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Two-In-One Tower: An Expansion in Typology and Technology in Hanoi

二合一塔楼：在河内项目上类型与技术的扩展

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He is also Callison's Director of Sustainable Design and supports teams across the entire firm. He is responsible for the ideation, development, and implementation of Callison's free design tool, Matrix by Callison.

马希亚斯·奥特是一位拥有二十年经验的高级专业设计人才，擅长于大容量全球环境设计。作为设计总监，他最近刚刚完成了以下几个项目：河内乐天中心，267米，河内，越南（2014年），万象城，201米，成都，中国（2012年五月开业，LEED黄金认证），拉森&图布高层开发，孟买，印度（2014年）。

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崔希瑄是美国宋腾添玛沙帝结构事务所的一名高级主管，拥有二十年世界各地各类建筑包括超高层建筑的结构设计经验，如纽约巴克利银行总部大楼，韩国新松岛市开发区，阿塞拜疆Socar塔楼和越南河内乐天中心等。她担任CTBUH（高层建筑与都市环境委员会）外伸臂工作组的副主席一职，并作为合著作者发表过"高层建筑外伸臂设计"一文。崔希瑄高级主管拥有美国麻省理工学院获的硕士学位以及库柏联盟学院的学士学位。

Abstract

Standing 267m tall, Lotte Center Hanoi is Vietnam's second tallest tower and set to open this summer. Innovative high-rise design solutions were incorporated that respond to the cultural, environmental, and technical challenges of tall construction in Hanoi. Culturally, the tower has already been embraced by the Vietnamese due to its distinct formal reference to the "ao dai", the Vietnamese long dress. The Two-Towers-In-One scheme is unique: The continuous atria design conjoins and separates distinct building functions of commercial offices, hotel, apartments, and a public viewing deck. Annual solar heat gain is minimized by the tower's deliberate orientation. The central sky garden spine provides spatial relief at optimized luminance and luminance levels. Here, independent, steel-framed decks provide for flexible, multi-story atria configurations. Structural optimization further reduced the concrete volume, minimizing CO_2 emissions. Membrane bioreactors for waste water treatment have been built in the basement where all sewage will be treated on-site.

Keywords: Lotte Center Hanoi, Vernacular, Design Tool, Structural Sustainability

摘要

矗立在那里267米高的河内乐天中心塔楼是越南第二高的建筑，预计今年夏天开业。纳入了创新高层设计解决方案来回应河内高大建筑在人文，环境和技术上的挑战。在文化上，由于正式引用了越南人的长礼服奥黛模式，项目深受越南人的喜爱。独特的两塔合一方案，连续不断的中庭设计连接并分隔着不同的建筑功能，像商业写字楼、酒店、公寓、和公共观景台。塔楼的走向意在降低年度太阳能的摄取量。中央空中花园的脊椎架构结合了优化的亮度且亮度水平达到使用人的健康标准。在这里独立的钢结构平台提供了灵活多层的中庭配置。结构优化进一步减少混凝土的使用量。使CO2 排放量降到最低。所有的污水都会由地下室的膜生物反应器进行现场处理。

关键词: 河内乐天中心，方言，设计工具，结构可持续性

Vietnam Rising

Vietnam's Affluence

Market-oriented economic reforms together with trade and investment liberalization have brought a huge influx of foreign direct investment. Vietnam's accession to the World Trade Organization (WTO) in 2007 played a significant role in this process. Thanks to the country's reform policies and the resulting investment by foreign corporations, Vietnam has achieved one of the most remarkable performances internationally in economic growth, raising standards of living and poverty reduction. The overall national poverty head count ratio has declined substantially from 58% in 1993 to 15% in 2008 (WTO, Trade Policy Review 2013).

Between 2005 and 2010 Vietnam's gross domestic product (GDP) has grown by 36% (WTO, Trade Policy Review, 2013). According to a recent ranking by PricewaterhouseCoopers, Hanoi will be

越南 崛起

越南的富裕

以市场为导向的经济改革连同贸易和投资自由化带来了大量涌入的外国直接投资。在2007年，越南加入世界贸易组织（世贸组织）在这一进程中发挥了重要作用。国家的改革政策和外国公司的投资使越南在国际的经济增长方面取得了卓越成绩，提高了人民的生活水平和减少了贫困。国家总体贫困人口比率已从 1993的58% 大幅度下降至2008 年的15 %。（世贸组织，贸易政策审查，2013 年）

2005 至 2010 年间，越南国内生产总值（GDP）增长了 36%（世贸组织，贸易政策审查，2013年）。按照普华永道最新排名，河内将是在世界上国内生产总值从 2008 年至 2025年增长最快的城市。在未来 25 年内，越南的城市和城镇，预计年均增长率为 6%，国家的城市人口从三分之一增长到二分之一（建设部、越南，2009年）。

the fastest growing city in the world in terms of GDP from 2008 to 2025. Over the next 25 years, Vietnam's cities and towns are expected to grow and an annual average rate of 6%, increasing the country's urban population from one-third to one-half (Ministry of Construction, Vietnam, 2009).

