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Burj Khalifa: Creating the World's Tallest Integrated "Vertical City"

哈利法塔：创造全球最高的复合性“垂直城市”



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Fred Durie, a U.K. civil engineer by training, has worked in Dubai since 1986, initially with the Dubai Municipality, before joining Emaar in 2001. In his role as Executive Director of Development he managed Emaar's major developments at Dubai Marina, Emirates Living, Arabian Ranches and most notably its flagship development at Downtown Dubai, which includes Burj Khalifa, currently the world's tallest building.

In 2008 he became CEO for Emaar JV companies in Saudi Arabia and, until late 2011, headed a team carrying out development services for Kingdom Holdings on projects in Riyadh and Jeddah. The project in Jeddah is planned around the Kingdom Tower which will be the future tallest building in the world.

Based in Dubai, he is now CEO for Emaar International working on developments in Egypt, Saudi Arabia, Morocco, Syria, Jordan, Lebanon, Turkey and Pakistan.

弗雷德·杜里是一位来自英国的土木工程师。他1986年去迪拜工作。先是服务于迪拜市政府，2001年加入了艾马尔公司。他在艾马尔公司任发展部执行主任一职，主要负责迪拜码头、阿联酋生活、阿拉伯农场和著名的迪拜市中心的旗舰发展项目。哈利法塔是该旗舰发展项目的一部分。哈利法塔是目前世界上最高的建筑。

2008年，杜里被任命为沙特阿拉伯的艾马尔JV公司的首席执行官（CEO）。至2011年下半年，由杜里领导的团队主要负责王国控股在利雅得和吉达的项目开发。在吉达的项目位于王国塔附近。该项目将成为未来世界最高楼。

杜里现在任职总部设在迪拜的艾马尔国际公司的首席执行官。他们负责的开发项目遍及埃及、沙特阿拉伯、摩洛哥、叙利亚、约旦、黎巴嫩、土耳其和巴基斯坦。

Abstract

Burj Khalifa, the world's tallest building, is more than simply an icon for fast-growing Dubai. Emaar Properties created the world's most dramatic example of an integrated vertical city, combining residential space, a luxury hotel, restaurants, offices and retail space into one efficient tower, where people can live, work and play. The average daily occupancy of Burj Khalifa is more than 6,000 people. The 828-meter tower also serves as a centerpiece of Downtown Dubai, a \$20 billion, 500-acre development which creates a new urban environment for the emirate. The increasing value of land and projects in the area due to the presence of the tower is now known as the "Burj Khalifa Effect." This paper discusses the challenges in designing and building the world's tallest building and making it a vertical community, while integrating the project with the surrounding development plan.

Keywords: Dubai, Burj Khalifa, Planning, Environment

摘要

哈利法塔作为世界上最高的建筑，不仅仅是快速发展中的迪拜的标志。艾马尔地产公司创造了世界上让人印象深刻的成功案例，一个综合性的垂直城市。哈利法塔包含了居住空间、豪华酒店、餐馆、办公室和零售空间。人们可以在那里生活、工作和娱乐。哈利法塔平均每天入住超过6000人。828米高的哈利法塔也是迪拜商业区的核心，该商业区耗资200亿，占地500英亩，将为酋长国创造新的城市环境。由于哈利法塔的存在，该地区的土地和项目都有所增值，大家称之为“哈利法塔效应”。本文讨论了在设计和建造这座世界最高建筑，使其成为一个垂直社区，并同时结合周边发展项目过程中的挑战。

关键词：迪拜，哈利法塔，规划，环境

Introduction

The Burj Khalifa, unlike previous "World's Tallest" buildings, is a mixed use development accommodating the world's first Armani Hotel, hotel serviced apartments, residential apartments, restaurants and office space, and as such operates on a "round the clock" basis. The average daily occupancy of the building is in excess of 6,000 people (see Figure 1).

At 828 meters (2,716.5 ft) in height, Burj Khalifa features more than 1.85 million square feet of residential space and more than 300,000 square feet of prime business space, in addition to the Armani Hotel Dubai and private Armani Residences Dubai. It also includes four pools, clubs, an exclusive residents' lounge, health facilities and At.mosphere, a fine dining restaurant. In many ways, the tower represents a coherent set of ideas about technology, design, art and ambition. The scale is unprecedented: 330,000 cubic meters of concrete, 142,000 square meters of glass and 57 elevators.

But tall buildings in the 21st century do not stand alone. Alone they might come to be seen as little more than grandiose gestures. If they are to truly live, then they must be part of a greater scheme, and that greater scheme is the city. A city must build a social space, a

介绍

哈利法塔与以往的“世界最高”建筑不同。哈利法塔是一个综合性大楼，包含了世界上第一个阿玛尼酒店、酒店服务式公寓、住宅、餐馆和写字楼，并为大楼内人员提供不间断的服务。哈利法塔平均每天入住超过6000人（见图2）。

哈利法塔高828米（2716.5英尺），内部设有超过185万平方英尺的住宅区和超过30万平方英尺的高级业务空间。塔内包括阿玛尼迪拜酒店和私人阿玛尼迪拜公寓。它还包括4个游泳池、会所、居民休息休闲区、医疗设施和名为At.mosphere的高级餐厅。在许多方面，哈利法塔的设计将高科技、设计、艺术和野心融为一体。哈利法塔的规模是空前的：33万立方米混凝土，142000平方米的玻璃幕墙和57台电梯。

21世纪的高楼大厦不是独立的。单独看这些建筑，他们可能显得很宏伟。如果真正实现这些建筑的价值，那么他们必须是城市规划的一部分。一个城市必须建立一个社会空间、商业空间、艺术、体育和文化空间，人们才可以在这一个城市工作、休息和娱乐。一个城市由建筑物组成，城市也需规划建筑物。

就像吉隆坡的双子塔一样，哈利法塔在城市规划中占有更重的分量。该塔是新迪拜“商业中心”的核心焦点。造价200亿

commercial space, a space for art and sport and culture, a place within which people can work, rest and play. Buildings make cities, but cities also make buildings.

