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# Making the World's Greenest Tall Building

## 打造全球最生态的高层建筑

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Shanghai Tower is poised to become the world's tallest green building after receiving the Chinese 3-star green building design label and the U.S. LEED-CS Gold Pre-qualification. This chapter will introduce how to realize similar achievements in the future. Firstly, the eight issues that exist for sustainable high-rise developments are studied. Solutions for achieving high energy efficiency and environmental quality such as the unique glass walls, tall atrium, tri-generation system, ice storage system, renewable energy use, rain and grey water reuse, structural optimization, and green construction are also discussed.

本文介绍了上海中心大厦为打造世界最高绿色建筑的建设目标，如何通过整体与系统的技术融合，从八大方面开展技术关键应对，有效解决独特玻璃幕墙、高大中庭、三联供、冰蓄冷、可再生能源、雨污水、结构体系、建筑施工过程等能源资源利用与环境影响难题，很好地诠释了获取高星级绿色建筑的技术途径，并获得中国绿色建筑三星级设计标识和美国LEED金级预认证的成功经验。

### Introduction

A wave of supertall developments are coming to China and it is reported that 30 to 40 high-rise buildings with height greater than 400m will be planned and constructed in the next ten years. The problems about the energy, resources and environment issues that need to be met when developing supertall buildings are complex, so studying sustainable development strategies is necessary for future supertall buildings, especially in China.

The Shanghai Tower is striving to become the world's tallest green building and has been pre-certified for several green rating systems. Creating a green super vertical city that harmoniously coexists with human beings, buildings, cities and nature is the goal for future skyscrapers. The green strategies of the Shanghai Tower for sustainable development will be very useful to future developers.

### Green Strategies

The Shanghai Tower is the tallest of a group of adjacent supertall buildings in lot Z3-2 of Lujiazui Financial Center of Pudong, Shanghai. The other two are the Jin Mao Tower and the Shanghai World Financial Center (see Figure 2.12). The Shanghai Tower, standing 632 meters high and 128 stories and has many program areas such as office, hotel, conference center, retail, and observation (see Figure 2.13). Shanghai Tower began construction work on 29 November 2008; topped out structurally on 3 August 2013, and is expected to complete in 2015.

To realize sustainable development goals, more than 60 green strategies are implemented in Shanghai Tower to achieve the goal of being humane, energy efficient, and convenient. Light pollution and outdoor wind environment issues are solved by designing the unique curtain wall structure. The energy consumption is reduced by arranging the reasonable function partition and designing the high efficient air-conditioning system and lighting equipment. The structure also utilizes effective building shading and energy storage technologies. The effect of wind load on the building structure is weakened about 24% by twisting the building's appearance by 120 degrees. The use of recycled water is about 24% by making full use of grey water and rainwater

### 背景

中国已进入超高层建筑快速发展期，在未来十年内可能出现30~40栋400m以上的超高层建筑，其在充分提高土地利用率的的同时，也带来了能源、资源、环境与交通等问题，因此对超高层建筑实施可持续发展战略十分必要。

上海中心大厦以中国绿色建筑三星级和美国LEED-CS金级为目标，定位于打造一个资源高度集约化、能源高度节约化、实现人、建筑、城市与自然和谐共存的绿色超级垂直城市，其绿色建筑发展策略对于后续的超高层建筑可持续发展具有积极的借鉴意义。

### 绿色策略

上海中心大厦地处浦东新区陆家嘴金融中心Z3-2地块，东邻上海环球金融中心，北为金茂大厦(见图2.12)。项目占地面积约3万平米，共128层(见图2.13)，总高度632m，总建筑面积约57.5万平米。项目功能主要为办公、酒店、会议中心、商业、娱乐、观光休闲等配套设施。于2008年11月29日正式开工建设，2013年8月3日完成结构封顶，预计2014年底竣工。

上海中心大厦提出以“体现人文关怀、强

while a reduction of noise, dust and lighting pollution are realized by adopting green construction techniques. This chapter will address how to reduce the energy and environmental impact of Shanghai Tower as low as possible by using eight technical responses including: the unique glass curtain wall, tall atrium, tri-cogeneration, ice storage, renewable energy, rainwater and grey water and structure system.

