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Author:	Kenneth Turner, Director, CallisonRTKL
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The Tower of the Future
未来塔楼

Kenneth Turner
Director | 总裁

CallisonRTKL | CallisonRTKL建筑设计事务所

Dubai, United Arab Emirates
迪拜，阿联酋

There are only a few architects in the world who have been involved in-depth, from design concept through the technical phases, for a "world's tallest" tower. As an Associate Partner with SOM, Kenneth Turner directed design for the world's current tallest building – the Burj Khalifa in Dubai, UAE. Since then, he has continued his explorations of tall building design throughout the Middle East and Asia. As a Director at RTKL, Turner incorporates a high level of design and technical knowledge that ensures a comprehensive project delivery through all phases of design.

全世界仅有几位建筑师曾深入参与世界最高大楼从设计概念至建筑阶段的各方面工作。作为SOM建筑设计事务所的副合伙人，Kenneth主持了世界最高大楼阿联酋迪拜的哈利法塔的设计，赢得了设计大赛，参与了概念设计、方案设计至设计开发等各阶段。Kenneth现在继续在中东及亚洲开展他的高层建筑设计探索。作为RTKL建筑设计公司的总监，他融高水准的设计及技术知识于一身，确保贯穿所有设计阶段的综合项目交付。

Abstract | 摘要

It's a well-known and oft-quoted statistic: by the year 2050, 70 percent of the world's population will live in urban areas. What we don't yet know is what portion of that 70 percent will live – or work, or play – in skyscrapers; however, we can make some educated guesses about what the tall tower will look like and how it will best accommodate this rapidly rising number of urban dwellers. Using the latest trends and advancements in tall building design concepts as a starting point, this paper will explore the "Tower of the Future," including its technology, potential uses, and the value it brings to the end user and the community it serves. What will the term "high-performance" come to mean as our designs adapt to the needs of a changing world, and what role will tall towers play in future master plans? Which of today's challenges will be seen as tomorrow's biggest opportunities?

Keywords: Community, Mixed-Use, Technology

截至2050年，世界上70%的人口将生活在城市中。这项数据不仅广为人知，而且经常被引用。我们尚未得知的是这70%的人口中，将有多少人会生活——或工作、或游乐——在摩天大楼中。但是关于高层建筑未来的形象，以及它如何才能最好地为迅速增长的城市居民人口服务，我们还是可以做出一些合理的猜测。 本文将以高层建筑设计概念中的最新趋势及进步为着眼点，探索未来高层建筑的方方面面：技术、潜在用途、带给最终用户和所服务社区的价值。设计需要适应这个不断变化的世界的需求，此时"高性能"将意味着什么？高层大楼又将在未来总体计划中扮演怎样的角色呢？

关键词：社区、混合用途、技术

It's a well-known and oft-quoted statistic: by the year 2050, 70 percent of the world's population will live in urban areas. What we don't yet know is what portion of that 70 percent will live – or work, or play – in skyscrapers; however, we can make some educated guesses about what the tall tower will look like and how it will best accommodate this rapidly rising number of urban dwellers (Figure 1). Using the latest trends and advancements in tall building design concepts as a starting point, this paper will explore the "Tower of the Future," including its technology, potential uses, and the value it brings to the end user and the community it serves. What will the term "high-performance" come to mean as our designs adapt to the needs of a changing world, and what role will tall towers play in future master plans? Which of today's challenges will be seen as tomorrow's biggest opportunities?

这个数据非常有名，经常为人引用：即到2050年，70%的人类将在城市生活。 只是我们还不知道，这70%中有多少会在摩天大楼里生活，工作或是休闲。 然而，对于未来的摩天大楼会是什么样子，以及它们如何才能以最佳方式消化迅速上涨的城市居民数量，我们可以对此做一些有根据的猜测（图1）。本文以高层建筑设计理念的最新趋势和进步成果为出发点，探索建设未来摩天大楼的技术，摩天大楼的潜在用途，它会给终端用户带来什么样的价值以及它服务的群体。 随着我们的设计不断适应着世界日益变化的需求，"高性能"到底意味着什么？在未来总规划当中，摩天大楼又扮演着什么样的角色呢？今天我们面临的哪一项挑战将会被视作明天最大的机遇呢？

Survival and Adaptation

It may sound bleak to make the case for urban development as a fight for survival, but in many ways, it is. As populations steadily and rapidly increase around

生存和适应

将城市生活说成是挣扎求生，听起来有些令人黯然，但很多方面来讲，事实如此。随着世界人口稳定快速增长，资源在不断减少，我们有责任来适应这种变化，并且责任重大。

也许这所有一切的关键在于"适应"。

Figure 1. Urban dwellers (Source: Mario Tama/Getty Daily Beast By Joel Kotkin, The Revolt Against Gigantism)
图1. 城市居民（来源：Mario Tama/Getty Daily Beast By Joel Kotkin, The Revolt Against Gigantism）

the world and resources dwindle, the responsibility we have to accommodate this growth is hugely consequential.

