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Intelligent Advances in Ping An Tower

平安中心的智能化设计

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Wai Ming "Thomas" Tsang joined Ping An Real Estate as the CEO of Shenzhen Ping An Financial Centre Construction and Development Limited Company in April of 2012. Before he joined Ping An, he worked in Sun Hung Kai Properties – one of the largest global real estate developers headquartered in Hong Kong. He acted as Project Director of Sun Hung Kai Properties, mainly in charge of Shanghai IFC and Suzhou ICC. Tsang has over 25 years of building construction and design management experience on many large-scale projects and megatowers in Hong Kong and China.

曾伟明（Thomas）先生于2012年4月加入平安地产，出任深圳平安金融中心建设发展有限公司首席执行官。在加入平安之前，他曾任职于新鸿基集团，该公司是一家总部位于香港的大型全球房地产开发商。作为新鸿基集团的项目总监，他曾担任上海国际金融中心及苏州环贸广场的主要负责人。他拥有超过25年的建筑施工及设计管理经验，在香港及中国内地参与过许多大规模项目（尤其是巨高层塔楼）。

Abstract | 摘要

This paper presents client requirements on both functional and aesthetic aspects for four mega-scale gates on the Ping An Financial Centre (PAFC) north tower. The PAFC north tower is a 600-meter-tall super high-rise building located in the Futian District CBD in Shenzhen, Guangdong Province, PRC. In order to carry out maintenance on the 97th-plus-story of the tower, there is one building maintenance unit (BMU) seating on BMU floor at +567.65m. This BMU is 12 meters (long) by four meters (wide) by five meters (high), with a total extension to 32.5 meters and an extra extension of 20.5 meters. Proving way out for the BMU, four intelligent mega-scale doors with a size of nine meters (wide) by 8.15 meters (high) weighted 30T each mounted underneath the "diamond crown" of PAFC north tower. These four intelligent mega-scale doors are designed with special functions, including special operation requirements, adverse weather proofing, and good appearance.

Keywords: Building Maintainence, and Supertall

本文展现了平安金融中心（PAFC）北塔四个智能巨型库门的功能及美学方面的客户需求。平安金融中心北塔是一座600 米高的超高层建筑，它位于中国广东省深圳市福田区中央商务区。为了维护该大楼97层及以上的部分，本项目在567.65米高的建筑维护楼层安装了一台大型擦窗机（BMU)。该擦窗机为12m（长）x 4m（宽）x 5m（高），最大伸臂距离32.5米，另可延展20.5米。为了让擦窗机正常工作，四扇面积9m（宽）x 8.15m（高）、重30吨的超大规模智能库门分别安装在平安金融中心北塔的"钻石皇冠"之下。这四扇超大规模智能库门设计特别考虑了使用需求、恶劣天气及美观。

关键词：建筑维护、超高层建筑

Project Introduction

Ping An Insurance (Group) Company of China, Ltd. (abbreviated as Ping An Group) is building a substantial new tower for its headquarters in Shenzhen. On in 6th Nov 2007, Ping An subsidiary China Ping An Life Insurance Co., Ltd. acquired the lot acquired a lot in Futian District, enclosed by Fuhua Road, Yitian Road, Fuhua 3rd Road and Zhongxin 2nd Road. The tower is now complete, and is known as Shenzhen Ping An Financial Center (PAFC) (Figure 1).