Like Kuala Lumpur's Petronas Towers, Burj Khalifa is part of a much larger, greater scheme. The tower is the central focus of the new Dubai "downtown," a US\$20 billion mixed use development covering 500 acres. Key elements include The Dubai Mall, one of the largest shopping and entertainment destinations in the world; The Dubai Fountain, the world tallest performing fountain, shooting water 500 feet high; and more than 1 million square feet of office space. Building and integrating these diverse elements to create a living, breathing city were just as complicated as building the world's tallest tower (see Figure 2).

Even as the project evolved, staying true to the original vision for Downtown Dubai was crucial. Typically in a project like this on a mass urban scale anywhere in the world, a wide variety of compromises are made, due to the involvement of different interests. It is compromised because a city planner wants to change something, or one mayor wants it this color, another mayor wants it that color. With this project, that wasn't the case. From the commencement of construction in 2004 until the inauguration in 2010, the building became part of the collective experience both of those who worked there and of those who admired it from afar.

Early Stages

Burj Khalifa was designed as the tallest structure ever built by man. The tower itself required great leaps forwards in tall building technology. Gravity load analysis, aerodynamic shaping and wind engineering played a major role in the architectural massing and design of the project. From the commencement of construction in 2004, the tower became part of the collective experience of everyone who worked on the project, as they sought to solve issues and create new approaches for the structure.

Emaar Properties PJSC, the developer, is best known for luxury master-planned developments. Founded in 1997, Emaar is a Dubai-based global property developer listed on the Dubai Financial Market. It has operations in several countries, in addition to the UAE, where it has also developed the Dubai Marina - a master-planned waterfront development with the "world's densest block," including several of the world's tallest residential towers.

The design of Burj Khalifa is based on the geometry of a desert flower and patterns found in Islamic architecture. The towering mass is organized around a central core with three wings. Each wing consists of four bays. At every seventh floor one outer bay ends as the structure spirals to the sky. The Y-shaped floor plans maximize views and add natural light to the interior spaces. The tower is built from reinforced concrete to level 156, and then structured steel to the pinnacle. As it grows taller, the tower grows thinner, reducing wind dynamic effects (see Figure 3).

The lateral load reducing system consists of reinforced concrete core walls, linked to the exterior columns through a series of shear wall panels at the mechanical levels. The core walls vary from 500 to 1,300 millimeters (19.69 inches to 51.18 inches), and are typically linked through a series of 800 to 1,100 millimeter reinforced concrete or composite link beams at every level (see Figure 4).

The exterior cladding is comprised of reflective glazing with aluminum



Figure 1. Burj Khalifa standing among the buildings of the city. (Image: SOM, Nick Merrick Hedrich Blessing, 2010.)

图1. 哈利法塔耸立于城市的建筑物之间。(图片提供: SOM, Nick Merrick Hedrich Blessing, 2010)

美元, 占地500英亩的商业区包含综合用途。其主要元素包括: 世界上最大的购物和娱乐目的地之一迪拜购物中心; 射水500英尺高, 世界上最高的表演喷泉迪拜喷泉; 和超过100万平方英尺的办公空间。建设和设计整合这些不同的元素, 创造一个活生生的、会呼吸的城市, 其复杂程度不亚于建造世界第一高楼(见图2)。

即使项目已经启动, 保持迪拜市中心的城市特点是至关重要的。通常, 无论这样一个大尺度的城市项目发生在世界的哪个地方, 由于不同利益方的参与造成的各种各样的妥协和修改是难免的。比如, 城市规划者想要改变一些东西, 或者一个市长希望这个颜色, 另一个市长希望不同的颜色。这个项目的情况并非如此。从2004年破土动工, 直到在2010年的典礼, 大楼的建设是基于在当地工作的人和远道而来的专家集体经验基础上的。

初期阶段

哈利法塔被设计为人类有史以来建造的最高建筑。在建造时, 需要拥有高超的高层建筑技术。重力荷载分析、气动成型和风力工



Figure 2. The master plan for the Burj Khalifa development.