## Solutions

### The Unique Glass Curtain Wall Design

The glass curtain wall system of Shanghai Tower was designed creatively with the help of the parametric analysis to address the influence of wind load on outside & inside environmental comfort. The shape of the outside façade was designed using a wind tunnel test and verified by the outside wind environment comfort simulation. The structure and reflectance of exterior façade glass was optimized by the lighting pollution prevention analysis method. The visible light transmittance of glass was determined to meet the indoor natural lighting requirement. The heat transfer coefficient and solar heat gain coefficient of the façade were studied through the energy efficiency analysis method.

The results of the wind tunnel test (see Figure 2.4) showed that twisting the façade by different degrees can influence the wind load on the building and 24% of the designed wind load can be reduced by rotating the building with 120° compared to a rectangular form of the same height, so the twist degree of outside façade of Shanghai Tower is determined to 120° (Thornton Tomasetti Inc, 2009).

According to the outdoor wind environment comfort simulation, the maximum wind speeds at the 1.5m height of the surrounding pedestrian zone with the above design are less than 5m/s and meet the outdoor wind comfort and ventilation requirements under the typical wind environmental evaluation conditions of the different seasons in a year.



Figure 2.12. The site of Shanghai Tower from across the Bund (Source: Shanghai Tower Construction & Development Co., Ltd.)

图2.12. 从黄浦江对岸的外滩眺望上海中心大厦场址 (来源: 上海中心大厦建设发展有限公司)

调节资高效、保障智能便捷”为建设目标，通过独特幕墙结构设计与数字化技术应用控制建筑的光污染与室外风环境，通过有效的空调系统分区与高效建筑设备系统和照明系统设计及选用，结合有效遮阳与蓄能技术实现建筑综合节能目标，通过建筑外型旋转角度优化降低风荷载对建筑的影响，重视中水和雨水的利用实现24%的建筑非传统水源利用率，通过建立绿色施工实施方案，施工过程的噪声、粉尘和光污染也有明显降低。

本文重点介绍上海中心大厦在破解超高层建筑建设发展过程中碰到的玻璃幕墙、高大中庭、三联供、冰蓄冷、可再生能源、雨污水、结构体系、建筑施工等八大能源资源利用与环境影响难题及相关的技术应对。

## 解决方案

### 独特玻璃幕墙体系设计

为解决建筑幕墙的风荷载影响，提高建筑室内环境的舒适度，上海中心大厦创造性地引入建筑信息模型方法设计了一种独特的玻璃幕墙结构形式。该幕墙外形设计通过风洞实验优化，根据室外风场舒适性模拟验证。其构造和玻璃反射率通过光污染防治进行控制，可见光透射比通过自然采光要求确定，幕墙传热系数和遮阳系数通过节能目标要求进行选型设计。

根据风洞测试结果 (见图2.4)，当建筑采用120°扭度时，可使大楼的设计风荷载降低约24%，因此上海中心大厦外立面的最终扭转角度确定为120° (Thornton Tomasetti Inc, 2009)。

