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Author: Wai Ming (Thomas) Tsang, CEO, Ping An Financial Centre Construction & Development

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Ping An Finance Center: The Development and Construction of a Megatall

平安金融中心: 一栋超级高层的发展和建造

Wai Ming (Thomas) Tsang

Wai Ming (Thomas) Tsang

Shenzhen Ping An Financial Center Construction & Development Co., Ltd.
16, 4th Fu Hua Road, Fu Tian District
Shenzhen, Guangdong Province
China 518048

tel (电话): 86-13802885501
fax (传真): 86-0755-82726306
email (电子邮箱): ttwm1962@gmail.com

Mr. Wai Ming Tsang joined Ping An Real Estate as the CEO of Shenzhen Ping An Financial Center Construction & Development Co., Ltd. in April 2012. Before this he worked in Sun Hung Kai Properties, one of the largest global real estate developers, headquartered in Hong Kong. He acted as the Project Director in charge of the Shanghai IFC & Suzhou ICC projects. He is a registered architect in Hong Kong, an accredited mediator of the Hong Kong International Arbitration Center, and a Corporate Member of the Australian Institute of Building. He has over twenty five years of building construction and design management experience in Hong Kong and mainland China for many large scale projects, particularly in mega towers.

曾伟明，于2012年4月加入平安不动产，担任深圳平安金融中心建设发展有限公司首席执行官。在此之前，曾在大型房地产发展企业香港新鸿基担任项目总监，期间主管项目包括上海国际金融中心及苏州环贸中心等。他是香港注册建筑师，持有香港国际仲裁中心总调解员资格，也是澳大利亚建造师学会会员。在香港和内地从事建筑行业工作超过25年，拥有丰富的大型项目管理经验。

Abstract

The extraordinary megatall tower adopts extraordinary shape-optimization techniques and requires unprecedented levels of coordination to achieve its unique form.

Keywords: Megatall Building, Unique Form, Keynotes

摘要

这栋卓越的超高塔楼使用了顶尖的外形优化技术，并通过前所未有的协调规划，实现了独特造型。

关键词: 超高层，独特造型，亮点

Introduction

The Ping An Group has been undergoing rapid growth and development. It now has more than 200,000 staff, and office space is in significant demand. In an effort to consolidate functions in a single headquarters building, Ping An began construction of the Shenzhen Ping An Financial Center (PAFC) in 2009, which is targeted for completion in 2016. (Figure 1)

The project is being built in the Futian District of Shenzhen, a coastal city near Hong Kong that has expanded in population from 300,000 to more than 13 million in the past 35 years since it was declared a special economic zone by the government.

The tower comprises118 levels with GFA of 460,665 square meters, accommodating a daytime population of more than 20,000 users. Despite its size, it will also have significant sustainability credentials. With an extremely dense program and well-chosen materials and mechanical engineering strategies, PAFC will achieve an 18% to 25% savings beyond ASHRAE standards, and a 46% annual savings in energy costs over a conventionally constructed commercial office building of the same scale.

The confluence of these factors is by no means incidental. Only through highly coordinated design and communication efforts, the, PAFC project could be realized. This paper highlights some of the past experiences.

High-Performance Objectives

FFrom the start, the owners were determined to have a high-performance, sustainable

简介

平安集团正在飞速扩张和发展中。现在它拥有超过20万正式员工，办公面积有着很大的缺口。为了能在一个总部大楼中集合多种功能，平安集团在2009年开始在深圳建设平安金融中心 (PAFC)，预计在2016年交付使用。 (见图1)

项目位于深圳福田区，深圳是一个毗邻香港的海滨城市，在被政府设为经济特区之后在35年中人口从30万增加到1300万以上。

塔楼有118层，总建筑面积达到460,665平方，白天可达到20，000以上使用人次。然而，除去规模，它在可持续性方面也可圈可点。通过超高密度、精心选择的材料以及机电工程策略的考量，PAFC比起ASHRAE标准能再节约18-25%的能源，与传统方式建造的同规模商业办公楼相比每年能够节约46%的能耗。

这些因素的汇合绝不是偶然性的，只有通过在设计中高度的协调和充分的沟通，PAFC项目才可能实现。本文将重点介绍已经经历的一些亮点。

高性能目标

在项目的最开始，业主就决心要建设一个高性能的生态建筑，能够作为企业文化的一个缩影。聚焦点主要有以下3个:

1. 高效的竖向交通系统;
2. 高能效的立面;
3. 高质量室内空气 (IAQ)

定义"高性能"的基本原则是根据美国能源高性能生态建筑部门 (HPSB) 的规范来制定

building that epitomized their corporate values. The focus centered around three main areas:

1. an effective vertical transportation system
2. an energy-efficient façade, and
3. high indoor air quality (IAQ).

