost the same amount of carbon as in the ground level.
- The landscape will assist to control climatic influences via deflecting wind, framing views, providing shade, sun or cooling.
- The landscape is flexible and dependent on the climate and context of the building. Example scenarios have been devised for desert, tropical and sub-temperate zones e.g.) Middle East, South-East Asia and Northern Europe.
- Water will be captured and reused, waste will be composted and reused and sharing of resources has been developed.

Cultural

The ground floor landscape is intended as a working urban forest that references a new version of the 'Old English Common': a communal functional forest and meeting area. The new version 'common' will be functional, communal and provide a 'green lung'.

[1] North Sydney Council, (no date), accessed 7th April 2014, http://www.northsydney.nsw.gov.au/carbon/carbon.html.
Carbon is assumed to be 50% of total biomass: Gifford, Roger M. (2000) Carbon Contents of Above-Ground Tissues of Forest and Woodland Trees: National Carbon Accounting System - Technical Report No. 22., Department of Climate Change, Canberra.

接地层。

- 剪力墙管孔在选定单元的花园层相互连接，其间距不超过32米 (为单元尺寸的2倍) 。这些连接在建筑的三个角部位置各不相同，呈现出巨大的螺旋型排布，并最终形成一道连续的竖向支撑筒体。
- 混凝土是基础方案材料。可广泛应用于普通钢筋、预应力、现浇、预制及其他的永久模板体系方案。混凝土的优点包括保温、声学性能、防火、坚固、易塑、材料处理容易、减少贸易复杂性 (因为可塑型) 、可回收的工业废料含量高以及耐久性好。
- 钢结构或钢/混凝土组合框架结构也具有可行性，特别是在地基条件不佳或地震活动频繁等对自重非常敏感的区域。在上述地区最好使用回收率高的材料;
- 建筑高度较低时，也可采用木结构或混凝土/木组合结构或钢/木组合结构如CLT承重墙方案。但是需要仔细考虑其耐久性。

次结构框架的设计使用寿命为50至100年。

次框架不影响整体结构的侧向稳定性或重力支撑框架;

- 固定隔层间的楼板;
- 每个单元底部用于方便机电管线布置的"假"楼板;
- 固定隔层之间的出口、机房及公共区域的楼板;
- 机电管井、电梯井以及楼梯井;

第三级结构框架的设计使用寿命为30至50年。

三级结构框架是与住宅区关联，对主框架结构及其相应防火分区内的空间起到支撑作用。随意调整或改变这些结构框架对建筑的稳定性及承重力没有任何影响。

这些结构框架最好采用轻质、防火的装配式预制构件，这有利于将来的调整或拆卸，如:

- 交叉复合木材 (CLT) ，其特点是材料加工容易，技术成熟，环保且可再生。
- 由CFC、陶土、酚类、树脂及其他材料压缩复合成都建筑用绝缘板材。

风作用

结构平面与竖向的开孔有效减小了涡流所导致的结构动态响应。

Figure 12. Typical View of Pocket Park (Source: Ecosystem Architecture and Elke Haege Landscape Architect)
图12. 典型小花园图 (来源: Ecosystem Architecture and Elke Haege Landscape Architect)

Ground-plane landscape forms part of the surrounding neighborhood by diffusing boundaries to become integrated and inviting. The landscape continues under each tower embracing the arrival experience.

Social

Above the ground floor, elevated private and communal gardens function in providing health benefits including:

- Passive and active outdoor recreation (local pocket parks, sport zones, parks)
- Places to meet, gather and interact and relax
- Improving air quality (reducing airborne particulate pollutants)
- Views (private and communal) of landscape (proven to make people calmer, healthier and productive.
- Connection to nature (biophilia)

Similar to 'The City Beautiful Movement' emphasis on health, efficiency and wellbeing is a function of the landscape design. Applying simple principles from 'The City Beautiful Movement' to high-rise sky allotments, much improved living environments set this building apart from apartment living.

Providing flexibility in style, configuration and material use gives each module uniqueness (not accomplishable in regular apartment developments). This individuality makes the sky allotments more closely aligned to row houses/terraces than regular apartments, adding to the living standard. This flexibility allows for changing household dynamics further contributing to wellbeing and stability.

Conclusion

As a conclusion to this paper a summary of the set of design principles generated by this case study could contribute to achieving more socially, economically and environmentally sustainable very tall buildings.

1. Open core planning to facilitate breeze flow, natural ventilation, solar access, flexibility of services and vertical transportation.
2. Open core planning to generate conservative slenderness ratio values to reduce wind force structural loadings and therefore contribute to robust, simplified structural forms and parallel construction processes.
3. Open core planning and glass lifts for social engagement and observation of social activities happening in the various communal and pocket parks. Vertical journeys as socially valuable experiences.
4. Decoupling of building forms to reflect life cycles and purpose e.g.: apartment building envelope separated from tower structure.
5. Flexibility for change in individual apartments while avoiding disturbance to neighboring units or common areas.
6. Ease of accessibility for service risers and horizontal routing.
7. Strict adherence to privacy coupled with multiple opportunities for social engagement.
8. Planning of the journeys for arrival and departure from home as opportunities for social engagement.