项目简介

中国平安保险（集团）股份有限公司（简称平安集团）正在深圳修建一处新总部大厦。2007年11月6日，隶属于平安集团的中国平安人寿保险公司在福田区获批了一个地块，位于福华路、益田路、福华三路和中心二路之间。该塔楼即为深圳平安金融中心，现已竣工（图1）。

该建筑工程由深圳平安金融中心建设发展有限公司负责。

Figure 1. PAFC (Source: Ping An)
图1. 深圳平安金融中心（来源：平安）

PAFC North Tower Design Parameters 深圳平安金融中心北塔楼设计参数			
Lot Area 地块面积	18931.74m2 18931.74平米	Site Area 占地面积	18931.74m2 18931.74平米
CFA 地块面积	459187.0 m² 459187.0 平米	Plot Ratio 容积率	20.0
		Adjusted Plot Ratio 调整容积率	20.39
Countable Area 建筑面积	386018.18 m² 386018.18 平米	Road and Plaza Area 道路与广场面积	0
Non-Countable Area | 不可数面积	73168.82 m² 73168.82 平米	Parking Space No. 停车位	1100
Base Area 地基面积	10157.45 m² 10157.45 平米	Basement Parking Space No. 地下停车位	1100
Site Coverage 上盖面积	53.65%	Ground Parking Space No. 地上停车位	0
Public Area 地基面积	2000 m² 2000 平米	Bicycle Parking Space No. 自行车停车位	1400
Above Ground CFA | 地面建筑面积		377232.0 m² | 377232.0 平米	
Below Ground CFA | 地下建筑面积		81955.0 m² | 81955.0 平米	
Podium Height 平台高度	Tower Height 塔楼高度	Tower Roof Height 塔顶高度	Total Floors 总层高
≤52m ≤52米	599m 599米	555.6m 555.6米	118

Figure 2. PAFC North Tower Design Parameters (Source: Wai Ming Thoman Tsang)
图2. 深圳平安金融中心北塔楼设计参数（来源：曾伟明）

The construction project was managed by the Shenzhen Ping An Financial Centre Construction and Development Co. Ltd.

PAFC has the following design parameters, as tabulated in Figure 2.

Functional Usage

The main tower consists of 118 stories above ground, 5 stories below ground, one 5-story link bridge and one 4-story pedestrian subway connecting PAFC north and south towers. The tower is divided into eight zones.

The demarcation of all zones is listed below:

- Car parking – B5 to B1
- Entrance lobby – L1
- Refuge floor – L10
- Zone 1 – L11 to L24
- Refuge floor/mechanical floor – L25
- Mechanical floor – L26
- Zone 2 – L27 to L34
- Refuge floor/mechanical floor – L35
- Zone 3 – L37 to L48
- Refuge floor/mechanical floor – L49
- Mechanical floor – L50
- Sky lobby – L51 to L52
- Zone 4 – L53 to L64
- Refuge floor/mechanical floor– L65
- Zone 5 – L67 to L80
- Refuge floor/mechanical floor – L81
- Mechanical floor – L82
- Sky lobby – L83 to L84
- Zone 6 – L85 to L96
- Refuge floor/mechanical floor – L97
- Zone 7 – L99 to L112
- Mechanical floor – L113
- Refuge floor/mechanical floor – L114
- Sight-seeing zone – L115 to L117
- 2 BMU floors at the highest levels, i.e. 567.65 meters and 584.5 meters, respectively.

To enhance human comfort with respect to building sway induced from lateral loads, e.g. wind load, there are two hybrid mass dampers (HMDs) on L113, separately mounted at the southeast and northwest corners of the tower. Each damper weighs about 600 metric tons and provides 1% damping effect.

Structural Characteristics

The main structure rises up to 592.5 meters, making this the highest structure under construction in Shenzhen. Its structural form is a hybrid outrigger-composite structure. From basement to the top, vertical support is provided by core walls and columns outside the core walls.

The PAFC north tower has a structural DNA of 7-8-9. Figure 3 means that it has 7 layers

图2为深圳平安金融中心的设计参数。

功能使用

主塔包括地上118层，地下5层，另有一座5层连接桥，以及一处4层地铁地下通道连接平安金融中心的南北塔楼。塔楼分八个区域。

- 隔火层/设备层–L49
- 设备层–L50
- 空中大厅–L51到L52
- 4区–L53到L64
- 隔火层/设备层–L65
- 5区–L67到L80
- 隔火层/设备层–L81
- 设备层–L82
- 空中大厅–L83到L84
- 6区–L85到L96
- 隔火层/设备层–L97
- 7区–L99到L112
- 设备层–L113
- 隔火层/设备层–L114
- 观光区–L115到L117
- 顶部2层为擦窗机设备层，离地高度分别567.65米和584.5米。