Perhaps the key word in all of this is "adaptation." What if we imagine the tower of today and the tower of the future through a Darwinistic lens? Understanding the tower's potential to be a solvent for the world's problems requires understanding the inherent traits and value added by this building typology and how those will shift and respond to changing conditions – an analysis not unlike Charles Darwin's evaluation of the Galapagos finches (Figure 2) – the crux of his theory of evolution.

Darwin asserted that all species of organisms arise and develop through the natural selection of small, inherited variations that increase the individual's ability to compete, survive, and reproduce. Traits that benefit the organism in its interaction with and relationship to its environment are strengthened, while traits that do not serve it fall away (Figure 3). To predict patterns in future evolution, historical knowledge of the organism and its responses to past stimuli in its environment are critical.

Similarly, the tower of the future must adapt to, respond, and support its environment to survive and thrive. Architectural features that

要是我们从达尔文进化论的角度，是否可以通过今天的摩天大楼来想象未来的摩天大楼呢？ 要理解摩天大楼如何才能解决世界难题，要求我们首先理解这种建筑类型的本质特征和附加价值，以及理解这种建筑是如何改变去适应不断变化的条件的——这种分析和达尔文对进化论的关键物种加拉帕斯群岛雀类（图2）的评估并无不同。

达尔文认为，所有物种的出现和发展都是由大自然对于个体生物的微小遗传变异的选择的结果，这些保存下来的变异能够增强个体生物竞争，生存和繁殖的能力——即有利于生物体与环境互动，或能够适应它所处的环境的特征被强化了，而相反的特征则慢慢消失（图3）。 要了解物种未来的进化方式，就有必要了解物种的起源和它们遇到环境刺激因素时是如何应对的。

同样，未来的摩天大楼必须适应环境，能够应对环境变化，并支撑环境使其能够生存并繁荣发展。 不能为建筑本身或其服务群体带来价值的建筑特色终将淘汰，而反复改进，不论大小，则能使它持久，兴旺并得到完善。 这就要求在可持续性，科技和施工技术上进行平价创新，以摩天大楼突破现今的形式。

我们还要记住，成功建筑设计必须以人为本，而人们如何适应周围不断变化的环境对建筑设计也至关重要。 人们是建成环境的主要商业动机，因此人们生活方式的偏好必将塑造未来的摩天大楼。

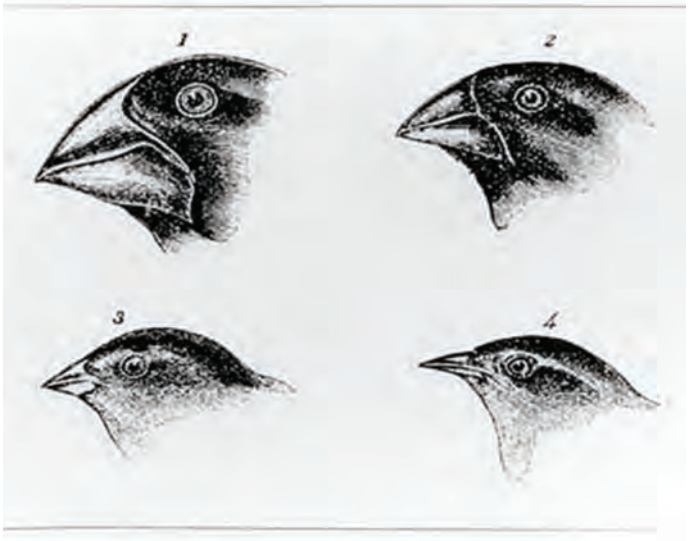

Figure 2. Galapagos finches (Source: Darwin's drawings of the different heads and beaks he found among the finches on the Galapagos Islands)
图2. 加拉帕戈斯群岛鸟类（来源：Darwin's drawings of the different heads and beaks he found among the finches on the Galapagos Islands）