The general principles governing the definition of "high performance" were modeled after the United States Department of Energy's High Performance and Sustainable Buildings (HPSB) guidelines. The primary characteristics of HPSBs are:

- **Quantifiable.** Every aspect of environmental performance is monitored throughout the building life-cycle. This ranges from computational modeling during the concept and design stages, the specifications and implementation during the construction stages, and the measurement and verification during the operation stage.
- **Integral.** No single discipline alone can provide the exemplary performance in all aspects of environmental performance. Hence the design of High Performance Buildings is an integrated design process, where the performance goals are agreed upon, with all teams aware of their responsibilities during each stage of the building life-cycle.
- **Visual.** To achieve the cross-team exemplary performance described above, it is necessary to develop effective means of communication to achieve the environmental performance. This is achieved through Building Environmental Modeling, which analyses the various aspects and presents it on a Three-Dimension visual platform from computer modeling tools.

Through implementing these principles, PAFC aims to achieve the US Green Building Certification System – Leadership in Energy and Environment Design (LEED) Gold rating.

Site Planning and Architectural Design

The broad vision for PAFC as expressed by the architects was that the building would be visually striking reconciliation of the demands for a high design occupancy requirement of 11 meters per person and a floor-to-site area ratio exceeding 20. PAFC's entire full-time office-employee population of 20,000 employees is stacked on a 72-meter by 72-meter footprint constrained by the tower's irregular piano-shaped site. At this density, the entire global workforce, estimated at 3 billion workers, could be housed in a land area less than 1,000 square kilometers – the size of Shenzhen itself.

The shape of the tower is thus like that of a taught steel cable, pulled by the sky and ground at once, emphasized by the eight composite super-columns that pass beyond the building envelope. Its benefits are more than aesthetic – they are also practical. The streamlining of the tower shape brings measurable benefits in improving structural and wind performance. In all, PAFC achieves a 32% reduction in overturning moment and 35% reduction in wind load compared to China code, due to the shape of the tower. To support a target 12.5-meter leasing depth throughout, the core is packed extremely densely and efficiently into the center of the building, by way of double-decker elevators with destination-dispatch controls, with upper local elevators stacked in the same shaft above mid- and low-zone elevators.

Figure 1. Shenzhen Ping An Finance Center rendering (source: Ping An)
图1. 深圳平安国际金融中心效果图 (来源: 平安)

的。HPSB的主要特征有:

- **可量化。**建筑全生命周期中每个方面的环境效应都能被监控。从概念和设计阶段的计算模型，施工阶段的指定和安装，运营阶段的测量和核查。
- **整体性。**单一的方面不能够满足各项环境效益都达到典范值。高性能建筑的设计是一个整体的设计过程，总的性能目标必须通过各个方面在建筑整个生命周期中各司其职协同作用才能实现。
- **可视化。**为了实现上文所说的跨团队协作，必须要有有效的沟通方式来达到理想的环境效益。这就是建筑信息模型 (BIM)，它能够记录各个方面然后在一个三维可视化的电脑模型工具平台上展现出来。

通过以上三个原则，PAFC旨在达到美国绿色建筑认证系统——绿色能源与环境设计先锋奖 (LEED) 金奖。

基地规划和建筑设计

建筑师对于PAFC的构想是: 由于需要高达11平米每人的人均使用面积以及超过20的容积率，建筑必然会有一个惊人的形体。由于钢琴状不规则的基地限制，PAFC多达20,000个全职员工将会被集中在这个72m见方的地块内。如果以这样的密度计算的话，全世界所有的工作人口，大约30亿人，只需要不到1000平方公里，一个深圳市的面积就能容纳下。

The site of the tower is also important. PAFC is a "transit-integrated tall building" that will occupy a major node in the increasingly connected mega-city of Hong Kong / Shenzhen / Guangzhou: home to 120 million people and one-third of China's trade value. By 2017, Hong Kong and Shenzhen will only be 15 minutes from each other by train, and in Shenzhen, PAFC is strategically located at the terminus of the under-construction XRL line to Hong Kong, as well as Shenzhen Metro lines 1 and 3.