图2. 哈利法塔的总体规划

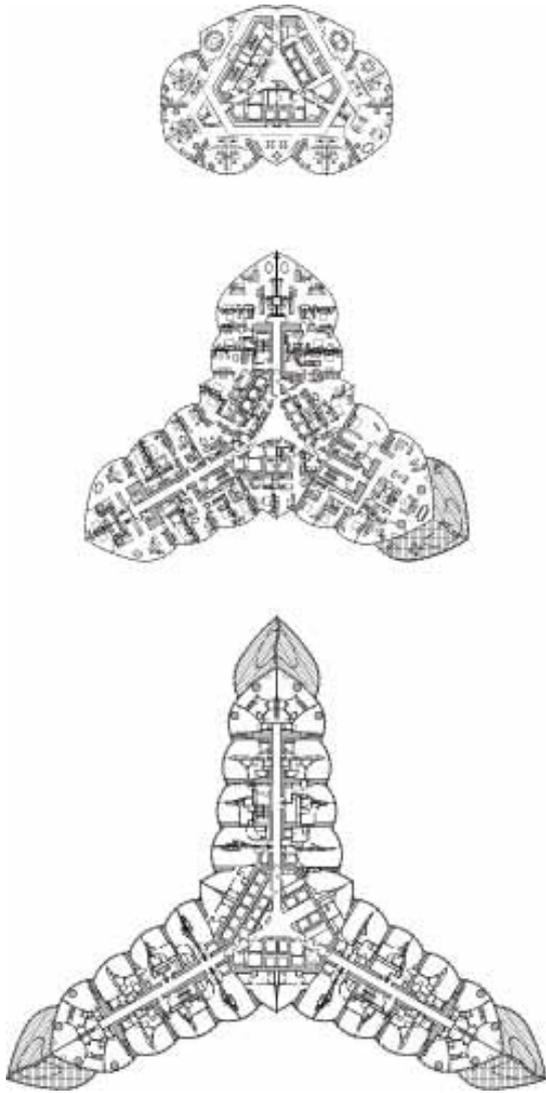


Figure 3. The floor plates reduce in size as the building ascends.
图3. 塔面积随塔高而减小

and stainless steel spandrel panels and stainless steel vertical tubular fins. Close to 26,000 glass panels, each individually hand-cut, were used in the exterior cladding, designed and fabricated by more than 300 cladding specialists from China. The curtain wall would cover what is equivalent to 25 American football fields. The cladding system is designed to withstand Dubai's extreme summer heat. A World War II airplane engine was used for dynamic wind and water testing (see Figure 5).

Making the building people-friendly was as important as the structural engineering. The podium, constructed with a suspended cable-net structure, allows three separate entries for the offices, residences and Armani hotel. The observatory elevators are double deck cabs capable of traveling at 10 meters per second, with a capacity for 12-14 people per cab. Burj Khalifa is the first mega-high rise in which certain elevators are programmed to permit controlled evacuation for fire or security events. For the convenience of homeowners, the tower is divided into sections with exclusive Sky Lobbies on Levels 43, 76 and 123. There are state-of-the-art fitness facilities including Jacuzzis on Levels 43 and 76. The sky lobbies on 43 and 76 both have swimming pools and a recreational room that can be utilised for special gatherings and receptions. Other facilities for residents include a private library, an upmarket convenience store, Downtown Deli, and a meeting place.

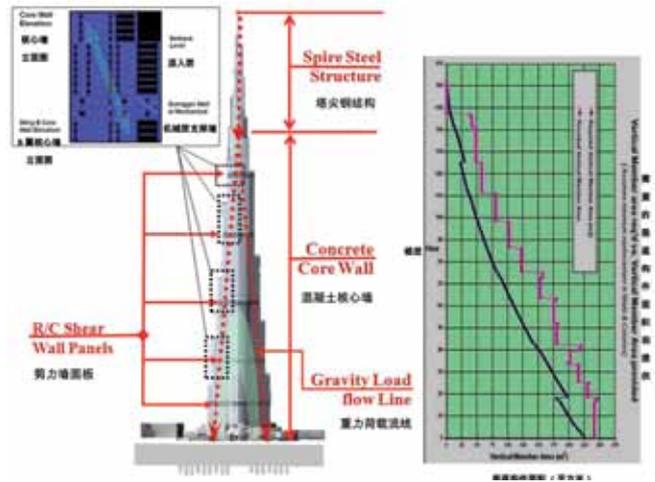


Figure 4. Gravity Load Management diagrams (Image: Ahmad_Adelrazaq).
图4. 重力负荷设计图 (图片提供: Ahmad_Adelrazaq)

程在建筑重量和项目设计上起到了重要作用。从2004年开始建设，哈利法塔的建设集中了大家的集体经验，在项目过程中，大家不断寻求解决问题的办法，并创造新的方法。

开发商艾马尔地产PJSC最出名的是豪华项目的开发。艾马尔公司成立于1997年，是一个总部设在迪拜的国际开发公司，并是迪拜金融市场上市的房地产开发商。除了阿联酋，该公司在几个国家都有分部。该公司的迪拜码头项目是一个在海港旁发展的“世界上最密集的区块”，其中包括了一些世界上最高的住宅大楼。

哈利法塔的设计参考了伊斯兰建筑模式和沙漠之花的几何形状。建筑由一个核心与三翼组成。每个翼都由四个凸出部组成。每七层楼都有一个外层凸出部终止螺旋结构指向天空。Y形的平面图扩大了视野，并增加室内空间的自然采光。该塔的前156层使用钢筋混凝土结构，上层使用结构钢材直至顶峰。随着塔身增高，塔的面积减小，从而降低了风力对建筑结构上的影响（见图3）。