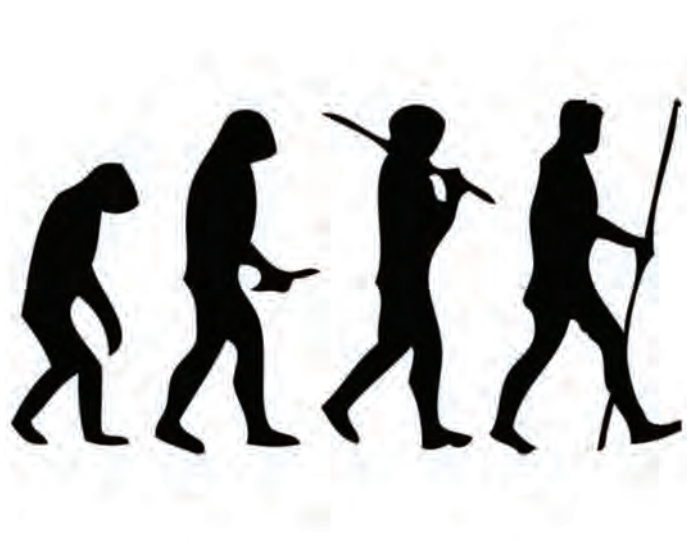

Figure 3. Darwin's Theory of Evolution (Source: Incredible Evolutionary "Big Bang" Supports Darwin's Theory By James Fenner on September 13, 2013)
图3. 达尔文进化理论（来源：Incredible Evolutionary "Big Bang" Supports Darwin's Theory By James Fenner on September 13, 2013）

provide no value for the building itself or for the community it serves should become obsolete, and iterative improvements – some big, some small – will help it sustain, thrive, and compete. This will require affordable innovation in sustainability, technology, and construction techniques to move the tower past its current form.

It is also important to remember that successful design is human-centric, and the way in which humans adapt to their changing environment will have an outsized influence. People are the primary commercial motivation for the built environment, and lifestyle preferences will most certainly shape the future.

Performance-Driven Design

The tower's evolution can be predicted and measured via performance-driven design (Figure 4) – CallisonRTKL's strategy for improving the value of the built environment by applying the greatest available intelligence to create compelling design with measurable social, economic, and environmental benefits. However, measuring progress this way will require a shift in our culture and the industry.

Historically, tall towers have had generally one goal: to be a representation of a city or country's financial power and modernity. Reaching ever higher into the skies has become a way to put a city or country on the map and to mark its progress in a very public way. Towers become "icons" – a symbol of the city, a paragon on the skyline with which all the city's residents identify and a draw for visitors who will pay top dollar to visit the top. Densification and limited resources, however, demand that tall towers move beyond mere icons to become, instead, catalysts for change. If a tower is designed to be self-sufficient, finding new ways in which to sustain its own livability and contribute to the growth of the community, it could be significantly impactful in solving a city's most pressing issues. The tower as a living organism has to do more than simply sap up the available resources if it is to survive.

If the tower is to be designed as a machine operating as a self-sustaining, closed-loop assembly, what type of resources does it need to survive and, in turn, what should it contribute to its environment? Should a residential tower, for example, provide opportunities for farming and food production, and what resources would this require? How can towers consume less energy but also generate their own power and clean the air around them? Could energy be generated by the tower's stack effect airflow, and could water harvesting be optimized

效能驱动设计

我们可以通过效能驱动设计来预测和衡量摩天大楼的进化演变（图4）——即用最伟大的现有知识来创造引人入胜的设计，并能够衡量它能给社会、经济和环境带来的好处，并以此方法改善建成环境的价值，这就是CallisonRTKL的战略。 然而通过这种方式衡量进步要求文化和产业发生转变。

纵观历史，所有的摩天大楼的建造目的无外乎作为一城的形象标志或是一国的金融实力和现代性的象征。 拥有一座直入云霄的摩天大楼能够让一个城市或国家在地图上有一席之地，或是公开宣扬该城市或国家的进步。 摩天大楼成为了一种“象征”——城市的象征，耸立天际的完美标志，不仅城市里的每一位居民认得，还吸引了大量游客，花上大把钞票，只求登顶一览。 然而密集的人口和有限的资源要求摩天大楼不应仅仅作为标志性建筑，而是应该成为变革的催化剂。 如果可以将摩天大楼设计成自给自足，寻找新途径使其能够保持适宜居住性并有利于居住群体的成长，那么这种建筑一定能有效地解决城市最紧迫的问题。 摩天大楼这个生物体想要存活下去，就必须加以完善，而不仅仅是消耗现有资源。

如果要把摩天大楼设计成一种像自给的闭路组合体一样运作的机器，那么它要生存下去需要哪些资源？反过来，它又该为它的环境做哪些贡献？ 比方说，一栋住宅大

Figure 4. Performance-driven design (Source: Performance-Driven Design—CallisonRTKL)
图4. 性能驱动设计（来源：Performance-Driven Design—CallisonRTKL）