In essence, the main architectural design moves behind the PAFC are the following:

- **Widened Base**, to increase structural stance
- **Tapered Profile**, to reduce seismic and wind forces acting on the structure
- **Shaped Corners**, to improve aerodynamic performance
- **Mega-structural System**, as a means of economic structural resiliency
- **Multi-stage Vertical Transport**, to minimize the size of the services core
- **Modular Design** of the structure and façade systems
- **Mass Transit Connectivity**, to network with other urban clusters

Structural Design

The PAFC needs a structural design that would be optimized for typhoon wind speeds of 60 m/s or more, while providing maximum floor space to a tight program. The main structure thus consists of a mega frame - core wall - outrigger truss system, with four outrigger trusses and three belt trusses connecting the two tubes, complemented by exterior diagonals. Embedded steel plates reinforce walls from the foundation up to level 12, reducing the necessary thickness and enhancing ductility. Two 500-ton tuned mass dampers (TMDs) at the 113th floor maintain stability from above. (Figure 2)

The PAFC has a unique structural health monitoring (SHM) system, consisting of 428 sensors delivering full lifecycle monitoring from construction through service, via LAN and 3G wireless connections. Factors under measurement include climate, seismic and wind load, horizontal displacement of the top of the tower, deformation and settlement etc.

Cladding

Once the main structural issues have been overcome, the cladding system has to be determined. The choice of cladding system would be influenced by its performance under wind load, temperature changes and building movements, as well as weather-tightness against sunlight, water and thermal conductivity. The PAFC primarily adopts a unitized curtain wall system, whereby some part of the columns are complemented by stone walls from ground to 123.8 meters' height, and some part of the columns from the first floor up to the top are covered by 1,700 tons of 1.5 mm-thick stainless steel. The selection of the "linen" pattern of stainless steel is partially due to its ability to limit undesirable reflections and light pollution, and the fact that it can easily be cleaned by rain. The panels consist of 85% recycled materials which are 100% recyclable. (Figure 3)

塔楼的形态就像一根从地面朝着天空拉起来的钢缆，建筑表面的8根复合巨柱进一步的强化了这一点。这些巨柱不仅仅处于美学上的考虑，他们同样有着实际作用。流线型的塔楼在提升结构性能和抗风性能上有着可观的效益。PAFC与中国建筑规范相比，收益与塔楼的形态，倾覆力矩减小了32%，风荷载减小了35%。由于12.5m的进深，核心筒部分非常密集而高效的放在建筑中心部分，通过双层轿厢以及分区管理，同一个电梯井内能同时叠加高区电梯、中区电梯和低区电梯。

建筑的选址极其重要。PAFC是一栋"枢纽高层建筑"，会在逐步成型的香港/深圳/广州超大都市圈 (容纳了1.2亿居民，实现全国1/3的贸易总额) 中占据一个重要的节点。到2017年，香港和深圳之间能够15分钟火车直达。PAFC非常有策略地选在了深圳在建的广深港高铁XRL线终点站之上，同时也是深圳地铁1号线和3号线的换乘点所在地。

简而言之，PAFC的主要设计侧重点有以下几点:

- **宽阔的基础**， 增加结构抓地力
- **收缩的形体**，减小结构受到的地震力以及风力。
- **切削的边角**，提高空气动力学性能。
- **巨型结构体系**，能够有经济效益反馈的结构形式。
- **分区垂直交通**，减小运输服务分区体量。
- 结构和外墙系统的**模数化设计**。
- **和大区域的交通联系**，与其他都市建筑组团形成网络。

结构设计

PAFC要求建筑的结构强度能够抵御60m/s甚至更大的台风，同时在有限的基地中实现最大的楼层面积。主体结构是一个巨型框架-核芯筒-外伸臂体系，两个筒之间有4个伸臂桁架和3个带状桁架连接，还有补充的外部对角桁架。嵌入的钢板墙体从地基延伸到12层，减小了结构厚度并增强韧性。113层的两个重达500吨的阻尼器维持建筑上部的稳定。 (见图2)

PAFC拥有一个独特的结构健康监控 (SHM) 系统，共在建筑中安装了428个通过LAN或者3G无线网络连接的传感器，收集施工到运营的整个生命周期内的信息。对气候、地震、风荷载，建筑顶部水平位移，变形和沉降等等因素进行监测。

围护结构

在主体结构的问题解决后，接下来要决定的就是外墙结构。外墙结构的选择会考虑在其风荷载、温度变化、建筑摆动下的性能，以及对于阳光、雨水的气密性以及热传导系数。PAFC的外墙结构主要是单元式幕墙，从地面到123.8m的巨柱部分使用的是石材幕墙，部分巨柱部位则是使用重达1700吨1.5mm厚的不锈钢板。选择"亚麻"纹理的不锈钢除了考虑到能够减小反射和光污染之外，还考虑到这种材料通过雨水冲刷就能实现自洁。这些板的原材料有85%都是回收的，并且100%可循环。 (见图3)