横向负荷减荷系统包括钢筋混凝土核心墙，并在机械层通过外柱将核心墙连接于一系列的剪力墙板。核心墙厚度不同，从500毫米到1300毫米（19.69英寸至51.18英寸）不等。核心墙通常与每一层的800至1100毫米的钢筋混凝土或复合链接横梁连接（见图4）。

哈利法塔外部幕墙材料是由反射玻璃、铝和带纹理的不锈钢拱肩板、不锈钢管状垂直片组成。用于外墙的26000块左右的玻璃面板，每个都经手工切割，由300多位来自中国的专业人士设计和制造。幕墙面积大小相当于25个美式足球场。幕墙系统的设计将能承受迪拜的酷暑。一个二战时的飞机引擎被用于动态风力和水的测试（见图5）。

人性化设计与建筑设计同等重要。裙房为悬索网结构。办公区、住宅区和阿玛尼酒店各自配备了独立的出入口。观景电梯具备双层轿厢，可容12-14人，以每秒10米的速度行驶。哈利法塔是第一个在火灾或安全事件中允许使用电梯控制疏散的超高层建筑。为方便业主，哈利法塔在第43、76和123层设置了空中大堂。在43和76层的空中大堂备有最先进的健身设施和按摩池。43和76层还都备有游泳池和娱乐室，供业主召开聚会和招待会。居民的其他设施包括一个私人图书馆、高档便利店、熟食和会议室等。

不论是最简单的照明电路，还是生命安全系统，哈利法塔都提供了最先进的建筑智能化体系。哈利法塔这个聚集了住宅区、办公区和阿玛尼酒店的独特建筑，通过优化环境的性能和运营效率来加强对能源和资产的管理。从基础设施的角度来看，这是非常和谐的建设。设计者致力于优化建筑物的使用周期，主要手段为减少资产成本，降低能源成本和通过技术协调减少备用设备。

As a facility, the Burj Khalifa delivers the latest generation in building intelligence from the simplest lighting circuit through ambience and life safety systems. Energy and asset management was enhanced in ways that optimize environmental performance and operational efficiencies across a single lifestyle building, facilitating the unique combination of residential, offices and the Armani Hotel. It is very much a converged building, from an infrastructure standpoint. The designers focused on a key opportunity to optimize the building's life cycle by reducing the cost of assets, reducing energy costs and reducing requirements for spare parts by coordinating these technologies.

Construction

The foundation work on Burj Khalifa was completed in February, 2005 and level 100 was reached in January 2007. By April of 2008 it was the world's largest man-made structure. Exterior cladding of Burj Khalifa began in May 2007 and was completed in September 2009. At the initial stage of installation, the team progressed at the rate of about 20 to 30 panels per day and eventually achieved as many as 175 panels per day (see Figure 6).

More than 30 on-site contracting companies were involved in the construction process. At the peak of construction, more than 12,000 workers and contractors were on site every day, representing more than 100 nationalities. The building opened to the public in January, 2010.

The finished tower is the result of several new advances in material technologies, structural engineering, wind engineering, seismic engineering and computer technology, as well as construction methods. Several key technologies were necessary to achieve the tight construction schedule:

- Auto-climbing formwork system
- Rebar pre-fabrication
- High performance concrete
- Advanced concrete pumping technology
- Simple drophead formwork system

The tower accomplished a world record for the highest installation of an aluminum and glass façade, at a height of 512 meters. The total weight of aluminum used on Burj Khalifa is equivalent to that of five A380 aircraft and the total length of stainless steel bull nose fins is 293 times the height of the Eiffel Tower in Paris.

In November, 2007, the highest reinforced concrete corewalls were pumped using 80 MPa concrete from ground level, a vertical height of 601 meters, smashing the previous pumping record on a building of 470 meters on the Taipei 101, the world's second tallest tower; and the previous world record for vertical pumping of 532 meters for an extension to the Riva del Garda Hydroelectric Power Plant in 1994. The concrete pressure during pumping to this level was nearly 200 bars. The amount of rebar used for the tower is 31,400 metric tons—laid end to end this would extend over a quarter of the way around the world.

The Spire comprises 4,000 tons of structural steel and was constructed from inside the building then jacked to its full height of over 200 meters (700 feet) using a hydraulic pump. In addition to securing Burj Khalifa's place as the world's tallest structure, the spire is integral to the overall design, creating a sense of completion for the landmark. The spire also houses communications equipment (see Figure 7).



Figure 5. Glass façade of Burj Khalifa (Image: SOM, Nick Merrick Hedrich Blessing, 2010)
图5. 哈利法塔的玻璃幕墙 (图片提供: SOM, Nick Merrick Hedrich Blessing, 2010)

施工

哈利法塔的地基于2005年2月完成。至2007年1月，已建成100层。2008年4月，它成为了世界上最大的人造结构。哈利法塔的外墙施工于2007年5月开始，并于2009年9月完成。在安装的初期，施工队的进展为每天20至30块幕墙板。在后来的施工中最终达到了每天安装175块幕墙板（见图6）。