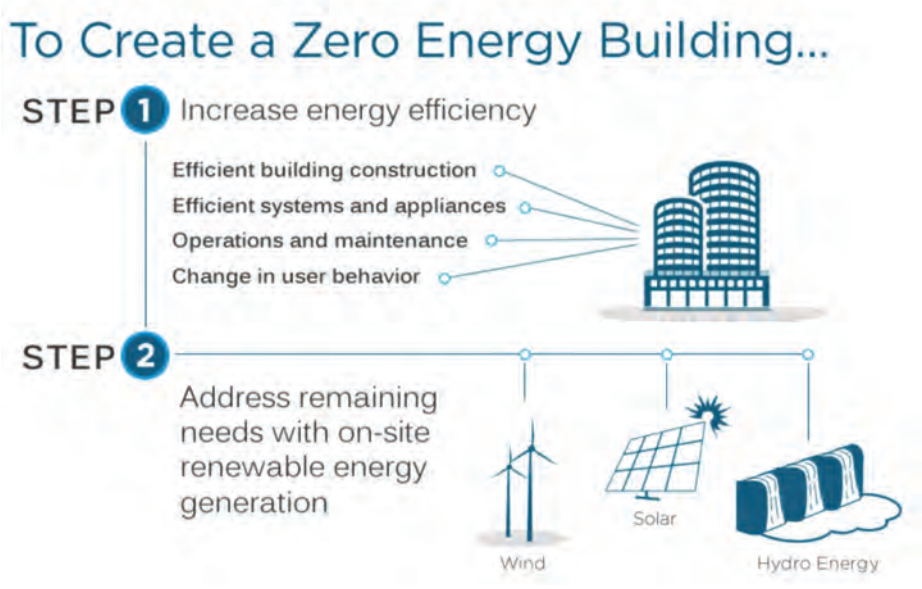

Figure 5. Net-zero energy building (Source: Energy.gov, Office of Energy Efficiency & Renewable Energy)
图5. 净零能耗建筑（来源：Energy.gov, Office of Energy Efficiency & Renewable Energy）

such that the tower would require no water from public utilities? Is any of this feasible?

The "how" may be uncertain, but the "why" is clear. There has to be a break from dependence on outside resources, utilities, and infrastructure, and to facilitate it, innovation is needed in three areas: how the tower is used, how it is built, and how it addresses human scale and human needs.

Construction Innovation: New Ways to Build

The tower of the future needs to be a fully efficient, lean material assemblage that integrates all aspects of its mechanical operation and fusion of those traditionally different parts of construction into one high-performance engine. Affordable, innovative, holistic approaches to net-zero energy and performance principles need to be incorporated, and a full consideration and understanding of how the tower's component pieces help contribute to its ultimate performance is essential (Figure 5).

Also important to the tower's evolution are the quality and handling of materials from which it is made. Identifying new strategies for reducing construction materials and the removal of excess by-products can be instrumental in making the tower of the future less wasteful from the outset (Figure 6). With the assistance of research and development, finding new ways to use recyclable construction materials and lowering the amount of material that makes its way to landfills will also be a step in the right direction. To further eliminate excess materials, MEP can be fully integrating into structural systems, rendering MEP ducting conduit for electrical and other materials unnecessary.

Another exciting area for innovation is 3-D printing (Figure 7). Currently, it is mostly being used and tested in the construction of smaller-scale projects, but the benefits are many. Limitations aside, 3-D printing allows for the creation of customized systems as innovative as you can draw them. Additionally, the ability to manufacture pieces and parts on-site and in a controlled environment can further contribute to waste reduction, quicker construction, and an increase in the overall quality of the built environment in ways previously unimaginable.

This latter is not necessarily unbroken ground, but it would be new in its application to architecture and design. Take, for instance, the ways in which surgical teams have adopted new strategies for accuracy and efficiency by learning from race car pit crews over the last several years. Consider this from a 2010 American Medical News article:

Figure 6. Construction waste (Source: by Philip and published on August 23, 2013 at 1:05 pm. It's filed under C&D Waste, Economics, Facts, Landfills)
图6. 建筑废料（来源：by Philip and published on August 23, 2013 at 1:05 pm. It's filed under C&D Waste, Economics, Facts, Landfills）

楼是否需要满足耕种和粮食生产的要求？以及这将会需要哪些资源？ 塔楼如何才能减少能量消耗，同时做到自发电和净化周围空气？ 如何利用气流烟囱效应发电？以及如何优化水回收利用，使塔楼无需从公共设施取水？ 这些设想可行吗？