这些不锈钢板通过竖向的人形石材来加固，不仅为建筑提供了一种独特的建筑特征，也提供了有实际功能的的外遮阳。立面的总体性能比起当地建筑规范值提高了20%。

主动性高能效和能源节约系统

通过对周边建筑和基地地形3D模型的日照模拟，设计团队认为项目应该尽量减小遮阳，让更多的光线进入建筑内部。因此使用了低辐射率高透光率的上釉玻璃，使得更多的可见光进入建筑同时阻挡不需要的热辐射。在光照充足时，通过光感器和可调节灯具来减小人工照明的能耗量。

Figure 2. Structural rendering
图2. 结构渲染效果图

The stainless-steel panels are complemented by chevron-shaped stone verticals, which not only provide a unique architectural feature to the building, but also provide functional external shading. The overall façade performance is approximately 20% higher than the local code requirements.

Active Energy-Efficient and Energy Cost Saving Systems

By applying a daylight simulation tool against three-dimensional models of surrounding buildings and site topography models, the design team determined that the project would have a low shadowing impact, thereby enabling daylight penetration into the building. Low-emissivity and high visible-light-transmittance glazing is applied to allow sufficient visible light entering the building while reducing the undesirable heat gain at the same time. Photo sensors and dimmable lighting devices are used to reduce the artificial lighting energy consumption when there is sufficient daylight.

提高用户舒适度的电梯设计

PAFC不仅对能源效益上有极高的标准，同样也追求更加卓越 用户体验，这需要机械、电力、管道工程的协同，同样对于垂直交通的设计也紧密相关。PAFC的一个核心目标是提供最高效的垂直交通系统，不仅运载量客观，并能够在正常运营中将等待时间最小化。PAFC电梯系统规划的关键点在于电梯分区。业主、建筑师和系统设计团队共同参与了电梯规划。

建筑一共拥有80架电梯，其中45架是双轿厢电梯。为了提供更好的服务，办公楼被划分成了7个区域，有两个转换大厅。33架每层停的电梯荷载为1600kg，运行速度达到3.5-7m/s，穿梭电梯荷载为1800kg，速度达到9m/s。每个分区跨越8-14层，这是通过对于前往特定区域人群流量和轿厢需求量仔细研究后得出的。两架10m/s的高速电梯能够直达观光层。（见图4)

效率最高的电梯需要避免频繁启停。因此，每个子分区都有4-6个双层轿厢电梯。高速双轿厢的使用能够增强运载力，并且缩短电梯等待时间。每个区域之间的间隔时间维持在30秒，也符合国际电梯设计规范要求。（见图5)

PAFC的垂直交通策略中用户的舒适度是首要考虑的因素。例如，在建筑摆幅超过预警值时，摆幅探测器能够指示轿厢停在非共振(最稳定) 的楼层。

设备工程

PAFC所有的机械、电气和管道设计策略都旨在提高建筑性能。

制冷，按需通风和热能回收

办公和零售层都设有二氧化碳监测系统。空气处理器 (AHUs) 和新风处理器 (PAUs) 能够根据二氧化碳浓度来调节室外进风量。这样能够在通风风扇和新风处理上都节约大量能耗。

新风处理器 (PAUs) 有热循环系统。废气中的能量可以回收对新风进行预冷，从而减小建筑制冷能耗。

分区和冰蓄冷

其他主要的用户舒适度提升工程手段包括热交换器和冷却器的水力分区，一个变风量 (VAV) 系统，建筑地下一个40,000吨/小时的冰蓄冷系统，能够满足建筑每年能量消耗的4%。

电气系统

建筑有9根10kv的电缆线，6根为运行电缆，另外3根为备用电缆。用户能够通过开关装置进行即时的切换。高层建筑中，电压下降是一个很大的问题，PAFC的工程小组在建筑不同高度上多个机械层设置了变压器。6个2,000kw的柴油发电机能够在电力中断提供备用电力，双重的母线槽竖管能够保证某一个竖管着火时不至于电力中断。尽管复杂以及空间有限，电力和机械系统依旧能够高效地为电梯系统提供冷却，避免出现交通中断。

室内空气质量

考虑到建筑极高的使用密度和周边城市密集的人群和交通情况，PAFC的设计者需要使用一些特定的策略来保证优质的IAQ (室内空气质量）。尽管在很多方面都是一个挑战，此时建筑的高度反而转变成了一个优势。600m高的塔楼上部区域的空气温度更低更舒适，HAVC系统中会完全使用室外新鲜空气，将循环率降到很低。这样最大化地降低了交叉污染的可能性。