Investment in Vertical Growth

Economic expansion and growth in developing urban centers, if not managed strategically, can lead to unplanned, scattered expansion of urban areas. Sprawl, as everyone agrees, is inefficient, undesirable and unaffordable, particularly in the context of future development of high-density urban centers. The Capital Construction Master Plan to 2030 and Vision to 2050 provide the underlying planning frame work for development in Hanoi that responds to demographic growth and redistribution efforts within and outside of the overcrowded urban core.

Today, facilitated by official development aid and foreign direct investment, the capital of Vietnam undergoes a strategic expansion and modernization of civic infrastructure developments. In tandem, the real estate sector is experiencing an unprecedented shift in planning for high-rise construction, a typology new to Vietnam. Nine surrounding provinces close to Hanoi will establish new regional centers where vertical expansion can blend in and support densely populated communities destined for growth. These regional centers will be connected with urban mass transit and light rail systems and include centers for education, research & development, and health care. They are also next to commercial offices, multi-residential, retail, and commerce. As one example, the so-called Lang Hoa-Lac Hi-Tech City will accommodate major universities, high quality manufacturing and human resources. (Nguyen Thai Huyen 2009)

The Vietnamese government and municipal authorities are intent in developing a knowledge-based economy and develop large scale, high-technology satellite cities as a core element of this plan.

Making Value Relevant

The Capital Construction Master Plan enables a long-term vision for the city and constitutes a crucial framework. In the short-term however, acute planning challenges will need to be addressed before the community experiences the infrastructure intended by the master plan. More than ever before due to unprecedented growth, the solutions to these challenges require in-the-moment ingenuity and collective willpower.

Low-rise, high-density cities in developing countries – such as Hanoi with a population of 6.5 million – face logistical challenges of managing and constructing complex, mixed-use high-rise buildings. For large projects, delays in planning, authorization, and construction are common, particularly if they involve tall towers. Key project challenges involve site management and supervision, project management, procurement, construction economics, and shortages of skilled labor. Currently, both high-rise engineering expertise (and to some extent skilled labor) must be imported into the country.

In addition to logistical improvements, there is an acute demand for inspiring, attractive, and high-performing design which produces a vibrant and livable city of tomorrow.

Callison's Contribution in Hanoi

Lotte Center Hanoi (LCH) is the country's first, distinct two-in-one tower design with central sky garden atria climbing up the entire height of the tower (see Figure 2). Two-to-five-story, stacked gardens offer an urban respite with expansive city and river views, over the entire height

纵向增长的投资

经济扩张和城市中心的发展和增长，如果不采取战略性的管理，就可能导致计划外、分散扩大的城市地区。大家都同意这个观点，无计划的扩展是无效的、不可取的，也是负担不起的，尤其是在未来高密度城市中心的发展上。首都的建设总规划到2030年，远景展望到2050年，对河内的发展提供基础规划框架工作回应拥挤的城市核心内部和外部的人口增长和重新分配。

今天，在官方发展援助和外国直接投资的促进下，越南首都正进行着战略扩张和现代化的市政基础建设和发展。紧随其后，房地产业在规划上也正经历着前所未有的转变，向高层建筑、新的建筑类型转变。河内附近的九个周边省份将建立新的区域中心，这些建筑中心将融入纵向扩展，配合注定增长的人口密集的社区。这些区域中心将与城市轨道交通和轻轨系统连接，包括教育、研究 和发展及医疗保健中心。他们也紧邻商业办公楼、多套住宅、零售、和商务。作为一个实例，那个Lang Hoa- Lac 高科技城将容纳主要大学、高质量的制造业和人力资源。(Nguyen Thai Huyen，2009年)

越南政府和市政当局意图采用以知识为基础的经济发展模式，开发规模大、高科技卫星城市是这个计划的核心要素。

未来开发价值

首都的建设总规划促进了城市的长远规划，并形成了一个至关重要的框架。然而，在社区按照总规划进行基础设施建设之前，将需要解决短期内的紧急规划挑战。由于前所未有的增长，对这些挑战的解决比以往更需要--时的独创性和集体的意志力。

Figure 1. Sunrise with Lotte Center Hanoi (Source: Phillip Roo)
图1. 河内乐天中心日出 (出自: Phillip Roo)

Figure 2. Mixed-Use Integration of Lotte Center Hanoi (Source: Pham Hoang)
图2. 河内乐天中心多功能一体化 (出自: Pham Hoang)

of the tower. This core design element directly corresponds to the Vietnamese design vernacular as it relates to the cultural identity of the "ao dai" long dress (see Figures 3 and 4).

Completed in 2014, LCH is the city's first tower that was conceived as a live, work, and play destination which recycles its own waste water. Standing 267m tall, the tower is Vietnam's second tallest. Centrally located at the corner of Lieu Giai and Dao Tan streets in the capital's Ba Dinh district, (the city's prestigious embassy district), the tower is just west of the main train station and a block away from the soon-to-be-open Kim Ma metro rail station. LCH is located on a site parcel of 14,100m^2. The total gross floor area is 264,000m^2, with an above grade floor area of 197,000m^2, distributed over 65 floor levels. The development opened in June 2014, when all facilities of Lotte Center Hanoi commenced operation, simultaneously. In an effort to attract international companies and travelers to the country's growing economy, the high-rise features the latest in sustainable design solutions and modern conveniences. The tower's design maximizes energy efficient principles to respond to the city's intense year-round climate.