在施工过程中，有多达30多个承包公司共同施工。在施工高峰期，每天在工地有来自100多个国家的超过12,000名工人和承包商。哈利法塔在2010年1月向公众开放。

哈利法塔在材料技术、结构工程、风工程、地震工程和计算机技术，以及施工方法上均采用了新技术。在工期紧的情况下，以下几个技术为关键：

- 自动攀行的框架系统
- 预制钢筋
- 高性能混凝土
- 先进的混凝土泵送技术
- 简单的软顶敞篷框架系统

哈利法塔的铝和玻璃幕墙的安装创造了最高安装世界纪录，高度为512米。哈利法塔上使用铝的总重量相当于5架A380飞机。不锈钢散热片的总长度是巴黎艾菲尔铁塔高度的293倍。



Figure 6. The concrete base for the tower.
图6. 哈利法塔的混凝土地基

Downtown Dubai was developed concurrently with Burj Khalifa to ensure that the area would quickly reach critical mass as a leisure and entertainment destination. The Dubai Mall opened in 2008, and features a total of 3.77 million square feet of gross leasable space. The mall includes Dubai Aquarium & Underwater Zoo, which holds the Guinness World Record for the largest acrylic viewing panel; the Olympic sized Dubai Ice Rink; the region's first SEGA Republic, the largest of its kind indoor theme park; KidZania®, the only one of its kind children's edutainment center in the entire Middle East region; and the 22-screen Reel Cinemas, one of the region's largest megaplexes that can seat over 2,800 people.

But the mall and Burj Khalifa are only the centerpieces for a diverse, self-contained destination and community. The site includes parks, green space, the 12-hectare Burj Lake and three-hectare Burj Park, in addition to the musical Dubai Fountain, which has become an attraction of its own. Downtown Dubai also features world-class hospitality & leisure facilities including the Armani Hotel Dubai, the world's first Armani Hotel, located in Burj Khalifa; The Address Downtown Dubai; The Address Dubai Mall; The Palace--The Old Town; and Al Manzil and Qamardeen in The Old Town.

Downtown Dubai also includes several thousand residential units, in addition to the 900 apartments in Burj Khalifa, helping to create that Downtown Dubai is a place for people to live and work, beyond the attractions. The initial marketing campaign labeled Downtown Dubai, "The Centre of Now" (see Figure 8).

Transition from Construction to Management

Transitioning from construction to Facilities Management and the associated mobilization, stabilization and optimization of both staff and systems was a challenge, considering the scope and diversity of the building. Mobilization allowed the FM Team to fully prepare themselves and all elements of the service providers and execution model to facilitate a seamless and painless transition from a construction site to an operational facility. By far the most demanding aspect of any such Facilities Management delivery provision is not only working with the usual defects liability period challenges, but also the ongoing operational understanding of the installed systems. It is essential that Facilities Management is part of the project team from the initial concept right through to the handover of the construction.

The early mobilization for Burj Khalifa helped form the solid foundation for FM's stabilization, allowing the functionality of the building and processes to settle down, while ironing out the few blips and glitches that naturally occur in any building worldwide. It was during stabilization that early failure curves were hit for some of the supporting utility services. This is a natural occurrence and unavoidable in a facility of this size and complexity. At the optimization phase, the Facilities Management focused on enhancing the Facilities Management provision and driving costs out while increasing customer satisfaction.

There were many challenges, including Dubai Law 21 which required the installation of additional security cameras in hotel corridors when the building was operational and last minute modification to the landscaping. Additional challenges included tenants eager to relocate prior to final completion, an Armani Hotel open two months ahead of schedule and numerous enhancements to systems to improve the customer and visitor experience. Adjustments and modifications to operational systems and procedures took place at the handover stage and this will continue throughout the life of the building.



Figure 7: Burj Khalifa satellite image (Image: GeoEyeSatellite)
图7: 哈利法塔卫星图 (图片提供: GeoEyeSatellite)

2007年11月,最高的钢筋混凝土核心墙的灌注使用了80兆帕斯卡的泵将混凝土从地面泵送,其垂直高度为601米,远远超过了470米的世界上第二高楼台北101大楼的建设,也超过了在1994 Riva del Garda的水电厂的扩建项目中创造的垂直泵送532米的世界纪录。混凝土泵送的压强达到了近200巴(bar)。哈利法塔的钢筋总用量是31400吨。如果把这些钢筋首尾相连,可环绕地球四分之一周。

哈利法塔的塔尖由4000吨结构钢建成。塔尖的建造是在建筑内部完成,然后使用液压泵将其抬高至其全高度200米(700英尺)。为确保哈利法塔作为世界上最高的建筑,塔尖是整体设计中不可分割的一部分。它使这个地标性建筑具有完整感。塔尖还设有通讯设备(见图7)。

为确保该地区将很快成为大众休闲和娱乐的好去处,迪拜市区和哈利法塔的开发是同时间进行的。迪拜购物中心于2008年开业,共设有377万平方英尺的可出租商业空间。迪拜购物中心内设有迪拜水族馆和水下动物园,它拥有创吉尼斯世界纪录的最大的塑胶观赏面板。购物中心中还有具奥运会规模的迪拜溜冰场,该地区的第一个也是最大的SEGA共和国室内主题公园,在整个中东地区唯一的一个寓教于乐的儿童中心KidZania,和一个具22个放映厅、可容纳超过2800人的地区最大的电影城。



Figure 8. The Centre of Now Dubai marketing campaign.
图8. “现在的中心”迪拜营销活动

When the building was first opened a sequence of operations was developed for the manual operation of the air conditioning system. Once the building was occupied, temperature readings were taken throughout the building at various fan speeds and chilled water temperatures to ensure that all areas were at a comfortable temperature for the end users. New software was developed in order to optimize the operation and include it in the Building Automation System.