为提高人体舒适度，减少因风压等横向荷重引起的建筑摇摆，塔楼第113层备有两个混合质量阻尼器（HMDs），分别装在塔楼的东南和西北角。每个阻尼器重约600吨，分别提供1%的阻尼效应。

结构特点

塔楼主结构高592.5米，是深圳在建的最高建筑。全塔由外伸臂桁架–复合板混合结构组成，从底部到顶层的垂直支撑由核心墙及其外部支柱提供。

深圳平安金融中心北塔楼的结构编码为7–8–9。数字7表示共有7层桁架（图3），分别位于10~11层（第一带状桁架）、25~27层（第一外伸臂桁架）、49~51层（第二外伸臂桁架）、65~67层（第二带状桁架）、81~83层（第三外伸

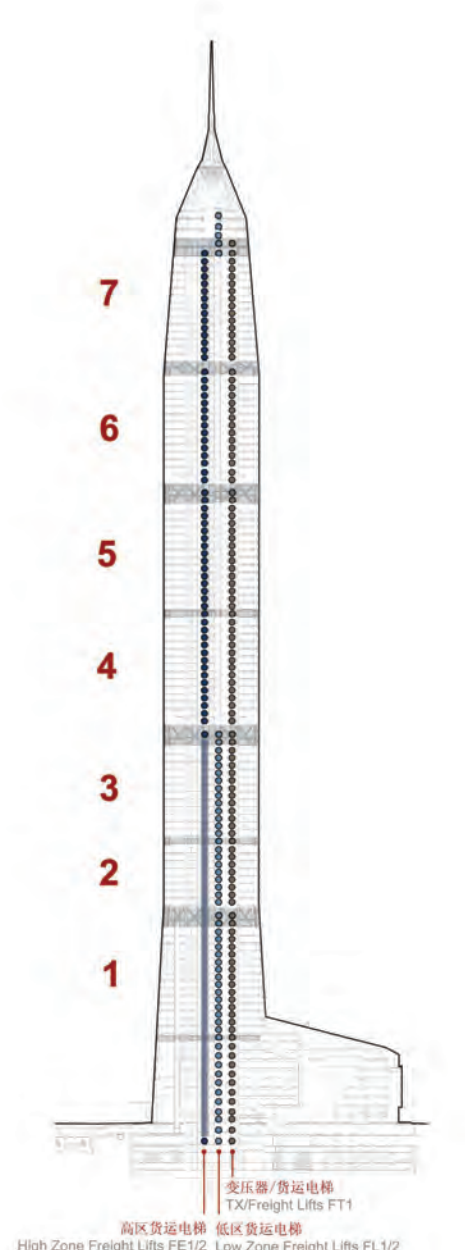

Figure 3. PAFC divided into sections (Source: Pin An)
图3. 深圳平安金融中心北塔楼设计参数（来源：平安）

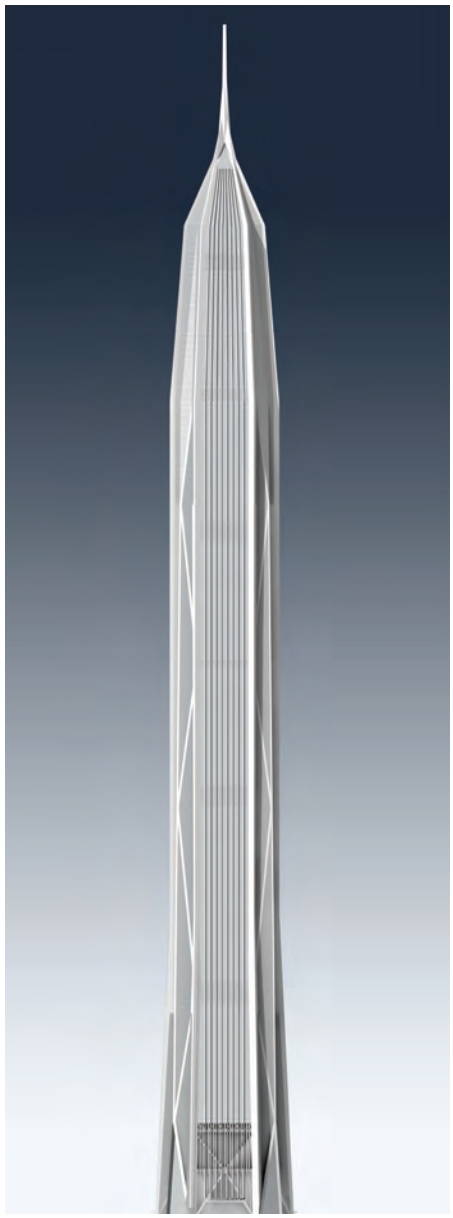

Figure 4. Structural rendering (Source: KPF)
图4. 结构渲染效果图（来源：KPF）

of outriggers, at floors 10~11(1st belt truss), 25~27(1st outrigger), 49~51(2nd outrigger), 65~67 (2nd belt truss), 81~83 (3rd outrigger), 97~99 (4th outrigger), 114~115 (3rd belt truss). The Figure 4 refers to its 8 megacolumns. The megacolumns are 6525 mm x 3200 mm in section at the basement floor level, and gradually reduce to 3118 mm x 1400 mm at the top floor. The core wall is formed from 9 pieces of square sub-core.

Since the tower is very tall, its structural vertical elements need to take a large amount of loads from gravity, wind, and earthquakes. Both core wall and columns are designed as composite sections, i.e. steel plate-formed sections embedded with concrete. A concrete strength grade of C70 prevails from ground level to level 86, and C60from L86 upwards