Exemplifying the spirit of design innovation and adherence to Hanoi's master plan, Lotte Center Hanoi is a powerful incubator of vertically-integrated sustainable design solutions. The success of Lotte Center Hanoi is rooted in its connection to the Vietnamese design vernacular: The tower's unique architecture is inspired by Vietnam's traditional long dress, the "ao dai." The sleek and tapered design is defined by bold vertical lines flowing upwards, reaching out toward the sky as a representation of Vietnam's growing influence in Asia. The tower's design is testimony that indigenous design products, cultural achievements, and intellectual heritage can evolve and emerge as a new form. The threads binding Vietnam's civilized society (particularly a country with geo-political history) are resilient and can be sustained through reinterpretation into urban, modern design.

The tower's full-height, central stack of sky gardens organizes the tower into two, independently operated towers with individual service and transportation cores (see Figure 12). The east tower features a 320-key hotel and the west tower includes 258 serviced apartments, reaching floors 33 to 64. Commercial offices are located at floors 7 to 32. A publically accessible, panoramic viewing lounge is at the top of the tower. The six-level podium includes a department store. A supermarket and on-site parking are accommodated in the five-story basement.

Design Tool for High-Rise Design

Matrix by Callison

The successful application of high-rise design principles (together with the systematic integration of project-specific sustainable design strategies) is imperative in today's business practice of developing tall architecture. Lotte Center Hanoi was the first design that applied sustainability data from a specific design tool, Matrix by Callison. Matrix by Callison is a tool designed and developed to ensure sustainable design strategies in architecture can be both assessed comprehensively according to project relevance or stakeholder expectations during the design phases (see Figure 5).

For the design of LCH, the Matrix streamlined the design process by allowing the high-rise design team to identify and select the top sustainable design strategies applicable specifically to this project.

Figure 3. Ao Dai Long Dress (Source: Shanghai Stock)
图3. 奥黛长礼服 (出自: 上海股市)

Figure 4. Ao Dai Long Dress Interpretation
图4. 奥黛长礼服诠释

在发展中国家低层、高密度的城市 — 如拥有650万人口的河内就面临着物流管理和构建复杂的、多用途的高层建筑综合体的挑战。对于大型项目，规划、授权和施工的拖延是普遍现象，尤其是涉及到高塔的情况下。项目关键的挑战包括工地管理和监理、项目管理、采购、和建筑经济和技术劳力的短缺。目前，高层工程专家 (某种程度上的技术劳力) 还必须从别国引进。

除了物流方面的提高，仍需求鼓舞人心的、有吸引力的、和高性能的设计创造出明天充满活力和宜居的城市。

凯里森在河内的贡献

河内乐天中心 (LCH) 是该国的第一座、不同于其它的二合一塔楼，设计出由底到顶的全程中央空中花园中庭 (见图二)。从两层到五层，层叠的花园提供了一个城市中的休息地，扩展的城市和河岸的景色遍布整个塔的高度。这种核心设计元素直接对应越南的设计语言，体现长礼服"奥黛"的文化特性。(见图三、图四)

LCH 在 2014 年完成，是这个城市的第一个塔楼，被设想为生活、工作和活动的目的地，废水就地回收。矗立在那里267米高的河内乐天中心塔楼是越南的第二高的建筑。坐落在首都的巴亭广场区 (市著名大使馆区)内Lieu Giai和 Dao Tan街道的拐角处，塔楼在主要火车站的西部，离即将开业的金马地铁站一个街区。LCH地块面积为 14,100 m^2。总楼面面积为 264,000 m^2，地上楼面面积为 197,000 m^2，总共65层。河内乐天中心在 2014 年 6 月开业，同时河内乐天中心的所有设施都开始运作。为了努力吸引国际公司和游客前往该国增长的经济环境，高层建筑功能体现了最新的可持续设计解决方案和现代便利设施。塔楼的设计把能源高效原则最大化来回应城市全年强日照的气候。

河内乐天中心彰显创新设计并坚持总规划的精神，是一个纵向整合、可持续设计的强大的工程。河内乐天中心的成功植根于与越南设计语言的连接: 塔楼独特的建筑灵感来源于越南的传统长礼服，"奥黛"。圆滑的锥形设计由粗体垂直线向上流动，向天空伸展来体现越南在亚洲的影响力。塔楼的设计证明了当地的设计产品、文化成就和知识遗产进而进化成为一种新形式。连接着越南文明社会 (特别是一个地理政治历史的国家) 的主线很有弹性，可以通过重新解释现代城市化的设计来持续。

塔楼的全高，中央层叠的空中花园把塔楼组成两个、独立经营的塔楼，两个塔楼各有各的服务和运输核心 (见图12)。东部塔楼

Using the Matrix, the team of architects and consultants compared and evaluated a pool of more than 80 specific strategies in five categories, concurrently. Categories include energy, water, waste, materials, and other tools.

Design is derived equally from performance-driven and aesthetic choices. The Matrix serves to establish the necessary qualifiers for high-performance building design. Design should work well, look attractive, be resource-efficient, look resource efficient, and meet the benchmarks of economy and marketability. Matrix by Callison is a tool that provides overview and access to valuable technical information that will make it easier for everyone to streamline the design process. Sustainable design strategies can be effectively evaluated for their relative merit and applicability for any built environment. Given this information, architecture and design teams are empowered to unlearn old habits and explore new design aesthetics, expressed by performance and environmental values.