景观方案

景观功能对地面层或其上下都起到了多重作用，以下是其中主要3项。

环境

典型的模拟计算表明,其景观面积可达到总占地面积 (6公顷)的 2.75倍。由于计算是基于绿地，场地原本很可能是闲置的废弃场地，这就更凸显了其价值。

- 增大的土地面积使其碳储存量相比原6公顷的未开发场地增大了约三倍。
- 所有楼层的树木都可以起到固碳的作用。计算表明首层计划栽种的3339颗20年树龄的本地乔木可以吸收92吨碳，相当于336吨的二氧化碳[1]。
- 土壤与树木的碳存量与大气中的碳存在一种动态平衡，部分碳会被植物与土壤吸收而通过蒸腾、光和作用及分解作用，又会释放一部分碳与二氧化碳到大气中。对于温和-亚热带气候区的首层植物，碳固计算是一种净平衡。
- 首层以上的景观能够提供与首层相当的固碳量。
- 景观也将通过调整风速、框定视野、提供遮蔽或日光等方式来控制气候对建筑的影响。
- 根据气候与建筑环境的不同，可以灵活地采用不同类型的景观布置。本案例已经按照例如中东、东南亚、北欧所在不同地区的气候即沙漠、热带、温带进行了设计。
- 水将被收集利用，废料将被集中处理，而能源将通过循环与共享系统被充分利用。

文化

我们意图将首层景观打造为一片都市森林，犹如一个新版的"旧式英国人聚集区":即一片承载了公共职能的森林和聚会区。新版的"聚集区"不仅仅具有功能性，公共性，更提供一个"绿肺"。

首层景观通过其边界的蔓延和富有吸引力形成邻里环境的一部分，将周边的各个塔楼有机地联系在一起。

社会

设置在首层以上的私人与公共花园可以带来如下益处:

- 主动与被动的户外休闲活动 (小公园、运动区、公园)
- 作为聚会区提供会面，集会，交往和放松等各类休闲娱乐活动
- 改善空气质量 (减少空气中的悬浮颗粒物)
- 私人与公共区域的景观能够使人平静、健康并充满创造力
- 亲近自然 (热爱生命的天性)

与"城市美化运动t"相似，强调健康、效率和舒适才是景观设计的要点。只要将这些源自"城市美化运动"的简单原则应用到高层住宅单元中，我们公寓生活之外的生活环境就能大大改善。

每间公寓灵活的风格,配置和材料的灵活性使每个单元有独特性（在常规公寓中不能实现）。这种独特性使高层住宅单元更接近单排的独栋住宅而非常规的公寓。这样的灵活性有利于构建更加和谐稳定的家庭生活。

结论

就此对本文进行总结，本案例所采用的设计原则有助于建造更具社会、经济、环境方面可持续性的高层建筑。

9. Fire safety design through integrated fire engineering, fire compartmentalization and space planning.
10. Structural and architectural design focusing on each building element contributing multiple roles to the building function. For example the high degree of modularity of the design and the continuous, porous diaphragm internal skin.
11. Rationalized construction processes to achieve a high degree of parallel construction processes.
12. Scaling elements that contribute to apartment streetscape identification and urban context (see Figure 5).
13. Simplicity of layout for ease of navigability.
14. Passive design principles to achieve high levels of thermal comfort coupled with very long life cycles.
15. Robust detailing for operable wind and solar load management screens.
16. Simple building forms to suit maintenance accessibility for Building Maintenance Units.
17. Diversified and comprehensively sited landscaping integral to private and communal spaces.
18. Indoor/outdoor living potential for all private as well as socially interactive spaces.
19. Equivalent levels of high quality amenity for all apartment types regardless of size.
20. Articulated building structure/infrastructure as separate systems from apartment building fabric to facilitate opportunities for multiple public or private financial models being applicable for achieving affordable housing.
21. Optimize the site and the building above it to generate an extension of the land capacity in order to support healthy ecosystems for the benefit of the urban environmental and quality of life for the residents.

1. 开放式的核心筒布置有利于气流、自然通风、获取太阳能、设备空间布置的灵活性以及垂直交通。
2. 开放式的核心筒高宽比较小因此所受风荷载相应减小。结构可以采用更为稳健简单，并易于采用并行施工工艺。
3. 开放式的核心筒布置与玻璃电梯的设置利于各种社交活动的展开。竖向活动是也将带来一种别具一格的社会活动体验。
4. 建筑形式的分解，比如将公寓结构从塔楼主体结构上分离，反映了不同的使用年限与目的的需求。
5. 个人公寓单元的空间可以在不影响隔壁单元或公共区域的情况下进行灵活的调整。
6. 机电管线易于维护。
7. 良好的隐私性与易于社交环境的结合。
8. 每次离家与回家都是一次社交的机会。
9. 通过完整的消防工程设计、防火分区及空间的规划来确保消防安全
10. 结构与建筑专注于每个建筑构件的设计，并确使能使其承担多项功能。例如高度模块化的设计与连续多孔隔膜内墙。
11. 合理采用并行施工方式。
12. 具有个性鲜明的公寓景像与城市特点 (参见图5)
13. 简化布置便于指引。
14. 被动式设计原则可以满足生命周期里高水平的热舒适度要求。
15. 可操控的风与太阳能遮挡板需要可靠的细部设计。
16. 简化建筑形式便于采用建筑维护系统来进行维护。
17. 广阔但又形式多样的景观将私人与公共空间完美地融合在一起。
18. 私人与社交区域都适宜进行户内外活动。
19. 所有类型公寓无论大小都具有同等高品质的舒适程度。
20. 主体结构与公寓结构分别采用独立的系统，以便于可采用不同的公共或个人金融产品采用购买，并以此改善购房者的购房承受能力。
21. 充分利用场地及其上的建筑空间来拓展用地承载能力，以此提供健康的生态系统并提高城市环境及居民生活品质。

References (参考书目):

Dasgupta, Professor Partha. (2001). **Human Well Being and the Natural Environment**, University of Cambridge.