为了知道最佳新鲜空气的引入高度，使用了运算流体力学 (CFD) 分析建筑围护在不用风压下的表现。分析最终在新风率上比当地建筑规范提升了30%，增大了室内空间含氧量并能刺激使用者有更高的生产效率。空调系统使用了高性能的过滤系统来去除室外空气中的悬浮粒子。

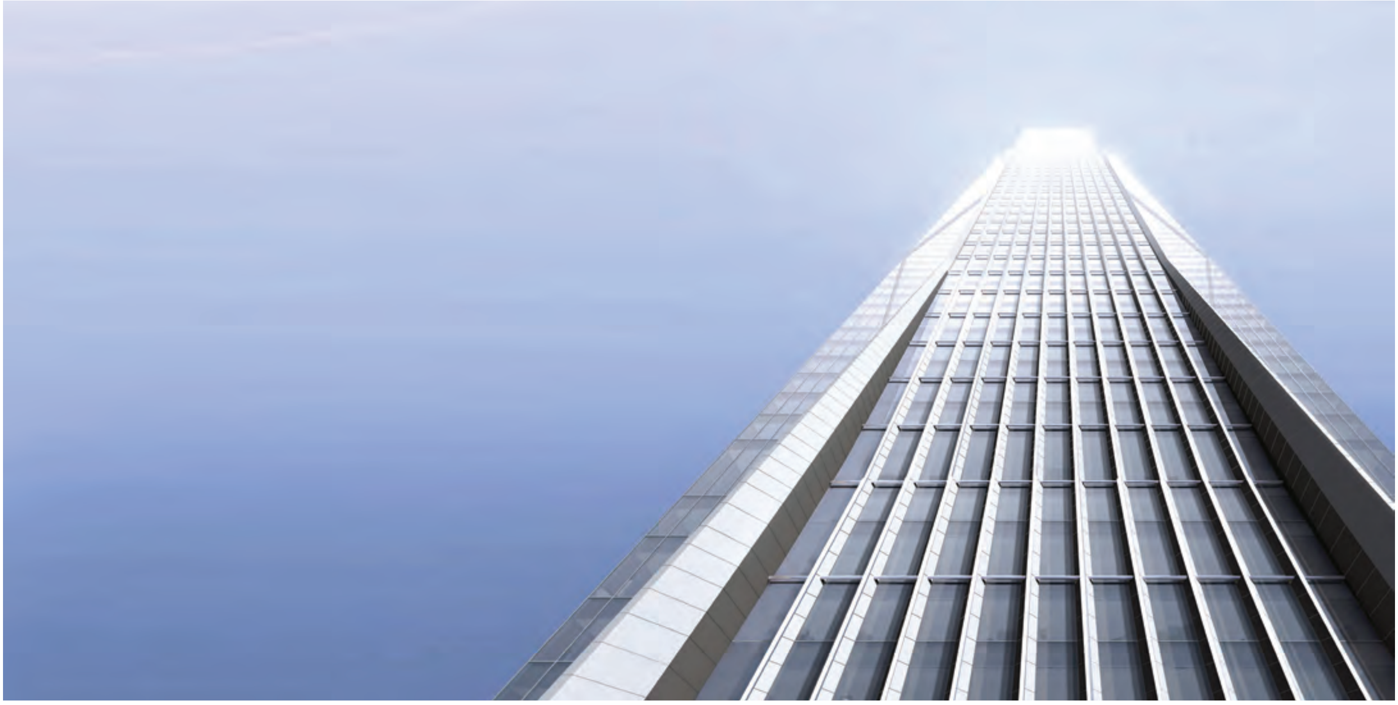

Figure 3. Illustration of the curtain wall system of PAFC
图3. 平安国际金融中心幕墙系统示意图

Elevator Engineering for Customer Comfort

The PAFC is held to extraordinarily high standards of energy performance as well as customer performance, which requires a unified approach to mechanical, electrical and plumbing engineering, at the same time closely integrated with the design of vertical transportation. One key objective of PAFC is to provide the most efficient vertical transportation system with optimized handling capacity and interval period during normal operation. As the initial step, the client, architect and the system design team have been involved in the decision process for the planning of the lift zoning.