Sustainable Design Strategies Used by Lotte Center Hanoi

LCH Sustainable Design Strategies

The design concept for Lotte Center Hanoi includes specific sustainable design strategies that are intrinsic to Vietnam's culture and place. Sustainable design for this project is a function of community embrace, urban fit, and passive and active measures to reduce resource dependencies. "High-performing" is a reference to reduced energy consumption and a qualitative description of a building's ability to emanate cultural relevance and civic pride, structural adaptability, innovative waste reduction, and formal beauty. Because strategies were introduced during the conceptual phase, the pertinent sustainability solutions remained intact in LCH's final design.

Cultural Relevance and Emotional Connection

Emotional connection played a key part for winning the city's acceptance for a modern building towering over a low-rise Hanoi skyline. Lotte Center Hanoi's sleek and tapered design is a formal reference to a traditional garment, the "ao dai". Adding a direct cultural reference to the design of the building offers a means for emotional connection and regional acceptance. When the Vietnamese and particularly Hanoi's communities acquired the press images and design information of the tower design, people immediately identified with the reference of the "ao dai" as a deliberate effort to respect the beauty of their culture. A public roof top observatory makes this connection accessible, further strengthening a sense of place, pride, and identity.

http://talkvietnam.com/2013/04/lottes-ao-dai-tower-rises-higher-in-hanoi/

http://www.hanoihomes.com/property/lotte-center-hanoi-for-rent/

http://www.monre.gov.vn/v35/default.aspx?tabid=675&CateID=55&ID=95282&Code=VB14V9528

Sun Path and Shadow Range Analysis Inform Best Tower Orientation

The tower is oriented along the solar intense southwest-northeast axis. The deliberate exposure of the narrow sides of the tower minimizes the direct solar heat gain during summer months. The proposed scheme (Option 1) showed at least 5% solar radiation reduction compared to other schemes. As a result, the tower experiences less cooling loads and associated cost, as compared to other possible tower orientations (see Figure 6).

功能是一个320 个客房的酒店，西部塔楼包括258 间服务式的公寓，位于33 到 64层。商业办公楼位于7层到32层。塔的顶部是一个大众全景观景酒廊。六层裙房包括一家百货商店。超市和停车在五层地下室。

高层设计工具

凯里森数据库设计工具.

高层设计原则的成功应用在今天发展高层建筑的商业实践中势在必行 (与具体项目可持续设计战略系统整合) 。河内乐天中心是第一次应用特定的设计工具-凯利森数据库设计工具的可持续发展数据而设计的。凯利森数据库设计工具是一个设计和开发工具确保可持续设计战略在设计阶段中按照项目相关性或利益相关者的期望全面评估。 (见图5)

对于LCH设计，数据库设计工具的使用简化了设计过程，并允许高层设计团队来识别和选择专门最适用于这一项目的可持续设计策略。使用数据库设计工具，建筑师和顾问团队同时比较和评估了五个类别超过 80 个具体的战略。这五个类别包括能源、 水、废物、 材料和其他工具。

设计来自业绩驱动和审美的选择。数据库设计工具帮助建立必要的、合格的、高性能的建筑设计。设计应好用、 看起来有吸引力、 资源高效、 看起来资源高效和满足经济和市场化的基准。凯利森数据库设计工具是一种工具，提供了宝贵技术信息概述及访问，便于大家来简化设计过程。可持续设计战略可以有效地评估它们相对的优点和任何建筑环境的适用性。鉴于这一信息，建筑和设计团队有权摒弃旧的习惯，并探讨新的美学设计，通过性能和环境价值来体现。

河内乐天项目上使用的可持续设计战略

LCH可持续设计战略

河内乐天中心的设计概念包括越南的文化和地方所固有的具体的可持续设计战略。这一项目的可持续设计是社区怀抱、城市契合、利用被动和主动的措施来减少资源依存关系。高性能，作为一个形容词，不只是减少能源消耗的参考，也是一种定性描述，描述建筑能力，散发文化相关性和人民自豪感、 结构适应性、创新性减废和形式美。因为在概念阶段引进了可持续设计战略，相关的可持续性解决方案原封不动地体现在LCH的最终设计中。

文化相关性和情感连接

Figure 5. The Matrix by Callison is a compilation of the top strategies in sustainable design. Lotte Center Hanoi was the first project to implement Matrix by Callison (Source: Callison)
图5. 凯里森数据库设计工具是可持续发展策略汇编，河内乐天中心是第一个使用数据库设计的项目。

Minor Modifications to the Floor Plan Geometry Leads to Reduced Electricity Consumption

To assess the tower's daylight performance, we compared the atrium scheme (the proposed scheme) and the baseline scheme (the rectangular shaped floor plan) by using Continuous Daylight Autonomy (cDA) of 300 lux/cDA 300. DIVA Radiance daylight simulation was utilized to evaluate both schemes. As a result, the cDA of the proposed scheme is 94%, which means that daylight contributes to 94% of occupied building hours to achieve the illuminance level target of 300 lux, while the cDA of the baseline is only 80%. Based on the cDA simulation results, we can approximate that the proposed design consumes 70% less electrical lighting energy during the day than the rectangular scheme (see Figure 7).