"如何做"我们尚且不清楚，但是"为什么要这么做"却再清楚不过。 我们必须改变依赖外部资源，公共设施和基础设施的现状。要实现这个目标，我们必须从三个方面实行创新：如何利用塔楼，如何建造塔楼，以及塔楼如何解决人类人口问题和满足人类需求。

施工创新 新建造方法

未来的塔楼应是完全高效的物质集合体，将机械操作各个方面和传统施工的各部分融合合并为一个高效能发动机。 我们应该将平价、创新、整体的净零能耗方法和实施原则相结合，同时充分考虑和理解塔楼组件如何帮助实现最终性能，这一点至关重要（图5）。

同样，塔楼建造材料的质量和处理方式对于塔楼的进化也是很关键的。 制定新战略，以减少建筑材料和去除剩余副产品，这有助于建造未来塔楼时，从一开始减少浪费（图6）。 借助于研发，寻找新途径来使用可回收建筑材料，并减少需要填埋的材料使用量，也是向未来塔楼建造迈进了正确的一步。 为了进一步消除过剩材料，机械、电气和管道可以完全融入结构体系，从而无需MEP管道、电气和其他物质导管。

另一个令人振奋的创新领域是3D打印（图7）。 目前多在小规模项目施工过程中使用和测试。 它的好处很多：没有限制，3D打印使定制化体系创造得以实现，只要你画的出来就行。 另外，它可以在施工现场和可控的环境内制作各种部件，这样有利于进一步减少废料，加快施工速度和增加建成环境的整体质量，这种方式在以前是不敢想象的。 （鸡蛋项目，设计师Michiel van der Kley）

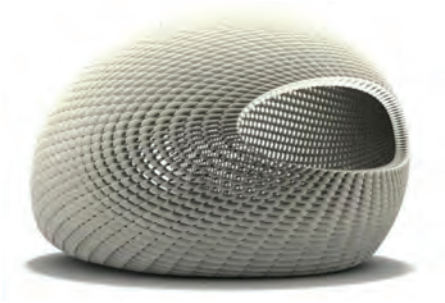

Figure 7. 3-D printing (Source: Crowd-sourced Project Egg Artwork, Posted on December 9, 2013 by KKHausman)
图7. 3D 打印（来源：Crowd-sourced Project Egg Artwork, Posted on December 9, 2013 by KKHausman）

Figure 8. Aviation assemblage process (Source: Photo courtesy Boeing : 8/10/2008 Modern Machine Shop, Sara Black)
图8. 飞机装配过程（来源：Photo courtesy Boeing : 8/10/2008 Modern Machine Shop, Sara Black）

> "Hospitals in at least a dozen countries, including the US, are learning how to translate the split-second timing and near-perfect synchronization of Formula One pit crews to the high-risk handoffs of patients from surgery to recovery and intensive care. The racing crews can refuel a car and change all four tires in seven seconds, and no F1 driver has died at the wheel in a Grand Prix race since 1994."

Could we not find similar areas for improvement in tall tower construction? Perhaps a Formula One pit crew isn't the solution, but maybe the architecture and design industry can learn from others, such as aviation (Figure 8) or the automobile industry, and conceive of new methods for pre-assembling large parts in the factory with a multi-disciplinary team, while controlling both quality and waste.

Finally, analyzing the 24-hour life cycle of a tall tower in order to maximize the use, potential, and synergy between its mechanical systems – perhaps resulting in a singular driving engine for the tower – will most certainly influence the ways in which towers are used and how spaces are connected, providing new benefits to end users. We already see this happening with office and retail spaces around the world through the concept of "flexible space." When office workers go home or the shops close up for the night, a little creativity with programming and configuration can take a space from being animated for eight hours a day to 24/7.

Figure 9. The human psyche (Source: http://www.fotfactory.co.uk/Brain/BrainOpening.html)
图9. 人类精神（来源：http://www.fotfactory.co.uk/Brain/BrainOpening.html）

Human Adaptation

With so many areas for potential innovation to aid the tower of the future's evolution, there are also plenty of limitations; however, it may be that the tower's ability to be self-sufficient and the way in which it is constructed may not present the greatest obstacles. Many of these advances will be made possible by new technology, and, over the course of history, what was previously considered impossible typically does not remain so for very long. We adapt; we find ways to deal with the logistics of building at ever-increasing heights and innovate with our usage of materials.