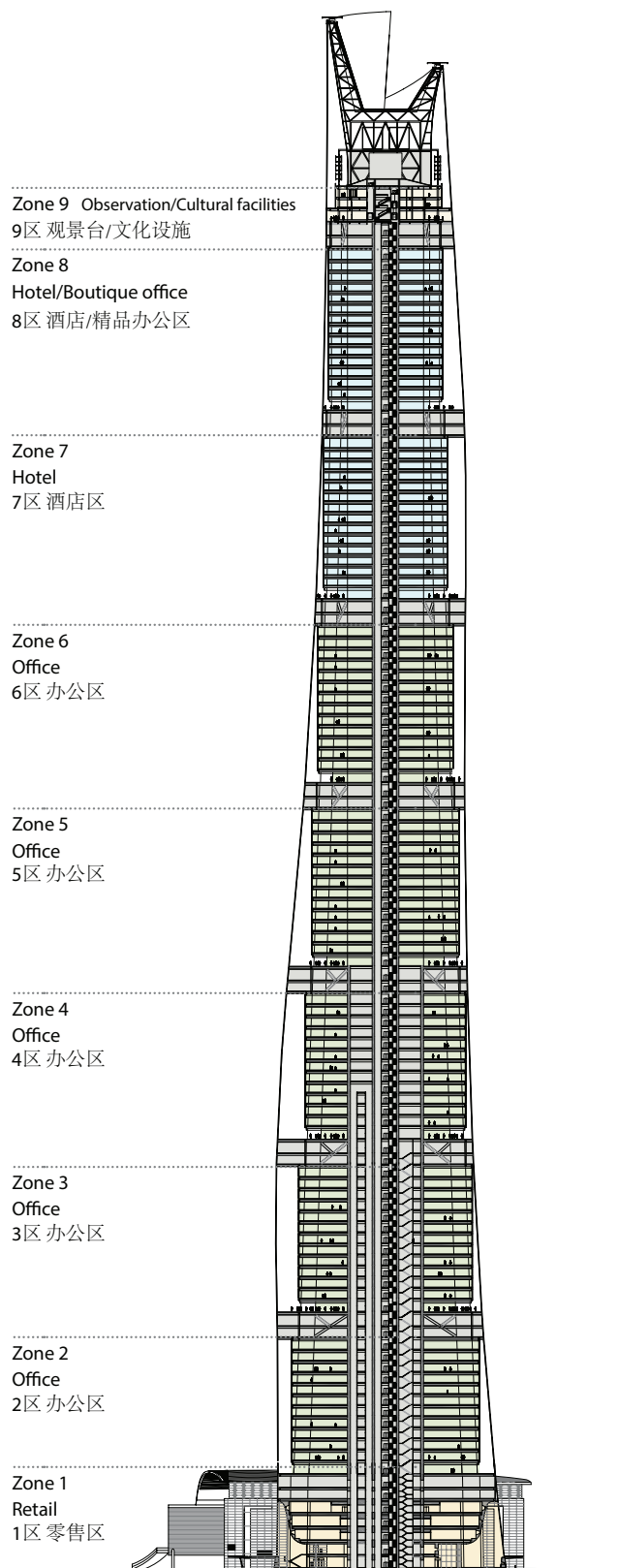


Figure 2.13. Section drawing. (Source: Gensler)  
图2.13. 剖面图 (来源: Gensler)

In order to control the lighting pollution of the façade, two kinds of façade styles design are studied, a staggered one and a smooth one (see Figure 2.14). The results of the lighting pollution analysis shows that the smooth façade has a good aesthetic effect but can form a large-area surface reflection. The staggered design can effectively reduce the severity of this effect by dispersing the reflection into discrete patches. The low light reflectance of the selected curtain wall glass is also important to reduce the lighting pollution. Finally, the selected structure of the exterior façade is a staggered one, with 12% of the visible light reflectivity (Shanghai Academy of Environmental Sciences, 2009).

建筑室外风环境模拟分析结果表明, 在上海市过渡季、夏季和冬季的典型风环境模拟评价工况下, 上海中心大厦周边人行区1.5m高处风速均不大于5m/s, 满足室外行人活动的舒适性和建筑通风要求。

为有效控制建筑的光反射影响, 幕墙设计主要提出了平滑与交错2种构造设计(见图2.14), 平滑设计玻璃拼接平滑连续, 具有良好美学效果, 但会形成大面积的反射面。交错设计通过幕墙中相邻玻璃单元的不连续将其反射分散成不连续小块状降低光反射的影响。建筑光发射环境报告显示, 采用交错幕墙构造方案可有效减少受影响敏感目标的数量、户数和影响时间, 而较低可见光反射率的幕墙玻璃可使敏感目标的影响程度明显减轻, 因此上海中心大厦的幕墙最终采用交错式构造形式, 幕墙玻璃可见光反射率也被控制在12%以下 (Shanghai Academy of Environmental Sciences, 2009)。