Sky Gardens

The garden is an integral Vietnamese design element as a reference to nature and has a profound effect on the LCH experience (see Figure 8). Emphasizing this cultural motif, LCH's key design element is a central, transparent stack of sky gardens, free of columns or service cores, symbolizing civic openness and transparency. The sky gardens are compartmentalized into zones of two-to-five story spaces and maintain positive pressure, effectively blocking outside air infiltration. The transparent sky garden atria serve as a fulfilling and healthy work/lifestyle environment for tenants and visitors. Sustaining people's quality of life becomes a result of integrating green spaces in a high-rise environment. Therefore LCH symbolizes a sustainable modern-day community.

Comfort Design of Sky Gardens Verified with Daylight Modeling

Luminance was measured as an indicator of how bright the interior atrium surfaces will appear. The average target value of 200cd/m^2 can be obtained throughout the space, allowing for comfortable, glare-free reading and working conditions with laptops and other LED screens. Illuminance measures how much light enters a space and to verify how much incident light illuminates the surfaces. 1500 Lux are generated inside the atrium, enough light for most activities without the need for electrical lighting (see Figure 8 and 9).

Renewable Energy. Integration of Photovoltaic (PV) Technology

The tower features a full-length canopy along its entire width. This canopy not only serves to deflect and mitigate wind-downdrafts from the tower's façade, but it also serves as a vast support wing for arrays of PV cells, designed as a year-round source of free electricity for the development.

Solid and Fluid Waste Treatment

The current technological challenges and costs associated with water supply and sewage treatment are critical and real in vast areas of developing countries around the world. Future projections further magnify the need for waste water technology and integrated solutions. Lotte Center Hanoi employs solutions that considerably reduce potable water needs with water efficient appliances. The hotel and residential functions are key-contributors in this measure. The development's sewage will be treated on-site to the greatest extent. Membrane bioreactors (MBR) for on-site waste water treatment are located in the podium basement. MBR provide highly compact, fully automated, low odor wastewater treatment in Lotte Center Hanoi. Its filtering system can treat black water to near drinking water quality that meets or exceeds the world's most stringent standards for water reuse. Sludge will be periodically collected in the basement and shipped to off-site fertilizer processing.

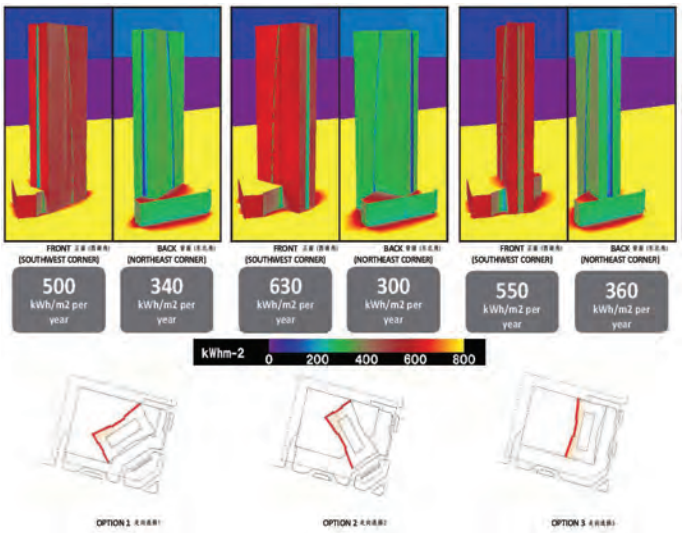

Figure 6. The tower was oriented to minimize cooling loads (Source: Callison)
图6. 塔楼的走向旨在降低空调冷负荷 (出自: 凯里森)

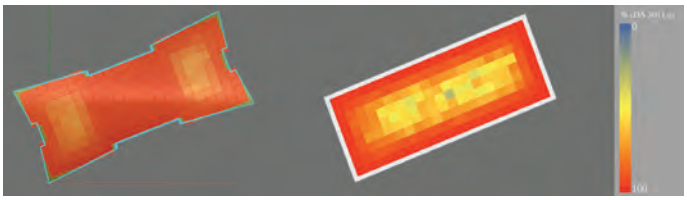

Figure 7. The floor plan geometry leads to a 70% reduction in electrical lighting use, relative to a rectangular floor plan (Source: Callison)
图7. 平面几何图相对于矩形平面图使电气照明减少了 70% (出自: 凯利森)

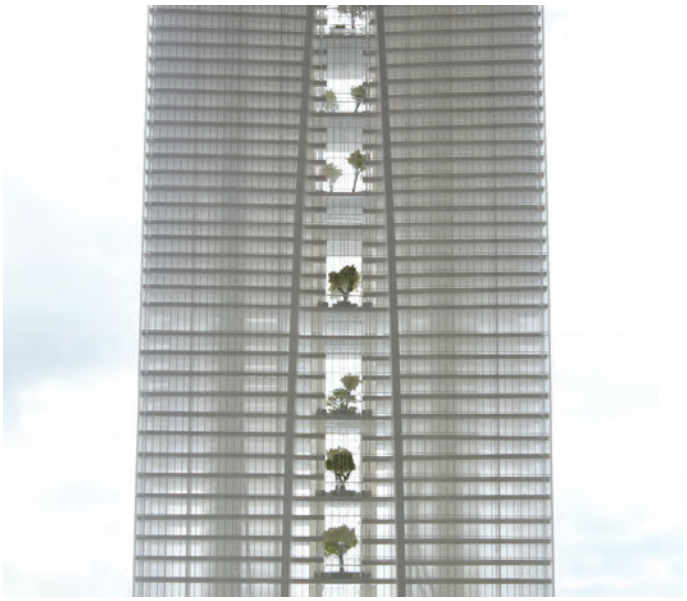

Figure 8. A central spine of sky gardens conjoins the two towers (Source: Callison)
图8. 空中花园中央脊椎架构连接两座塔楼 (出自: 凯里森)