Perhaps it is the human psyche that will be the only real barrier to how tall we will build (Figure 9). Many have commented on the impact tall buildings have from a psychological perspective, and studies have been completed to document the possible effects on end users. A study completed by Robert Gifford for Architectural Science Review gathers data demonstrating that people's perception of towers depends, predictably, on differentiators of gender, age,

后者的应用并不一定是前无古人，但是它是最近才被应用在建筑和设计上的。 比如，外科医师采用新策略，在过去的几年中，从赛车后勤维修人员身上学习如何提高准确度和效率。 看看这则2010年美国医疗新闻：

> "包括美国在内的近十来个国家的医院，正在学习如何将一级方程式赛车后勤维修人员的精确到秒的计时和接近完美的同步操作，转化应用在病患由手术到康复或重症特别护理期间的高风险转移上面。 车队团队成员可以在7秒内为赛车补给燃料，并更换四只轮胎。自1994年以来，没有任何一级方程式赛车手因轮胎问题在国际汽车大奖赛中身亡。"

那么在塔楼建筑中，有没有类似需要改进的地方呢？ 也许一级方程式后勤维修人员不能给我们解决方案，但是建筑和设计行业可以借鉴其他行业，如飞机制造业（图8）或汽车制造业，并构思新方法，使多专业人士组成的团队在工厂预组大部件，并同时控制质量，减少废料的产生。

最后，分析塔楼24小时生命周期，以使塔楼的使用、潜力、各机械系统的协同可以达到最大程度（也许会为塔楼带来单一的驱动引擎），将毫无疑问影响塔楼的使用方式和各空间的连接方式，并为终端用户带来新的益处。 这种方式已经在全世界办公空间和商业（设计，价值，动线，面积）空间上得到体现，依据是"弹性空间"理论。 当办公室职员下班回家，或是商店晚上关门后，塔楼编程和设置上的一点小创意就可以将塔楼一天8小时的使用方式变为昼夜服务。

人类适应性

尽管未来塔楼进化有这么多可以创新的地方，它也有很多限制。 然而，这可能是因为塔楼自给自足的能力和建造方式并不算最大的难题。 新科技会将这些改进都变为现实，并且纵观历史，许多以前被看做是不可能的事到变为现实并没有要太久的时间。 我们不断适应着。我们寻找新方式，以解决日益增高的塔楼后勤问题，并探索创新物资的使用方式。

也许针对塔楼的高度问题，我们唯一面对的是心理障碍（图9）。 许多人曾从心理角度来评价高层建筑的影响，人们也做了许多研究在证明高层建筑对终端用户的可能影响。 罗伯特 吉福特为《建筑科学评论》完成的一项研究收集的数据表明，我们可以预见，人们对塔楼的看法因性别、年龄、社会和婚姻地位及是否有孩子而有所不同。 尽管一些结论不算完整，并且需要进一步研究，人们一般认为，高层建筑不是适合孩子和老人的环境，因为它们

social and marital status, and whether or not they have children. While some conclusions were incomplete and in need of more research, it is generally agreed that tall towers are not a suitable environment for children and the elderly due to safety concerns and the risk of social isolation, leading to depression.[1]

Particularly as we are now capable of building one full kilometer high, we must keep in mind that the sky may not, in fact, be the limit. These tall buildings take longer to enter and leave, presenting barriers to social interaction and street activation; however, there have been promising advances in lift technology and the implementation of communal areas for entertainment and recreation throughout (Figure 10). Additionally, while social media is no substitute for face-to-face interaction, it does provide undeniable benefits when it comes to facilitating the feeling of staying connected – as long as there is internet access, of course.

Incorporating green space and being friendly to the environment helps, too. Basic passive performance principles – building orientation, shading, daylighting, natural ventilation, breathable external façades, and green roofs – are all vital to urban areas in general, particularly for tall towers. While the completely green tower is yet to be realized, any strides made toward greater sustainability will contribute positively to the way that humans interact with this particularly building typology.

Of course, social interaction and nature won't solve all of the problems. Inherent physical qualities of tall buildings can, at times, push human tolerance to its extreme acceptable levels. The speed at which someone can travel in an elevator lift has a direct connection to ear pressure and can therefore cause dizziness and nausea and, in some cases, may render people unconscious. How towers respond to natural weather events can also pose risks that not everyone is willing to take – for example, the back-and-forth lateral movement of a tower during an earthquake or wind shear can seriously test our limits. The March 2011 earthquake in Japan demonstrated that the desire to live in tall towers can be seriously dampened by such motion. The BBC reported that, months after the 8.9 magnitude earthquake, the sheer terror felt by tall tower occupants led unit sales to plummet and some existing tenants to vacate, opting instead for mid- to low-rise accommodations.