幕墙传热系数和遮阳系数则由节能要求确定, 全年负荷模拟分析结果显示, 对于上海中心大厦独特的玻璃幕墙体系, 采用外幕墙控制遮阳系数、内幕墙控制传热系数的方法可有效降低建筑全年建筑负荷。通过设计, 上海中心大厦各朝向窗墙比分别为东0.54/南0.51/西0.56/北0.52, 外幕墙玻璃采用12低铁HS+Low-E镀膜+1.52mm夹胶+12低铁HS, 内幕墙玻璃采用8低铁FT+Low-E镀膜+12A+6低铁FT, 幕墙综合传热系数为 $2.4 \text{ W}/(\text{m}^2\text{K})$ , 综合遮阳系数为0.47, 满足中国公共建筑节能设计标准要求。

采光模拟分析结果则显示, 上海中心大厦采用上述玻璃幕墙体系可实现较好的自然采光效果, 其主要功能房间满足采光标准要求的面积比例达到了89.9%(见图2.16)。

### 高大中庭

上海中心大厦内外幕墙之间形成了21个独特的缓冲中庭(见图2.17), 由于烟囱效应和温室效应的作用, 这些中庭的室内环境相对复杂。CFD模拟分析结果显示, 在不进行人工干预的情况下, 中庭夏季或过渡季存在过热的风险, 冬季极端情况下则可能造成外幕墙结露。

为营造相对舒适的中庭环境, 上海中心大厦在中庭区域进行了有效的通风设计(见图2.18), 其一方面可利用过渡季室外新风对中庭进行冷却, 夏季则通过空调区域



The annual energy performance simulation shows that it is better to control the sun-shading coefficient with the outer façade and the heat transfer coefficient with the inter façade for Shanghai Tower. Based on the analysis and the ratio of window to wall of 0.54(E)/0.51(S)/0.56(W)/0.52(N), the integrated heat transfer coefficient is  $2.4 \text{ W} / (\text{m}^2\text{K})$ , and the overall shading coefficient is 0.47, designing the 12HS+Low-E+1.52mm+12 low iron HS glass as the outer façade and the 8FT+Low-E+12A+6 FT low iron glass as the inter, to meet the design standard for energy efficiency of public buildings of China.

From the day-lighting simulation analysis, it can be shown that the main functions of Shanghai Tower can get adequate natural lighting with the designed glass curtain wall, with the area percentage reached by natural lighting of 89.9% (see Figure 2.16).

的溢风对中庭温度进行有效控制，中庭顶部则安装有空气源热泵热回收热水系统，将中庭顶部高温空气中的热量用来提供生活热水。为防止中庭幕墙冬季结露，其外幕墙内侧安装有辐射翅片。

### 三联供

上海中心大厦在B2和82F分别设置了低区和高区2个能源中心为整个大厦的供冷和采暖提供冷热源，三联供系统安装于低区能源中心中。上海中心大厦三联供系统的装机容量主要依据低区能源中心的冷、热、电负荷情况，根据“以热定电”原则，以及系统节能收益确定。

通过分析发现，上海中心大厦三联供系统最佳容量为2~3MW之间，鉴于燃气内燃机比燃气涡轮机具有更好地节能效果，并考虑到建筑实际负荷运行调控要求，上海中心大厦最终选择了2台1.065MW燃气内燃机作为三联供系统的原动机，燃气内燃机发电时产生的高温烟气和低温缸套水分别经过烟气-水热交换器和水-水板式热交换器与二次侧热水进行热交换，二次侧热水先经过水-水热交换器被加热至 $87^{\circ}\text{C}$ ，再通过烟气-水热交换器加热至 $95.5^{\circ}\text{C}$ 后作为热水型溴化锂吸收式制冷机的冷热源，系统一次能源综合利用率达到85%以上。

### 冰蓄冷

上海中心大厦采用冰蓄冷系统降低系统运行费用，并对电网实现移峰填谷的效果。通过全年负荷需求预测分析，结合上海市电价、设备费、材料费、土建成本及施工安装费用等，上海中心大厦低区最佳蓄冰容量被确定为26400Rth (Cosentini, 2009)。



Figure 2.14. The difference between a staggered versus a smooth façade design. (Source: Gensler)  
图2.14. 上海中心大厦平滑幕墙与交错式幕墙设计 (来源: Gensler)



Figure 2.15. The corner chamfer accentuates the twisting motif of Shanghai Tower (Source: Gensler)  
图2.14. 转角处的凹槽加强了上海中心扭转的形态特征 (来源: Gensler)

### Tall Atrium

There are 21 atriums (see Figure 2.17) created between the inner and outer façades in Shanghai Tower and the indoor environments of them are relatively complex due to the existence of the stack effect and the greenhouse effect. The CFD simulation results show that the atrium has the risk of overheating in summer and accumulating condensation in the winter without any human intervention.