and C60 are adopted for columns and core-wall, respectively. Other structural elements are poured with grade C35 concrete, except for the pile caps, which are formed with grade C40 concrete.

Each megacolumn is supported by one of Ø8m caisson pile, with a design strength of 95,000 metric tons. The core wall is supported by a total of 16 of Ø5.7m caisson piles, each with a design strength of 48,000 metric tons.

The total amount of concrete in use is 285,000 m3, while the total amount of rebar in use is 63,000 metric tons, and the total amount of structural steel is 96,000 metric tons.

The structural health of the building is monitored by a famous university in Hong Kong. Monitoring items include daily weather, pile loads, stresses induced from temperature changes, displacements induced from wind loads and earthquake, and settlements of the tower .

臂桁架）、97~99层（第四外伸臂桁架）以及114~115层（第三带状桁架）。数字8代表有8根巨型支柱（图4）。这些巨型支柱在地下楼层尺寸约为6525毫米x 3200毫米，随后向上逐渐缩小至顶楼的3118毫米x 1400毫米。数字9代表核心墙由9片方形子核心筒组成。

由于塔身较高，因此其结构垂直元素须承受重力、风压及地震等大幅荷重。两边的核心墙和支柱均为复合剖面，即钢板嵌混凝土。地上一层至86层混凝土强度等级为C70，86层以上，以及支柱和核心墙的混凝土强度等级皆为C60。除桩帽由C40强度等级的混凝土浇筑而成之外，其他结构元素的混凝土强度等级皆为C35。