(http://www.wateronline.com/doc/membrane-bioreactors-leeding-the-way-in-water-0001)

http://talkvietnam.com/2013/04/lottes-ao-dai-tower-rises-higher-in-hanoi/http://www.hanoihomes.com/property/lotte-center-hanoi-for-rent/

http://www.monre.gov.vn/v35/default.aspx?tabid=675&CateID=55&ID=95282&Code=VB14V9528

Structural System and Challenges

The 267meter tall, 65-story building consists of reinforced concrete flat slabs supported by perimeter beams, centrally located core walls at each tower, and steel encased reinforced concrete columns. The two towers are connected every four to six floors with steel framing and work as a two-in-one integral structure. Column locations are reduced to the perimeter, ensuring maximum flexibility relative to the architectural fit-out. The lateral load resisting system is a reinforced shear wall working with pairs of outriggers located at the mid-height (32nd floor) and the roof level. Challenges of building motion, a result of the high slenderness ratio of 1:9, required specific kinematic design provisions. In addition, since the typical floor plan is a narrow rectangular shape, 32.4m by 82.6m, the peak torsional velocity at the corner of the top floor was a critical structural design criterion. Strategic placement of both the outriggers and the connection points of the two towers counter the tower's peak acceleration and the peak torsional velocity, under 10-year and 1-year return synoptic wind, respectively. This approach ensured that acceptable building serviceability criteria such as ISO6897 and ISO10137 (see Figure 11).

Structural Longevity and Implied Sustainability

In commercial real-estate developments, the decision for a structural system is often driven by solutions of lowest first cost impact. Broader cost-benefit evaluations, however, can uncover significant advantages that challenge this approach, relative to directly marketable aspects of longevity, flexibility and sustainability. Initially, a structural system of post-tensioned slabs with interior and perimeter floor beams was suggested due to its low construction cost. Following further evaluation, however, that floor system design was replaced by a two-

为通过城市对耸立在低矮的河内天际线的现代建筑的验收，情感连接起了重要的作用。河内乐天中心圆滑的锥形设计正式引用了传统服装"奥黛"。在建筑设计上直接引用文化提供了情感联系，促进了区域的接纳。当越南人、特别是河内的社区获息了新闻图片和塔楼的设计，人们立即确定了"奥黛"的参考设计信息是故意尊重他们的文化之美。公共屋顶的观景台使这些连接更容易接近，进一步加强地域感、自豪感和认同感。

http://talkvietnam.com/2013/04/lottes-ao-dai-tower-rises-higher-in-hanoi/

http://www.hanoihomes.com/property/lotte-center-hanoi-for-rent/

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太阳轨道和阴影范围分析显示最佳塔楼方向

塔楼面向太阳能强烈的西南-东北轴。故意将塔楼的窄边暴露使夏天太阳能热直接摄取量降到最低。拟定的方案 (方案 1) 表明与其它方案相比至少降低 5%的太阳辐射。其结果是，与塔楼的其它走向相比，此塔楼降低了冷却负荷和相关的成本。(见图6)

对平面几何图稍作修改减少电力消耗

评估塔楼的采光性能，使用300lux/ CDA300连续日光自给 (CDA)，我们比较了中庭方案 (该拟定方案) 和基线方案 (矩形平面图)。利用DIVA日光光线模拟来评估这两种方案。因此，拟定方案的CDA是94%，这意味着日光能照射到94%的塔楼时间，达到300lux的照度目标，而基线的CDA只有80%。基于CDA的模拟结果，我们可以大致估计所拟定的设计在白天消耗的电气照明能源比矩形方案减少70%。(见图7)

空中花园

花园作为对自然界的引入，是越南设计元素中不可分割的一部分。对LCH项目也有着深刻的影响 (见图8)。为了强调这个文化主题，LCH 的关键设计元素就是中央、透明的叠层的空中花园，没有柱子或服务核心，象征着对公众的公开性和透明度。空中花园分割成两到五层空间区域和保持正压，从而有效地阻止外部空