In order to create a relatively comfortable atrium environment, the ventilation (see Figure 2.18) is designed to cool the atrium area in transition seasons and spill air exhausted from the office area to cooling it in summer. Meanwhile, the air source heat pump recovery/hot water system is installed in the top of atrium to generate domestic hot water and cool down the atrium. The condensation of moisture on the outer façade in the atrium in winter is solved by equipping radiation fins.

### Tri-Cogeneration

Two energy centers are designed for the cooling and heating of Shanghai Tower, and the low zone energy center is set up in floor B2 and high zone energy center in on floor 82. A tri-cogeneration system is installed in the lower energy center. The effectiveness of tri-cogeneration system of Shanghai Tower is dependent on the capacities of cooling, heat and power load of the low energy center, the "heat is first" principle, and electricity rates, and gas cost.

After the comparative analysis, the economic capacity of tri-cogeneration of Shanghai Tower is 2~3MW and the energy saving of gas engine is better than gas turbine. With these results, Shanghai Tower selected two 1.065MW reciprocating gas-oil dual-use generators. While running, the generator jacket cooling water will provide the first stage of heating while the flue gas heat exchanger will provide the final stage of heating before the water is introduced to the

项目最终选用了三台双工况离心式电制冷机配冰盘管内融冰蓄冰槽，双工况离心式电制冷机与蓄冰槽采用串联、主机上游的设置方式，冰蓄冷系统通过板式换热器向大厦低区提供6℃冷冻水，制冰工况下电制冷机的制冷量为3868kW，其蒸发器进出口温度为-1.57℃/-5.56℃，冰蓄冷可在单制冰蓄冷、单融冰蓄冷、主机单独供冷以及主机与冰槽联合供冷四种工况下运行。双工况离心式制冷机制冷效率为0.56kW/冷吨，制冰0.68kW/冷吨，100%负荷运行时，蓄冰总容量为26400RTh，蓄冰总容量占到低区总冷量的27.7%。