Finding service providers isn't easy for the world's tallest building. It takes time, focus and a world-class hospitality and facilities management strategy model to drive absolute world-class delivery. It also helps when there are several hundred staff members engaged in the hotel and facility management operations.

Impact

When Burj Khalifa opened in 2010, it was not only the tallest building in the world but also set a variety of other firsts:

- Tallest free-standing structure in the world
- Highest number of stories in the world
- Highest occupied floor in the world
- Highest outdoor observation deck in the world
- Elevator with the longest travel distance in the world
- Tallest service elevator in the world

Downtown Dubai, anchored by Burj Khalifa, was specifically designed to offer a mix of attractions and services. When Burj Khalifa opened, Downtown Dubai was already a thriving community, with businesses, hotels and residences. Still, Burj Khalifa had an impact. Rental rates for apartments rose 13 percent in the two months after Burj Khalifa opened, according to Landmark Advisory. "The most significant impact of the launch of Burj Khalifa will be on the overall master development surrounding the tower," Michael Michael, director of sales and leasing with Landmark Properties, told AMEinfo.com (see Figure 9).

While many communities around the world have struggled in the wake of the global economic slowdown, Downtown Dubai has been one of the quickest areas to recover. In the first quarter of 2011 apartment rents in Downtown Dubai increased 6 percent, according to CB Richard Ellis. The Dubai Mall, the most visited shopping and leisure destination in the world, attracted 54 million visitors in 2011, a 15 percent increase from 2010. The project continues to evolve. Construction is expected to start soon on an 820-meter air-conditioned glass walkway connecting the Dubai metro stop to The Dubai Mall, providing a further link to the rest of the city.

Reflections

Burj Khalifa is audacity, dreams and optimism converted into the reality of concrete, glass and steel. It is a coherent set of ideas about technology, design, art and ambition. It is also, more importantly, a reminder that a nation is rising and will continue to rise led by a strategy of hard work and unshakable determination.

Burj Khalifa is a virtuoso sculptor's masterpiece. It is an extraordinary union of art and engineering and a monument to passion and leadership. Great buildings, after all, speak of the cities where they reside and the aspirations of their leaders who built them. Buildings are where we store our memories. They are places where we can evoke history. They are a form of immortality, a place and a portal to

迪拜购物中心和哈利法塔仅是这个多样化且自成体系的城区的中心焦点。这个城区还包括公园、绿地、占地12公顷的哈利法塔湖、占地三公顷的迪拜公园和自成一景的迪拜音乐喷泉。迪拜市区还设有世界级的住宿和休闲设施，包括在哈利法塔内的世界上第一家阿玛尼酒店、The Address迪拜市中心、The Address迪拜购物中心、宫殿老城区和位于老城区的Al Manzil酒店和Qamardeen酒店。

迪拜市区还包括除了哈利法塔900个公寓住宅单元以外的几千个住宅单元，使迪拜市中心不光是观光景点，也为人们的生活和工作提供了场所。最初的营销活动称迪拜市中心为“现在的中心”（见图8）。

从建设到管理的过渡

基于哈利法塔的规模和多样性，从建设到管理的过渡、早期运营、稳定和优化工作人员和系统的关系是一个挑战。早期运营工作允许大楼管理团队充分做好人员和设备上的准备，实现从一个建筑工地到一个良好运作的大楼的无缝和无痛的过渡。迄今为止最困难的问题不仅是解决设施缺陷责任的过程，也有对各系统的运作的了解过程。管理团队的引入，从最初的阶段到建设移交都是必不可少的。哈利法塔的早期运营有助于帮助管理团队建立稳定坚实的基础，在修正瑕疵的过程中，使建筑的功能和运行流程逐渐平稳。瑕疵在世界范围内的任何建筑物中都是不可避免的。在稳定期，早期失效曲线会在一些配套的公用设施服务上有所体现。在这种规模和复杂性的建筑中是不可避免的。在系统优化阶段，管理团队着重加强设施管理和降低运营成本，同时提高客户满意度。

项目过程中的其他挑战包括迪拜的第21法案要求在酒店走廊额外安装的安全摄像机、在项目尾期对绿地设计的改进。项目过程中的挑战还包括住户希望在项目最终完工之前搬迁、阿玛尼酒店比原计划提前两个月开业，并要求对众多设施改进以提高顾客和游客满意度。对运营系统和流程的调整和修改不仅发生在交接阶段，并将贯穿整个建筑物的使用寿命。

当哈利法塔刚对外开放时，空调系统由手动操作。当商户和客人全部入住后，空调系统采取不同的风扇速度和冷却水温度，以确保大楼所有区域的用户都处在一个舒适的温度。通过开发使用新软件来优化系统操作，并将其包括在楼宇自动化系统之中。

对世界最高建筑来说，找到合适的服务提供商是不容易的。这需要时间、精力及世界一流的管理战略模板，以达到世界一流的服务。这还可以帮助协调几百名酒店及设施工作人员的业务。