每根巨型支柱由一根直径8米的沉箱柱支撑，设计强度达95,000吨。核心墙由16根直径5.7米的沉箱柱支撑，每根柱子设计强度为48,000吨。

在用混凝土总量为285,000立方米，钢筋使用总量为63,000吨，结构钢材总用量为96,000吨。

该建筑的结构健康度由香港一家知名大学监测，监测指标包括每日天气、桩荷载、气温变化导致的压力、风压和地震导致的位移，以及塔楼的沉降等。

环保建筑

深圳平安金融中心的设计满足美国绿色建筑委员会（LEED）黄金认证及中国绿色建筑铜质标准。美国绿色建筑委员会标准不仅包含设计项目，还包括施工阶段的建筑材料再利用状况。相比之下，中国绿色建筑准则主要集中在设计阶段，但也综合了对多种当地因素的考虑。因此，无论从国际还是本国角度而言，深圳平安金融中心都符合绿色建筑的标准。

深圳平安金融中心在水电风方面采用了几处特别的绿色设计：

1. 双层电梯：平安金融中心共有80多台电梯，其中23台不可调，12台可调。电梯在运行时能够产生可再利用的电能。现阶段，这些可再利用的电能会被储藏起来以待之后使用。

2. 隔音效果：该项目的设计师们通过其他项目得出了一条经验：机器发出的低频噪音会使人产生厌恶。为消除噪音，交易大厅上方的设备室中安有飘板层，能够防止低频噪音传至下方的交易大厅。

3. 通风设计：通风管道的原设计 宽度为3米，但之后发现这种设计会影响吊顶支撑架的安装，遂决定将一个大型通风管道分割成两个小管道，以方便吊顶支撑架的安装。另外还将安装

Green Building Aspects

PAFC is designed to satisfy LEED Gold and Chinese Green Building Bronze standards. LEED covers design items as well as the construction stage, in that credits are given for reuse of construction materials. Comparatively, Chinese Green Building Code mainly concentrates on the design stage, but it takes into account of a lot of local factors. Therefore, PAFC is green in both the international and local sense.

PAFC was designed with several special green MEP aspects:

1. Double-deck lifts: There are more than 80 lifts in PAFC, of which 23 are non-adjustable and 12 are adjustable. During operation, lifts can produce re-usable electricity. Presently, the re-usable electricity is retained for future development.

2. Sound and insulation: Through experience acquired from other projects, to reject designers ascertained that the low-frequency noise emitted from machines can be annoying to people. In order to eliminate such annoyances, machine plant rooms above trading floors were placed on a floating slab layer to eliminate low-frequency noise transmitted to trading floors below.

3. Ventilation: The original design of the ventilation ducts was about 3 meters wide, however, it was found that this would affect the installation supporting frames of the false ceiling. Therefore, it was decided to divide one large ventilation duct into two small ventilation ducts, so that the supporting frames of the false ceiling could be installed. In order to control both ventilation ducts with the same level performance, a variable-air-volume (VAV) system is adopted.

4. Ice storage: This system supports the overall sustainability of PAFC by producing ice while the electricity demand is low, and de-icing while electricity demand is at peak levels. Peak electricity is 25% more expensive at peak times than at low demand times. Ice storage thus reduces the use of electricity at high peak times, so that electricity consumption can be saved. Since the ice storage system occupies areas in the basement, this reduces the number of parking spaces provided. In accordance with LEED design guides, it is recommended to design the ice storage capacity based on 20% of the total amount of design chilling requirement, hence the amount of ice storage is to be designed as 34,000 RTH. With this design parameter for the ice storage, therefore, it is estimated that the initial cost is to be 86.14 million RMB, while operational cost would be 34.49 million RMB/year. The reduced income from parking is to be 0.85 million RMB/year, and electricity cost savings about 4.21 million RMB/year. With reference to these data, it is estimated that the break-even of using the ice storage is around 6.1 years.

5. Air quality monitoring: There is an air-quality monitoring system installed in the basement of the tower, which is to collect air samples from basement and carry out air quality analysis, providing information on the quantity of CO (carbon monoxide) in the basement, so that the property management company is capable of deciding whether air purification is required.