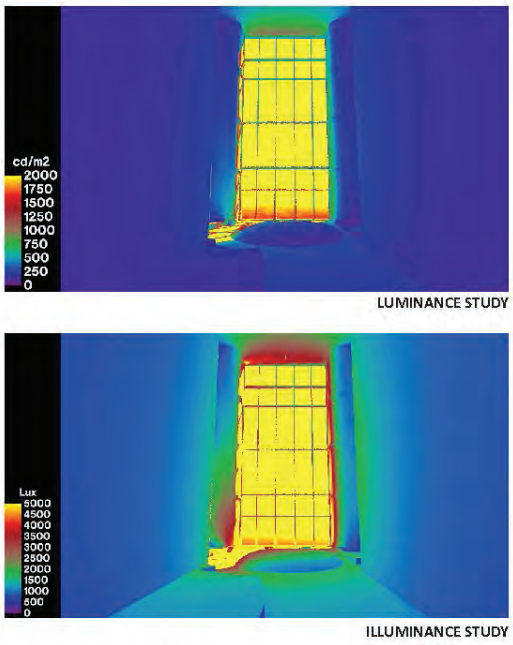

Figure 9. Sky Garden Luminance and Illuminance Levels Contribute to Visual Comfort (Source: Callison)
图9. 空中花园亮度及照度水平使视觉舒适 (出自: 凯里森)

Figure 10. Two-in-One Tower Via Sky Garden Geometry, Lotte Center Hanoi (Source: Hoangdong)
图10. 空中花园使两塔合一，河内乐天中心 (出自: Hoang dong)

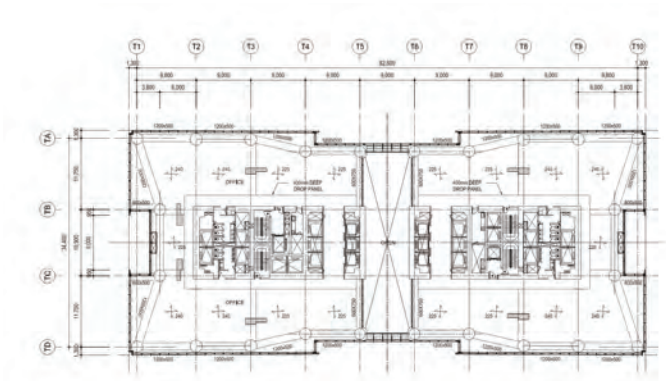

Figure 11. Typical Atrium Floor Framing (Source: Thornton Tomasetti)
图11. 典型中庭地板框架 (出自: 宋腾添玛沙帝结构事务所)

Figure 12. Tower geometry (Source: Vu Long)
图12. 塔楼几何形式 (出自: Vu Long)

way flat slab with perimeter beams. Multiple, sustainable structural design considerations informed this decision. Key drivers for this mixed-use tower development were future adaptability needs and anticipated tenant demands throughout the building life span. The initially planned post-tensioned slab system would be less capable of supporting high and variable local loads, and less accepting of future slab openings for mechanical risers, convenience stairs, atria and other possible changes. Although it was not possible to reduce the concrete volume by the application of high strength concrete due to challenges of local material availability, strategic structural system optimization was conducted to reduce the concrete volume wherever practical. An extensive geotechnical investigation was performed to establish appropriate seismic ground acceleration criteria for the project. Structural optimization incorporated the appropriate seismic load and code, resulting in a more refined building design and reduced concrete consumption minimizing CO_2 emissions. Steel-framed decks were inserted between the two towers, creating a multiple story atria that can be accessed from both towers. Most importantly, because the towers' unique atria geometry and location that allow for easy floor area expansion or contraction, the towers can support a variety of uses over time without affecting the building's design or being limited by it. The adaptability of the towers structural design offers all ingredients necessary to ensure longevity and maximize life cycle value (see Figure 11 and 12).

气渗入。透明空中花园中庭作为一个充实和健康的工作/生活环境服务于租户和访客。维持人们的生活质量将成为高层环境中绿色空间的一个整合结果。因此LCH象征着一个可持续的现代社区。

空中花园的舒适设计与白昼建模验证

亮度是中庭内部表面亮度衡量指标。在整个空间，可以达到平均目标值200 cd/m ^{2}，达到允许舒适、 无眩光阅读和适合笔记本电脑和其他 LED大屏幕的工作条件。照度衡量多少光进入一个空间并验证有多少光源照亮表面。在中庭内生成1,500 lux，光线足够大多数活动不需用电灯。(见图8、图9)

可再生能源. 光伏 (PV) 技术集成

塔楼沿着整个宽度设有一个全长檐。这个长檐不仅有助于把塔楼外立面来的倒焰风改变风向或减弱，它还可以作为数组光伏电池巨大的支持翼，这个设计可以作为全年免费电力开发的来源。

固体和液体废弃物处理

当前与供水和污水处理相关的技术挑战和成本在世界各地的广大发展中国家地区都很关键和实际。未来预测进一步扩大了对污水处理技术和综合解决方案的需求。河内乐天中心采用的解决方案，运用高效水电器大大减少了饮用水的需求。酒店和住宅是这项措施的主要参与者。将污水最大程度的现场处理。膜生物反应器 (MBR) 的现场废水处理位于裙房地下室。在河内乐天中心，MBR 提供高度紧凑、完全自动化、低气味废水处理。其过滤系统可以处理黑色污水使其接近饮水质量，满足或超过世界上水再利用最严格的标准。污泥将定期在地下室中收集并运送到异地进行肥料加工。