Figure 10. Social interaction (Source: Marc Much, Eater Chicago)
图10. 社交互动（来源：Marc Much，Eater Chicago）

会带来安全隐患，使人们与社会隔离，并导致抑郁。[1]

尤其当我们现在有能力建造整整一千米高的建筑物，我们必须记住，事实上，天空并不是限制所在。 进入和离开这些高层建筑都要花费更长的时间，为人们参加社会活动和街道活动设置了障碍。 但是，无论是升举科技，还是随处可见的娱乐休闲公共区域的建设，都取得了不小的进步（图10）。 尽管社交媒体无法代替面对面的交流，但它的好处是确实存在的，它使人们感到自己没有与社会脱节，当然前提是能够上网。

塔楼建筑还应设有绿色植物区，并做到环保。 基本的被动式建筑原则，例如建造朝向，遮光，采光，自然通风，可呼吸的外立面，屋顶绿化，对于所有的城市，尤其是塔楼建筑，十分重要。 尽管完全的绿色塔楼还无法实现，但我们在增加塔楼可持续性上取得的任何进展，都将有利于人类和这种建筑类型的良好互动。

当然，社交互动和天然绿色不能解决所有的问题。 高层建筑的内在“身体素质”有时能够将人推到无法容忍的边缘。 人们乘坐直梯时，直梯升降速度直接影响人的耳压力，这会让人们感到头晕，恶心，极端情况下，让人失去意识。 塔楼在某些天气条件下产生的安全风险，并是不人人都愿意承受的，比如，地震时，塔楼会发生前前后后的横向位移，或是塔楼引起的风切变，都严重挑战我们的忍耐极限。 日本2011年3月份发生的地震足以动摇所有想要住进高层建筑的人们的想法。 据英国广播公司报导，在8.9级地震发生过后的数月，高层建筑使用者陷入极度恐慌，直接导致塔楼房产销售量大跌，而部分商家则直接搬离，转而选择中低层建筑。

1: Gifford, Robert. "The Consequences of Living in High-Rise Buildings." Architectural Science Review 50.1 (2007): 12-13. Web.

1：罗伯特 吉福特“住在高层建筑的后果。”《建筑科学评论》50.1（2007）： 12–13.万维网

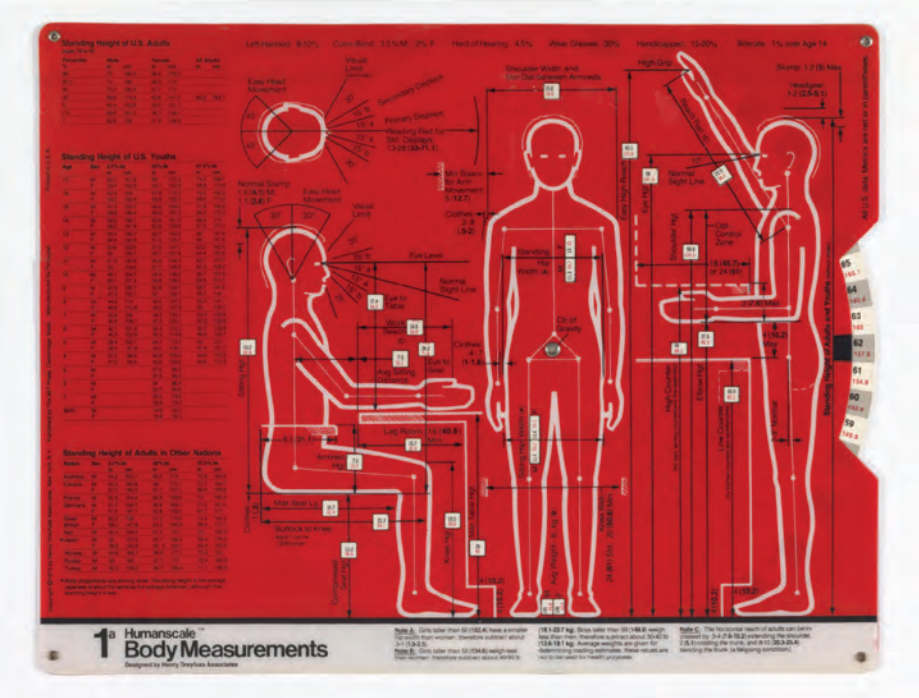

Figure 11. Human scale (Source: The Digital Humanscale is digitized version of Henry Dreyfuss and Neils Diffrient's classic HumanScale Charts)
图11. 人类尺度（来源：The Digital Humanscale is digitized version of Henry Dreyfuss and Neils Diffrient's classic HumanScale Charts）