Intelligent Mega-scale BMU Gates

It is said that "the clothes make the man." The cladding of buildings can be thought of as like clothes, but, like clothes, it also needs to be cleaned. At PAFC, cleaning is required quarterly. In the early days of skyscrapers, building external façade cleaning was carried out by acrobatic "spider-men" who climbed up buildings to clean external façade panels and vision glass, one-by-one. When high-rise buildings become common, in order to safely to carry out cleaning, building maintenance units (BMUs) became common. Normally, BMUs are hidden behind the building enclosure when not in use.

The PAFC tower's external façade mainly consists of framed curtain walls having about 17,500 pieces and covering an area of 210,000 m2. There were two basic schemes proposed for PAFC's façade cleaning. One scheme was to clean the external façade using BMUs mounted only at the top floor. The other scheme was to clean external façade using BMUs mounted on several BMU floors. After a comparative study of cleaning cycles of a large

一个变风量系统（VAV）以确保两个通风管道等效运转。

4. 冰蓄冷系统：该系统通过用电量低时制冰，用电量大时除冰的办法来维系深圳平安金融中心整体的可持续性。高峰电价比低需时段贵25%，因此，冰蓄冷系统能够减少高峰电量的使用，达到省电的效果。由于冰蓄冷系统位于地下层，这会导致可供停车位的减少。美国绿色建筑委 员会的设计指南中建议，把冰蓄冷系统的容量设计为整体设计制冷需求的20%，即34,000冷冻吨/小时。因此，根据冰蓄冷系统的该设计参数，初期成本预计将达8614万元，年运营成本3449万元。停车位减少将导致每年收入减少约85万元，而每年节省电费成本则可达421万元。根据以上数据，预计使用冰蓄冷系统的收支平衡拐点在6.1年左右。

5. 空气质量监测：塔楼地下室装有一套空气质量监测系统，可采集地下室的空气样本并进行质量分析，提供地下室一氧化碳量的相关信息，确保物业公司能对空气纯净度做出有依据的判断。

智能巨型擦窗机门

常言道，“人靠衣裳马靠鞍。”建筑的包覆材料可以比作衣服，衣服需要清洗，包覆材料亦是如此。深圳平安金融中心的清洁工作按季度进行。之前，摩天大楼外立面的清洗工作都交由身怀绝技的“蜘蛛人”打理，他们要爬上建筑逐个清理外立面板和视觉玻璃。当高层建筑变得越来越多，为确保清洁过程中的安全，擦窗机（BMU）开始普及。通常情况下，擦窗机在闲置时隐藏在建筑的围护结构中。

深圳平安金融中心塔楼的外立面主要由框架幕墙组成，共计17,500片，覆盖面积达210,000平米。平安金融中心塔楼的清洁有两个基本方案。一是仅用位于顶层的擦窗机清洁外立面，而另一个方案是用安装在几个擦窗机设备层的擦窗机清洗外立面。经过对大量幕墙清洗效果的比对，决定启用第二套方案（图5）。

深圳平安金融中心在四个楼层共装有13台擦窗机设备。具体来说，四套中型擦窗机设备安置在第50层，用于50层及以下楼层的清洁；另有四套中型擦窗机设备装在第97层，为51到96层楼提供清洁服务；一套大型擦窗机装在第119层，用于97至118层楼的清洁。最后还有四套小型擦窗机置于大型擦窗机的顶端，用于清洁建筑的钻石型顶部。

amount of curtain walls, it was decided to adopt the latter option (Figure 5).

PAFC has 13 BMUs, mounted on four BMU floors. Specifically, four medium-sized BMUs mounted at the 50th floor serve that floor and all those below. Four medium BMUs mounted at the 97th floor serve floors 51 to 96, while one large BMU mounted on the 119th floor serves floors 97 to 118. Lastly, four small BMUs mounted on top of the big BMU clean the diamond-shaped crown.

Of particular note are the access doors in the large BMU, which are referred to as "intelligent mega-scale gates," as the doors that enclose the BMU are larger than normal. The largest and highest BMU was mounted at 567.65 meters' height. It is 12 meters long by 4 meters wide by 5meters high, with an arm extension to 37 meters that can carry 700 kg of additional loads. Accordingly, the access area is required to be 9 meters wide x 8.15 meters high.