A total of 80 elevators, including 45 double-deck lifts, serve the building. For optimal service, offices are split into seven zones, served by two intermediate sky lobbies. The 33 local elevators can handle 1,600 kg, moving at a speed of 3.5 to 7 m/s. The shuttle elevators carry up to 1,800 kg each and can achieve 9 m/s. Each of the seven zones comprises 8 to 14 stories, a number derived from careful study of the potential for matching groups of cars to groups of people heading to a given zone. Two high speed lifts capable of 10 m/s are provided to serve the observation floor. (Figure 4)

The most efficient lifts are those that avoid frequent start and stopping. Thus, each sub-zone is served by four to six double-deck elevators. Use of high-speed double deck lifts enhances the handling capacity and shortens the travelling time for each car call. The overall interval period for each zone is maintained within 30 seconds, which complies with international standards of elevator design. (Figure 5)

Customer comfort is a paramount concern in the PAFC vertical transportation strategy. For instance, building sway sensors stop elevator cars on non-resonant (most-stable) floors if the building exceeds sway thresholds.

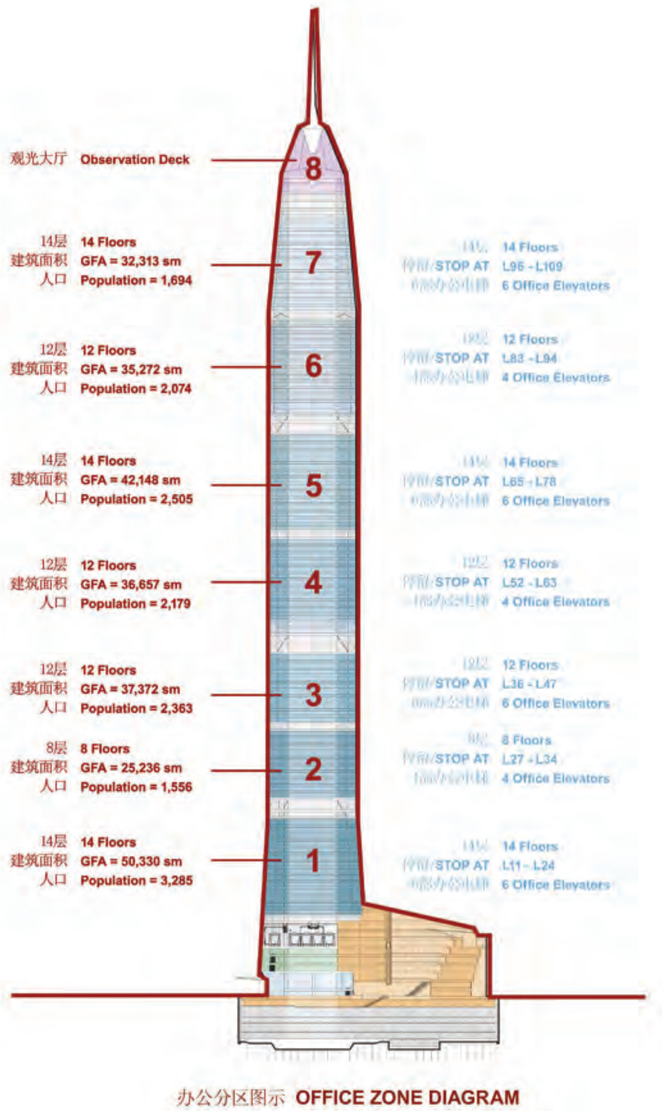

Figure 4. Vertical transportation diagram (Source: Ping An)
图4. 垂直交通示意图 (来源: 平安)

MEP Engineering

All of the mechanical, electrical and plumbing design strategies employed in PAFC work to enforce the high-performance objectives of the building.

Cooling, Demand Control Ventilation and Heat Recovery

BA CO_2 monitoring system is applied in office and retail floor space. The Air Handling Units (AHUs) and Primary Air Handling Units (PAUs) are able to adjust the outdoor air flow according to CO_2 concentration. These provide significant energy saving in both ventilation fan system and fresh air condition treatment.

Primary Air Units (PAUs) are completed with total enthalpy recovery wheel. The unused energy stored in the exhaust air could be recovered to pre-cool the incoming fresh air, so as to reduce the building cooling load.

Zoning and Ice Storage

Other major customer-comfort-focused engineering strategies include the provision of hydraulic zoning via heat exchangers and chillers, an all-air variable air volume (VAV) system, and a 40,000 ton-hour capacity ice storage system in the basement that contributes a 4% savings to the building's annual energy cost.

Electrical Systems

The building has nine 10 kV electric feeder lines, with six on-duty and three on standby. Immediate failover is provided by custom-designed switch gear. Voltage drops can be a big issue across buildings of great height, so PAFC's engineering team takes care to place transformers at multiple mechanical floors along the height of the building. Any interruptions in power can be compensated by six 2,000 kW diesel generators, and dual bus-duct risers are provided, so as to avoid a complete blackout in case of a fire in one of the risers. Despite all the redundancy and tight space requirements, the electrical and mechanical systems are designed efficiently enough to provide dedicated cooling for elevator machines, reducing the risk of a hoisting stoppage.