### 可再生能源利用

鉴于太阳能光伏发电与热水利用需要足够的面积保证，且对建筑外立面效果产生影响，上海中心大厦经过认真核实与设计优化分析，最终选择了地源热泵与高空风力发电方案。

根据测试结果，上海中心大厦地下土壤温度年平均为18.8℃，土壤导热系数为

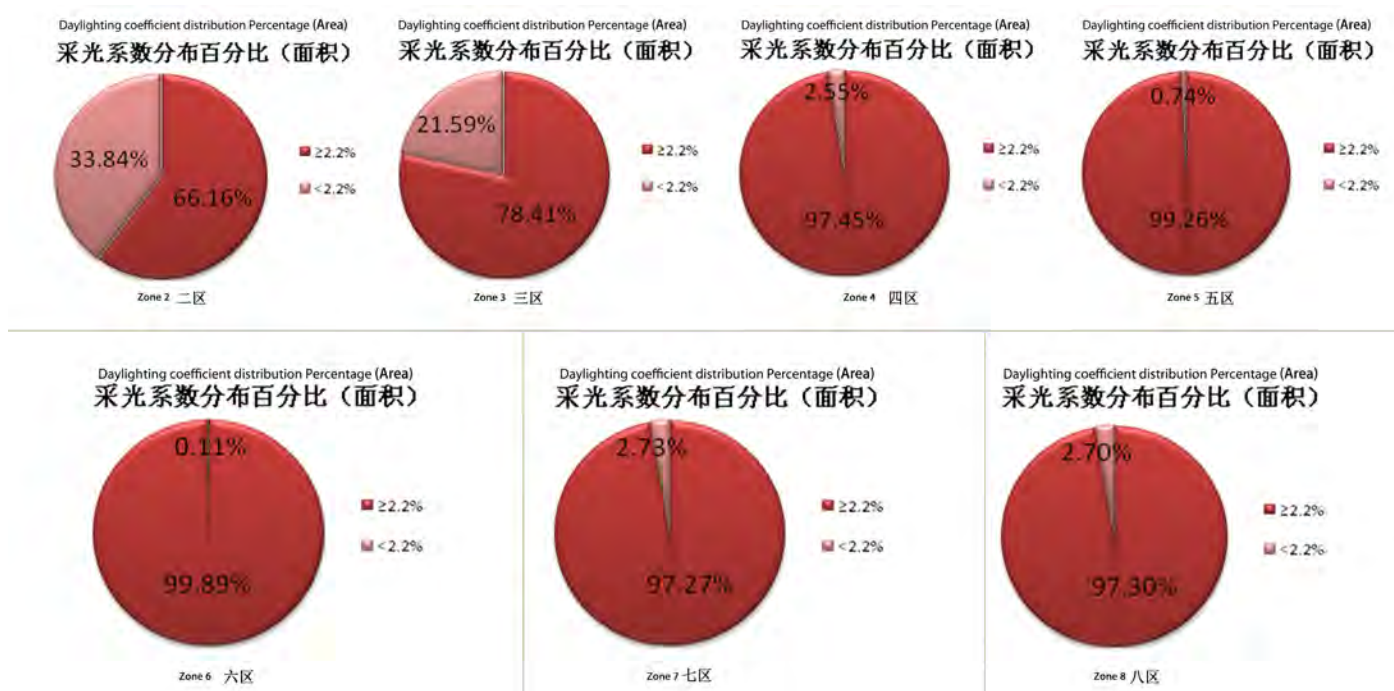


Figure 2.16. The natural lighting analysis of Shanghai Tower by zone (see Figure 2.13 for zones) (Source: Shanghai Research Institute of Building Sciences.)

图2.16. 上海中心大厦不同分区的(分区图见图2.13)自然采光模拟分析(来源:上海市建筑科学研究院(集团)有限公司)



absorber. The water is heated to 87 °C by the first water-water heat exchanger and 95.5 °C by the second flue-water heat exchanger. According to the design data, the primary energy efficiency of the tri-cogeneration system installed in the Shanghai Tower can reach above 85%.

### Ice Storage

An ice storage system is designed in Shanghai Tower to reduce the operation cost by reduce the peak load need. The optimal capacity of the ice storage system is studied by the annual load profile of the low zone cooling system and the capacity of 26400RTh is determined based on the energy price, the annual load profiles, investment and install cost (Cosentini, 2009).

Three sets of dual-condition chillers with ice disc internal melt ice storage tank are designed with "chillers upstream, ice bank downstream series connected circulation loop method" in Shanghai Tower, and 6 °C chilled water is offered by the ice storage system through the heat exchanger, the glycol solution enters the chillers at -1.57 °C and leaves at -5.56 °C to make the ice storage machine meet the maximum ice storage design capacity. Each ice-making capacity of dual-condition is about 3868kW. The efficiency of each dual-condition centrifugal unit is 0.56kW/ tons for cooling and 0.68kW/ tons for ice-making. The proportion of ice storage capacity to the total quantity of low zone is about 27.7%.

### Renewable Energy

The ground source heat pump system and wind turbine generator are designed in Shanghai Tower because there is no more space to install solar photovoltaic system and solar hot water heater, and can negatively impact building aesthetics.

The thermal performance test of ground soil shows that ground source provides the conditions for the use of a heat pump system in Shanghai. According to the test, the annual temperature average of the underground of Shanghai Tower is 18.8 °C, the soil heat conductivity coefficient is about



Figure 2.17. The atrium design of Shanghai Tower (Source: Gensler.)  
图2.17.上海中心大厦中庭设计 (来源: Gensler.)