影响

哈利法塔于2010年开业时，它不仅是世界上最高的建筑物，而且还拥有以下各方面的世界第一：

- 世界最高的独立结构
- 世界最高楼层
- 可容纳人数世界第一
- 世界最高室外观景台
- 世界上运行距离最长的电梯
- 世界上最高的电梯

与哈利法塔相结合，迪拜市区提供了一个旅游景点和服务设施的组合。哈利法塔开业时，迪拜市区已经是一个繁荣的社区，拥有企业，宾馆和住宅。尽管如此，哈利法塔的影响还是不可取代的。根据Landmark咨询公司的统计，在哈利法塔开业后两个月内



Figure 9. Burj Khalifa's grounds interact with the city on a deeper level (Image: SOM, Nick Merrick Hedrich Blessing, 2010.)
图9. 哈利法塔与城市的深层互动 (图片提供: SOM, Nick Merrick Hedrich Blessing, 2010)

history. The truth of a time and place is always elusive, but Burj Khalifa speaks irrevocably of the future.

As we forge ahead into the future, it is always worthwhile to look back from time to time, to see what we can learn from those who have gone before. Great human feats are achieved through advances in technology, through innovations in technology. There is also, however, the human element, the spirit and the will to get things done, the confidence and creativity to take that imaginative leap, the sheer determination to prove the doubters wrong. Very often, the impossible is simply that which has not yet been achieved.

What is the difference between a big building and a great building? The question is simple: Is it good for the human? Has it been designed properly to positively affect the residents and visitors to the building? In the case of the Burj Khalifa we believe that the answer is a resounding yes.

As Kotkin wrote: "Humankind's greatest creation has always been its cities. They represent the ultimate handiwork of our imagination as a species, testifying to our ability to reshape that natural environment in the most profound and lasting ways." The Emaar Chairman has always told us that we were not only building the world's tallest building in Downtown Dubai, but that we were trying to create the most prestigious square kilometer of real estate in the world, with an array of buildings and features, including Emaar Boulevard which forms the spine of the development, to complement and enhance Burj Khalifa. The number of visitors to the development has exceeded all of our expectations and is testament to the vision formed some eight short years ago.

A city must build a social space, a commercial space, a space for art and sport and culture, a place within which people can work, rest and play. Dubai is already well on the way to that end. Burj Khalifa is one single element, the still center of a dynamically changing habitat. It is growing because the strength of will and self-belief of its creators demand that it does so. Every day Downtown Dubai is being transformed. Burj Khalifa is simply the most obvious symbol of this transformation. It is the physical manifestation of a vision, a vision for

的, 当地公寓的出租率上升了13%。Landmark地产销售和租赁主任迈克尔·迈克尔告诉AMEinfo.com的代表, 哈利法塔的最显著的影响是对主塔周围的整体发展的影响(见图9)。

虽然世界上的许多地区都在因为全球经济放缓而挣扎, 迪拜市中心是恢复的最快的地区之一。根据理查德·埃里斯的统计, 在2011年第一季度, 迪拜市中心的公寓租金增长了6%。作为世界上访问量最大的购物和休闲目的地的迪拜购物中心, 在2011年吸引了54万人次, 比2010年增长了15%。这个项目还在继续的发展。一个820米长有空调的玻璃长廊的施工建造即将开始。这个长廊将连接迪拜地铁站和迪拜购物中心, 为城市提供了一个进一步的链接。

几点思考

哈利法塔将无畏、梦想和乐观转化为现实的混凝土、玻璃和钢材。它融合了技术、设计、艺术和野心的想法。同时, 更重要的是向世人提醒, 一个民族正在崛起, 并会继续上升。这与辛勤工作和不可动摇的决心是分不开的。

哈利法塔是技艺非凡的雕塑家的杰作。它是一个非凡的艺术和工程的结合体, 是一座集聚热情和领导力的纪念碑。伟大的建筑是所在城市和建造者的代言。建筑是我们保存记忆的地方。建筑是我们唤起历史的地方。他们是不朽的形式和一个历史的门户。时间和地点的真相总是难以捉摸, 但哈利法塔的未来是不可改变的。

在我们向未来稳步前进时, 应不时回头, 看看我们从以前的经历中能学到什么。人类伟大的壮举离不开技术的进步, 技术的创新。但是, 人的因素也很重要。精神和意志可以保证把事情做好, 信心和创造力来实现想象力的飞跃, 顽强的毅力来证明怀疑论者是错误的。很多时候, 所谓不可能完成的事, 只是尚未实现而已。

什么是一个大的建设和一个伟大的建筑之间的区别? 这个问题很简单: 它是对人类有益吗? 它的设计是否合理, 是否能对居民和游客产生积极的影响? 对哈利法塔而言, 我们相信, 答案是肯定的。

a new city for a relatively new nation. Along the highway the message was spelt out on billboards, "History Rising".

The construction of Burj Khalifa has fascinated the construction industry ever since the project started in Dubai in 2004. From the outset the height of the tower was confidential, but the ambition and goals of the client and designers remained very clear and open. Their aim was to construct the tallest building in the world, one with real iconic resonance, and they have been remarkably successful in achieving this.

There are critics who point to Burj Khalifa as a symbol of excess and say such monumental skyscrapers should not be built. We cannot agree with these opinions and hope that some of the heroic thoughts and rationale that have gone into the building, and the innovations that have made it possible, are there for all to see in this incredible, completed tower. Burj Khalifa has been a focal point of the international tall building world for many years. It has attracted worldwide attention towards Dubai and the tower is already a symbol of the Emirates. Burj Khalifa makes a clear statement to the world that Dubai has the technology, finance and determination to build the tallest and one of the most sophisticated towers in the world.