Indoor Air Quality

Given the high occupancy density of the building as well as the high population and motor traffic of the surrounding city, the designers of PAFC undertake special measures to ensure high IAQ. While facing all sorts of challenges, the height of the building here proves to be an advantage. As there is a suitable lower ambient temperature alongside the higher zones of the 600-meter tower, a full outdoor fresh air supply will be introduced into the HVAC system, with limited recirculation. This minimizes the potential for cross-contamination.

Computational fluid dynamic (CFD) analysis has been applied to evaluate the appropriate location for full fresh air supply under a range of wind pressures acting on building envelope. The analysis yielded a 30% increase in the air refreshment rate, compared with the local design standard, increasing the oxygen content to the indoor space and carrying the potential of enhancing occupant productivity. High-performance filtration systems have been adopted in air-conditioning system, which filters out the particulates in the outside air.

Overall Energy-Saving Achievements

Out of the total energy savings of 46% against a similarly sized conventional building, it is estimated that 27% of the energy reduction achieved has come from compliance with the local energy code design, which means that the local building energy efficiency code already provides a clear design direction for an energy conservation approach.

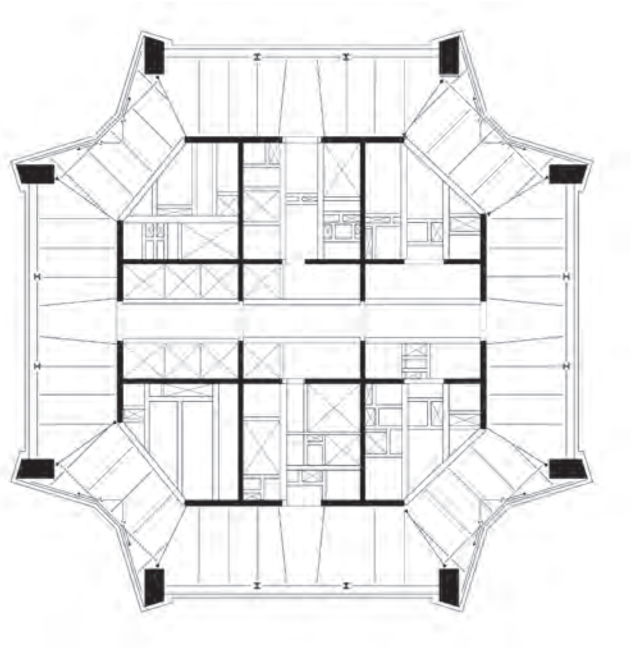

Figure 5. Typical office floor plan (source: KPF)
图5. 办公层标准平面 (来源: KPF)

Figure 6. Podium at tower base with public green space
图6. 塔底部裙房的公共绿色空间

A further 6% energy saving is achieved from the adoption of passive design strategies including the high performance façade and greenery solutions. The remaining 13% of building energy budget savings is achieved by active systems including free cooling, lower lighting power density design, daylight penetration, free cooling, heat recovery, demand control ventilation and thermal storage design. (Figure 6)

BIM Management

In order to achieve high level of coordination in the PAFC, an extensive Technology of Building Information Modeling (BIM) was undertaken, forming the essential "coordinator" between civil, steel, curtain wall, and MEP engineers.

Construction Management

Vertical Transportation Management

In order to abate the progress influence of curtain wall, the construction elevators were set in core wall. Need to arrange night transportation reasonably. The lift shaft would be divided into low and high zone lift installation, and will adopt no-scaffold installation scheme so as to remove the temporary construction elevators an soon as possible.

Enough unloading platform could abate the transportation pressure of construction elevators, if necessary some big size equipments are lifted through the empty shaft.

Hang the backup tower crane supports so as to ensure the climbing speed of tower cranes, 5 days per round.

Multi- floor steel beams are lifted at one time so as to speed up progress.

总体节能绩效

建筑比起同等规模的传统建筑能够节省46%的能耗，比起当地能耗规范设计值还降低了27%。也就是说当地的建筑能量效率规范已经清晰地指明了节约能源的设计方向。

此外通过包括高性能立面和绿色植物等被动式设计策略还能再减小6%的能源。还有13%的能量节约，能够通过自然冷却、照明功率密度设计、自然光渗透、热能回收、自控式通风和蓄热器设计来实现。(见图6)