With all of that said, there are measures to be taken to ensure a more intimate scale and comfortable interaction with tall towers. Bearing in mind that human scale and how we relate to the size and height of our surroundings is critical, it is advisable to understand and incorporate gradation such that the tower does not overpower those who inhabit it (Figure 11). Creating different levels also opens up interesting opportunities to introduce a sequence of experiences and to be creative with transitions and zoning. For instance, the entrance sequence is one of the most important, as it shapes the end user's initial impression of the building. Rather than standing directly under the tower façade with its full ground-to-sky elevation visible, a gradually stepped-up sequence of spaces can guide movement. Even small details like door sizes, hardware and entry-level façades can make a big impact when designed according to the proper scale. Pursuing a less dominant profile will help to reverse the consternation resulting from the tower's sheer height.

Conclusion

As our world's urban areas grapple with accommodating an increasing number of people, and as our cities turn to megacities, the tower will almost certainly continue to be a dominant building typology; however, the current approach to tower design and construction is unsustainable and, for all intents and purposes, must adapt to not only be self-sufficient but to improve its relationship to the urban fabric and end users. The tower must adapt, or it will not survive.

For the tower to be a living organism, it is our collective responsibility as architects and designers to forge a new way forward. We will have to address each pain point – construction waste, excessive costs, the need for advanced technology, and a better relationship to the human scale – in a holistic manner in order to spur the necessary "inherited" variations the tower needs to thrive. These innovations must be economical and environmentally sound, and thorough consideration must be given to how to adapt these new strategies to market and site conditions in different regions around the world if they are to be consistently and successfully applied.

Those who are drawn to the tall tower solely as a show of affluence and power and a symbol of the city writ large must seriously consider what makes for a better "symbol:" a wasteful, underutilized, expensive icon, or a pioneering structure that provides for itself and the city around it, thereby increasing the quality of life. Generating solar power, recycling wastewater, and facilitating urban farming – these are only a few possibilities for the tower of the future. Only time will tell where our ambitions and our ideas will lead us, but one thing is for sure: if we are to turn the tides of the backlash against and the fate of the tall tower, it must contribute to its own well-being and the well-being of those who inhabit its stacked floors.

尽管如此，我们仍可以采取措施，确保更加亲密的规模和与塔楼更加舒适的互动。记住，人性尺度以及周围建筑物的大小、高度对我们的影响是十分关键的。这里可取的做法是，牢记塔楼不能凌驾于它的使用者之上，并体现这种分级（图11）。创造不同级别也能提供有趣味的机会来引进各种经验，并在过渡和分区规划上体现创意。 比方说，建筑的入口序列是最重要的部分之一，因为它塑造人们对建筑物的第一印象。 比起直接立在塔楼正面下方，从地面到天空一览无余的入口，逐渐增加的空间序列能够引导运动。 根据适宜性尺度设计时，即使是很小的细节，入门的尺寸，五金，入门级立面都会产生很大的影响。 设计塔楼外形时，减少一些高耸林立的感觉，也能帮助转化人们因为高度而产生的恐惧感。

结论

世界上每个城市都在尽力克服人口膨胀问题，而我们的城市也都变成了特大城市，这种情况下，塔楼几乎必然继续成为主导的建筑类型。 尽管如此，塔楼目前的设计和建造方式却不是可持续性的。为了满足我们的所有意向和目的，塔楼必须实现自给自足，并且我们必须改善塔楼和城市构造以及终端使用者的关系。 塔楼必须适应新形势，否则必将淘汰。

为了将塔楼打造成一个活的生物体，我们的建筑师和设计师都肩负着迎难而上的共同责任。 为了刺激塔楼所需的”可遗传的”变异，使其蓬勃发展，我们必须全面地解决每一个痛点，如建筑垃圾，成本过高，缺乏先进技术，以及更好地回归人性尺度。 这些创新必须是经济环保的，我们还必须考虑周全，如何使这些新策略适应世界不同地区的市场和场地条件，以确保这些策略的应用能够始终如一，并获得成功。

而那些青睐塔楼建筑，仅仅因为它能够显示财富和权利，并且是大城市的象征的人们，应该严肃思考什么样的”象征”才是更好的，是浪费的、未充分使用的、昂贵的“象征”？还是一座开创式的、能够满足本身和所在城市需求的、提高人们生活质量的“象征”更好呢？ 太阳能发电，废水回收利用，城市农耕，这些在未来的塔楼都有可能实现。 我们的抱负和构想会创造一个什么样的未来，只有时间能告诉我们。 但有一点是肯定的，如果我们想要扭转反对的声浪和改变塔楼的命运，未来的塔楼必须能够自我完善，并为它的使用者创造幸福生活。