The outsize requirements and extreme mounting height of the BMU could not be met by an off-the-shelf solution, so the constructors employed a specialist team to design and build these gates. The specialist team will be referred to as the "fabricator" from this point forward.

The design of the gates took into account of the gravity load, the dynamic load during operation, wind load, and stress caused from temperature changes. The design value of a characteristic wind load was given from the project structural consultant; other design loads were considered by the fabricator, which also needed to take into account all architectural aspects specified in drawings, i.e. matching the tower profile and external style, etc.

Computerization of the Gates

The gates are called "intelligent" because the entire opening and closing process is automated by way of a Central Processing Unit (CPU). The only human operation is to press the "START" and "CLOSE" buttons.

When the gate operates from "closed" to "open" position, the controller determines whether the BMU is stationed properly, and then presses "START".

The first operation is called PLC Lock, in which the system determines whether all locks are stationed properly. Once this is confirmed, the system starts four hoisting machines simultaneously, which pull the gate

Figure 5. Illustration of the curtain wall system of PAFC (Source: KPF)
图5. 平安国际金融中心幕墙系统示意图（来源：KPF）

值得一提的是，大型擦窗机出入的门叫“智能巨型门”，因为这些门围护着该擦窗机，比常规的门尺寸更大。最大最高的擦窗机位于距地567.65米的高度，长12米，宽4米，高5米，另有可延展到37米的伸臂，能够承受700千克的额外荷重。因此，入口处设计尺寸需达到宽9米， 高8.15米。

超大的尺寸要求和超高的安装高度无法用现成的方法解决，因此建造者们雇佣了一支专家团队负责设计和建造这些巨门。下文将称这个专家团队为“制造团队”。

巨门的设计考虑了重力载荷、操作当中的动载荷，以及由于温度变化导致的压力等等因素。风载荷特性的设计值由项目的结构顾问提供；其他设计载荷由制造团队考虑，此外，他们还需要考虑图纸中与建筑相关的方方面面，包括将塔楼轮廓与外部风格相匹配等。

门的计算机化

这些巨门之所以“智能”，是因为整个开关过程均由中央处理器（CPU）自动完成。唯一的人工操作是按下“开始”和“关闭”按钮。

当门从“关闭”转为“开启”状态，操控者应在确定擦窗机安放妥当后再按下“开始”键。

第一步操作称为PLC锁。在该操作中，系统会确定所有的锁是否都已安置妥当。一经确认，系统会同时启动四台起重机，将大门垂直抬起。当大门移动到上方的停放位置，控制台会从四台起重机处接收到信号，届时两台附加牵引设备将开始上升。当起重机和附加牵引设备同时上升至拐点，两台牵引设备会开始把大门往上拉，大门折叠。同时，附加牵引设备回归原位。当大门折叠至拐点，控制台向引擎发出“停止”信号，同时还向大门发出开启信号。仅当大门完全开启后，擦窗机才会移出建筑外。

当大门需关闭时，系统会确认擦窗机是否已完全处于塔楼内。大门只有在擦窗机完全在塔楼内后才会关闭。操作者按下“关闭”按钮开始关闭大门。首先，中央处理器控制牵引设备反向工作，大门沿轨道滑落到最低点，接着向控制台发出信号，下降四台起重机的高度。一旦大门回到原点，控制台会发出信号停止四台起重机继续运作。当系统收到锁定信号便会将大门锁上，擦窗机回转至原来停放的位置。