BIM管理

为了提高PAFC的整体协调性，我们引入了一个建筑信息模型 (BIM) 技术，它成为多个领域特别是土建、钢结构、幕墙、机电之间的"协调者"。

施工管理

垂直运输管理

为了减少对幕墙进度的影响，所有施工电梯都设置在核芯筒电梯井道内，合理组织施工电梯的夜间运输。正式电梯井道采用无脚手架方案快速分段安装，以便尽早拆除临时施工电梯。

设置足够数量的卸料平台分担施工电梯压力，必要时通过空置的电梯井道运输大型设备。

悬挂塔吊后备支撑以便确保塔吊爬升效率: 5天每轮次 。

多层钢梁一起吊装，加快吊装进度。

现场平面管理

被四周道路包围的狭窄场地内，首层临时支撑在2013年和2014年的结构高峰期面临拆除过程中的运输和堆载难题，通过周密的调度方案确保了塔楼主体结构最快3-4天每层的速度。

Figure 7. Ping An's completion as of July 2014 and the impact on the Shenzhen skyline (source: Ping An)
图7. 2014年7月平安金融中心施工进度及其对深圳天际线的影响 (来源: 平安)

Site Plan Management

The site is surrounded by roads, during the construction of main structure from 2013 to 2014, while removing the ground temporary support, the transportation and stacking is a big difficulty. Through thorough coordination, ensure the construction speed of main structure: 3 to 4 days per floor.

Construction Progress

- November 2009, started foundation excavation
- December 2010 , completed 500,000 cubic meters substructure excavation and support.
- July 2011, completed mega pile foundation of the tower. (Figure 8)
- November 2011, completed the thick raft foundation.
- December 2012, completed core wall steel plates wall of floor 11 (60M). (Figure 9)
- December 2013, completed core wall steel structure of floor 68 (315M). (Figure 10)
- July 2014, completed core wall steel structure of floor 96 (446M). (Figure 7)

Conclusion

The Ping An Finance Center has become an outstanding first-class project. We are confident that its experience could be shared with the other global tall-building projects. Since mid 2014, the PAFC has entered an integral stage of simultaneous multi-trade processes, including structure, curtain wall, MEP, fitting out, lifts etc., where construction collaboration will be of utmost importance. With the major challenge of the total project completion ahead of us, we will continue to ensure the quality and safety at the same time.

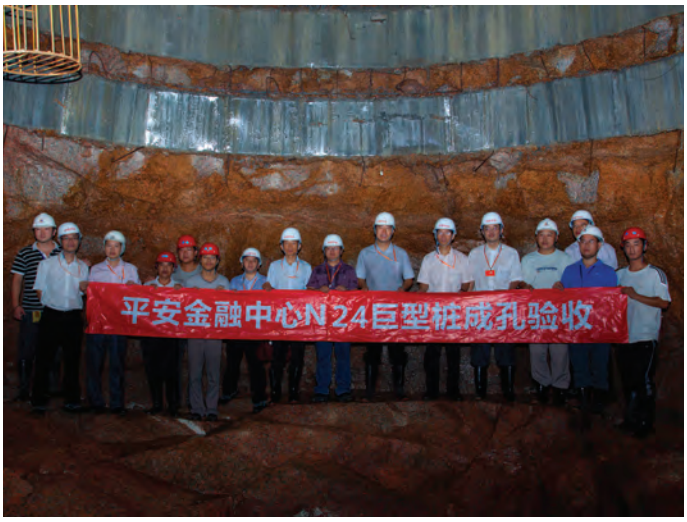

Figure 8. Celebratory picture after completing the mega pile foundation (source: Ping An)
图8. 庆祝成功完成巨型桩基础施工 (来源: 平安)

施工进度

- 2009年11月开始基坑开挖。
- 2010年12月，完成约500,000立方米的基坑开挖及支护。
- 2011年7月完成塔楼范围的巨柱。 (见图8)
- 2011年11月完成大底板浇筑。
- 2012年12月塔楼核芯筒钢板墙安装到11层 (60米) 。 (见图9)
- 2013年12月塔楼核芯筒钢结构安装到68层 (315米) 。 (见图10)
- 2014年7月底塔楼核芯筒钢结构安装到96层 (446米) 。 (见图7)

结论

平安金融中心将是一个杰出而优秀的项目，我们希望它的经验能分享给全世界的超高层建筑。2014年年中开始，深圳平安金融中心项目进入结构、幕墙、机电、精装修、电梯等专业的交叉施工阶段，施工协调管理显得尤其重要，我们将面临极大的竣工目标挑战，同时必须确保质量和安全。

Figure 9. Core formwork in blue moves up as concrete sets, with megacolumn and floor plates following below
图9. 核心筒中的蓝色模板随着混凝土的浇筑而向上搭建，巨型柱与楼板的施工随之进行

Figure 10. Construction progress as of December 2013
图10. 2013年12月的施工进程