(http://www.wateronline.com/doc/membrane-bioreactors-leeding-the-way-in-water-0001)

http://talkvietnam.com/2013/04/lottes-ao-dai-tower-rises-higher-in-hanoi/http://www.hanoihomes.com/property/lotte-center-hanoi-for-rent/

http://www.monre.gov.vn/v35/default.aspx?tabid=675&CateID=55&ID=95282&Code=VB14V9528

结构体系和挑战

这座267米高的65层塔楼结构包括由外围框架梁支撑的钢筋混凝土无梁楼板、居中布置的核心筒、以及钢筋混凝土劲性柱。两栋塔楼在每4到6层由钢框架结构连接形成一个整体。塔楼柱为了能保证建筑灵活布置的最大化而布在楼面周边。钢筋混凝土剪力墙以及布置在中间层 (32层) 和屋顶层的外伸臂桁架形成了塔楼结构的抗侧力体系。由于塔楼长细比为1: 9，需要采用特定的运动学设计来应对建筑结构运动带来的挑战。除此之外，塔楼典型楼面呈瘦长的长方形，尺寸为32.4mX82.6m，控制顶层角点的峰值扭转速度是结构设计的关键。外伸臂和两栋塔楼连接结构位置的战略布置可以帮助抵消在10年回归期和1年回归期风力下的塔楼峰值加速度和峰值扭转速度。这个设计方法保证了结构达到可接受的建筑使用标准，比如ISO6897和ISO10137。(见图11)

结构使用寿命和隐含的可持续性

在商业房地产开发项目中，结构体系方案往往是由最低成本因素驱动的。而在进行更加广泛的成本效益评估之后，可以发现在考虑直接与市场方面相关的使用寿命、灵活性和可持续性以后的设计具有更显著的优势，这给成本驱动的设计方式提出质疑。刚开始时，本项目的楼面结构建议采用造价较低的预应力混凝土楼板体系。经过后续进一步评估之后，最初的方案被双向楼板体系取代了，这个决定是在考虑了多个可持续发展因素以后促成的。这

Conclusion

Environmental sustainability and respective design solutions are critical components of high-rise design. This imperative is particularly relevant for developing countries such as Vietnam where the economy is growing fast and inevitably vertical. Lotte Center Hanoi addresses a variety of qualitative and quantitative criteria. Cultural connections were established via design references of the Vietnamese long-dress and Vietnamese garden architecture. Energy conservation principles were followed by virtue of an optimized tower orientation and daylight conscious plan geometry. Solid and fluid waste of Lotte Center Hanoi will be treated on-site to the greatest extent. Structurally, provisions were made relative to the primary system and the atria geometry to ensure the tower's adaptability relative to changes to the floor plan geometry.

Lotte Center Hanoi is the first speculative development-type project to take advantage of a newly developed tool for sustainable design strategies. By using this tool for strategy evaluation and selection, sustainable design approaches could be seamlessly developed and integrated into the design of a mixed-use, two-in-one tower.

In Vietnam, the sudden spike in demand for advanced design and engineering expertise in tall buildings is the result of a burgeoning population that generates the world's second largest GDP. The visionary advancement of solutions that embrace the cultural, environmental, and technological opportunities in Vietnam defines the design performance intent for Lotte Center Hanoi.

种混合功能型塔楼开发的主要驱动力来自于建筑整个生命跨度当中与未来变化相适应的需求和预期租户的要求。最初计划的预应力楼板体系将不能够支撑更高的和变化的局部荷载，也不能够接受将来由机电管道、便捷楼梯、前室新增楼板开口和其它的变化。虽然由于当地材料获取的局限性而不能采用高强混凝土来能降低混凝土用量，但是通过结构体系的优化，在可实现的部位做到了混凝土材料用量的降低。本项目通过详细地质勘查建立了合理的场地地震加速度标准。在结合合理的地震荷载和规范标准的基础上，结构设计在优化之后得到改善，并减少了混凝土用量和二氧化碳排放量。位于两栋塔楼之间的钢结构平台形成了一个多层用房，供两栋塔楼用户造访。最重要的是，因为塔楼中庭的独特几何形态和位置，给楼面使用面积的扩大或者缩小带来便利，随着时间的推移，塔楼能够支持各种不同用途的使用，既不影响建筑设计，也不受建筑设计的制约。塔楼结构设计的适应性给建筑物的所有必要组成部分带来了使用寿命和生命周期的最大化。(见图11、图12)

结论

环境的可持续性和各自的设计解决方案是高层设计的关键部分。这种需求对地方经济增长快和不可避免地纵向发展的越南等发展中国家尤其相关。河内乐天中心体现了各种定性和定量标准。通过越南长礼服的设计引用和越南的花园体系结构建立了文化连接。能源节约性原则通过优化的塔楼走向和有意识的日光平面几何来体现。河内乐天中心的固体和液体废物将在现场最大程度地处理。在结构上，相对于主系统和中庭几何做了几项规定以确保针对平面几何的变化塔楼的适应性。

河内乐天中心是第一个投机发展型项目，采取可持续设计战略的新开发工具的优势。通过使用此工具进行战略评价与选择，可持续的设计方法被顺利开发并融入了这个综合的二合一塔楼的设计中。

在越南，突然增长的对先进的设计和高层建筑工程专家的需求是一个新兴的群体，创造着世界上第二大GDP。在越南，对文化、环境和技术机遇的高瞻远瞩诠释着河内乐天中心的设计意图。