制造

制造测试和调试均由制造团队在江苏省的一处制造厂里完成。在把设备调往建筑工地之前，制造团队邀请了专家共同参与测试和调试的过程。

由于巨门的独特性，制造团队需要定制所有零部件，许多零件由Q345钢制成。每扇巨门重约25吨，原材料耗损率约为26%，制造过程如下：

门折页制造：门折页由Q345钢制成，厚约50毫米，经退火处理后制造而成。1/3原材料制成成品，其余2/3损耗。

起重机底座和滑轮框：起重机底座和滑轮框是加工成形的焊接钢板。

上轴锻件

- 固定框架和轨道
- 固定框架是由一两个方形中空剖面焊接而成，尺寸分别是300 x 300 x 20毫米和300 x 300 x 12 毫米，所有切割由铣床加工完成。
- 可移动框架
- 可移动框架由两个方形中空剖面焊接而成，尺寸分别为300 x 300 x 12 毫米和150 x 100 x 8毫米的方形中空剖面。所有切割由铣床加工完成。

perpendicularly. When the gate moves to its upper parking space, the control panel receives a signal from the four hoisting machines, at which point two auxiliary pulling machines move upward. When both hoisting machines and auxiliary pulling machines move up to the turning point, two pulling machines start to pull the gate upward, and the gate folds. Meanwhile, the auxiliary pulling machines return back to its starting point. When the gate folds to the turning point, then the control panel sends a "stop" signal to engine; at the same time it also sends an opening signal to the gate. The BMU moves outside the building only if the gate opens completely.

When the gate needs to close, the system determines whether the BMU is completely inside the tower. The gate is to be closed only if the BMU is completely inside the tower. The operator presses the "close" button to start closing the gate. Firstly, the CPU controls the pulling machines' reverse direction, the gate slides down the lowest point along the track, which then induces a signal to the control panel to lower the four hoisting machines. Once the gate is back to the starting point, the control panel sends a signal to stop the four hoisting machines in operation. When the system receives a locking signal, then the system will lock the gate, and the BMU rotates to its parked position.

Fabrication

Both fabrication also testing and commissioning were carried in a fabrication yard in Jiangsu province by the fabricator. The fabricator invited some experts to witness the testing and commissioning prior to dispatching the machines to the construction site.

Due to the uniqueness of the gates, the fabricator needed to tailor-make all components. Many components are made from Q345 steel. The gates weighed around 25 metric tons each after fabrication. Wastage comprised about 26% of the raw material. The fabrication processes are illustrated below.

Door hinge fabrication: Door hinges are made from Q345 steel with a thickness of 50 mm. Fabrication occurred after annealing. One third of the raw material formed the product, two-thirds was wastage.

Hoisting machine bases and pulley frame: The hoisting machine bases and pulley frame were formed, welded steel plates.

Upper shaft forgings

- Fixed frame and track
- Fixed frames were made from welding a 300 x 300 x 20 mm square hollow section with a 300 x 300 x 12 mm square hollow section; all cutting was by milling.
- Moveable frame
- Moveable frames were made from welding a 300 x 300 x 12 mm square hollow section and a 150 x 100 x 8 mm square hollow section; all cutting was by milling.

Testing

The fabricator's experts held this project in high esteem; they insisted upon completing all testing and commissioning prior to transportation to site. During meeting, the experts camr to fully understand the fabrication process and examination process is to be carried out.

All components are assembled in the fabricator's workshop

- Control Panel
- Experts examines products

Concluding Remarks

Although the sheer height of the PAFC project is remarkable, this paper has highlighted some of its most advanced technological and environmental characteristics, including its advanced MEP and BMU systems. The intent is to portray the extent of special arrangements that go into ensuring such a groundbreaking building will last long into the future.

测试

制造团队的专家们高度重视该项工程，他们坚持在将设备转移至场地前完成所有的测试和调试。会上，专家们了解了整个制造过程，检查程序也将启动。

所有部件均由制造团队的工作室负责组装。

- 控制台
- 专家查验成品

总结

虽然深圳平安金融中心项目仅楼高本身就已非常出众，但本文着重撰写了该项目采用的若干最先进的科技和环保特性，包括先进的水电风系统和擦窗机系统。本文旨在阐述，为确保这一开创性建筑的持久性而做出的一系列特殊布置。