Conclusion

While most of the world's past tallest buildings were almost exclusively office towers, Burj Khalifa changed the paradigm by creating an integrated vertical city, combining residential, hotel and office space. Creating the tower required collaboration and innovation by dozens of experts working together toward common goals. The finished tower is the result of several new advances in material technologies, structural engineering, wind engineering, seismic engineering and computer technology, as well as construction methods.

The success of Downtown Dubai changed the economics of megatall buildings by illustrating how the value of surrounding land can be increased by the presence of an iconic tower. Other international tall building developers often cite the success of Downtown Dubai in the financial analysis of their own projects.

Emaar provided design development services for Kingdom Tower, the one-kilometer-tall tower under development in Saudi Arabia,

科特金曾经写过“人类最伟大的创造是他们的城市。他们是我们非凡的想象力和高超的手工艺的结合，证明了我们以最深刻最持久的方式重塑自然环境的能力。” 艾尔玛公司董事长一直告诉我们，我们不仅是在迪拜市中心建设世界第一高楼，我们还在试图创造世界上最负盛名的一平方公里的房地产。这一地产建筑物林立，艾尔玛大道就像脊梁一样完善和巩固了哈利法塔的地位。游客数量的发展已经远超出我们的期望，证实了我们八年前的预测和展望。

一个城市必须建立一个社会空间、商业空间、艺术、体育和文化空间。在这里，人们可以工作、休息和娱乐。迪拜市在这一方面已经发展得很好。哈利法塔是一个单一的元素，但它仍然是这个动态的城市的中心。它的增长，因为它的创造者的自我意志和信念的力量要求它这样做。每一天迪拜市中心都在转变。哈利法塔仅仅是这一转变的最明显的标志。它是一个相对新的国家的一个新的城市的展现。公路沿线的广告牌上写着“历史的崛起”。

自从2004年哈利法塔开始建设，它就令建筑业界着迷。从一开始塔的高度就是保密的，但客户和设计师的野心和目标却是非常明确和公开的。他们的目的是建造世界上最高的建筑物，一个真正的标志性建筑。他们也非常成功地实现了这一目标。

有评论家指出哈利法塔象征着过度，并认为不应该建立这样巨大的摩天大楼。我们并不认同这种观点。这座完整而不可思议的大楼展现了英雄的思想、强实的理论基础和创新。哈利法塔多年来一直是国际高层建筑业界的焦点。它吸引了全世界对迪拜的关注，已经是一个阿联酋的标志。哈利法塔是对世界的一个明确表态，迪拜拥有技术、资金和决心建立最高最先进的建筑。

结论

过去世界最高的建筑物大多数都是办公大楼。哈利法塔改变了这个模式。它是一座结合住宅、酒店和写字楼的综合垂直城市。创建这座建筑需要数十位专家的协作和创新，朝着共同的目标一起工作。哈利法塔的建设采用了材料技术、结构工程、风工程、地震工程和计算机技术，以及施工方法的一些新技术。

迪拜市中心的成功改变，说明了一个标志性建筑对周边土地升值的影响，改变了建筑经济学对超高层大楼的认识。其他国际高层建筑开发商在自己项目的财务分析上，往往以迪拜市中心的成功为例。

艾马尔公司为位于沙特阿拉伯的一千米高的王国塔项目提供了设



Figure 10. Burj Khalifa against the skyline (Image: Tim Griffith)
图10. 哈利法塔对着天际（图片提供：蒂姆·格里菲斯）

and worked closely with Adrian Smith + Gordon Gill Architecture throughout the concept and the schematic design phase for the building. There were many lessons from the construction of Burj Khalifa, both from a technical and operational perspective. When the time comes that Kingdom Tower, or another building, takes over the mantle of being the world's tallest building, Emaar will be just as gracious as Mr. Harace Lin of Taipei 101 in congratulating the new owners of this title as we fully appreciate all of the hard work and dedication of the owners, designers and contractors, without which such achievements cannot be reached. We will also remind them, as Mr. Lin reminded Emaar, that the completion of the construction of such a building is a great milestone to achieve, but that much work and dedication is then required to turn an iconic structure into a living building which will delight residents and impress visitors (see Figure 10).

计开发服务，并密切与阿德里安史密斯+戈登·吉尔建筑设计公司合作完成了整个项目的概念和原理图设计阶段的工作。哈利法塔的建设，无论是从技术和业务的角度有许多经验教训值得借鉴。当王国塔，或其他建筑物成为世界上最高的建筑物时，艾马尔公司将向当年世界第一高楼台北101大楼的设计者霍勒斯·林先生一样，对世界第一高楼这一称号的新主人表示祝贺。因为为我们欣赏所有的业主、设计师和承包商的辛勤工作和奉献精神。没有他们，这样的成就是不能达到的。我们也会提醒他们，就像当年林先生提醒艾马尔公司一样，这样一座建筑的落成，是一个伟大的里程碑，但日后还需付出大量的工作和奉献精神，将大楼变成一个受居民喜爱和被游客赞叹的活生生的建筑(见图10)。

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