1.58~1.82W/mK范围内, 单位孔深放热能力为64W/m (单U) 和74W/m (双U), 吸热能力为42W/m (单U) 和52W/m (双U) [4], 为地源热泵的利用提供了条件。考虑到空调系统的稳定性与大楼结构的安全性, 最终确定大厦在低区能源中心设置一台螺杆式地源热泵机组与低区空调系统相连接, 夏季运行工况制冷量为191kW, 冬季制热量为302kW, 其地下换热系统采用与大厦裙房桩基结合的127根竖向W型能源桩形式, 间距4m, 有效管长34m。

高空风力发电是上海中心大厦可再生能源利用的又一创新, 根据风力分布预测, 上海中心大厦580m处的年平均风速约为地面风速的2~3倍, 甚至更高。上海地面10m处平均风速为3m/s左右, 这意味着上海中心大厦顶部风速会达到6m/s以上, 这为风力发电技术的利用创造了条件。为充分利用这部分可再生能源, 上海中心大厦将在顶部安装270台500W的风力发电机组, 总装机容量达到135kW, 预计每年可为大楼公共照明提供超过15万kWh的电力。

### 雨污水利用

为有效节约水资源, 大厦设置了中水利用系统, 通过利用大楼酒店客房洗浴废水、办公区卫生间废水、机房排水及塔楼与裙楼屋面雨水, 经处理后回用于低区办公楼、裙房、地下室的冲厕、室外景观补水、绿化浇灌、室外道路冲洗、地下车库冲洗等。

大楼原水收集与处理系统分为两套, 分设在66F和B5, 处理工艺为:



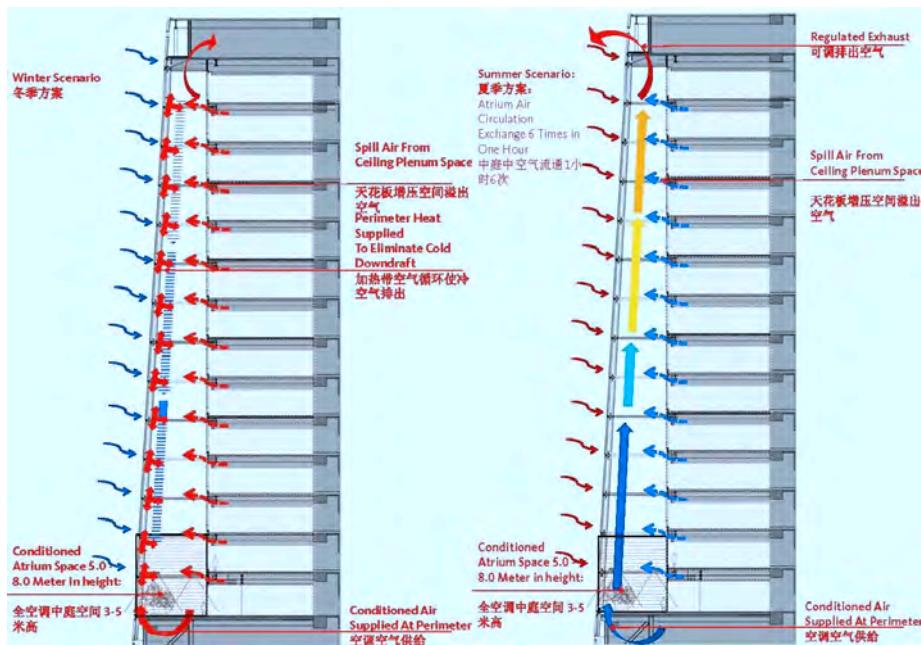


Figure 2.18. The ventilated design of the atrium of Shanghai Tower. (Source: Gensler)

图2.18.上海中心大厦中庭自然通风设计(来源: Gensler)

1.58~1.82W/mK, the heat release capacity is 64W/m for single U type and 74W/m for double U type and the absorption capacity is 42W/m for single U type and 52W/m for double U type. Considering the safety of building structure and stability running the air conditioning system, it was decided to bury 127 34-meter-long geothermal stakes at 4-meter intervals. Each stake is designed as 191kW for cooling and 302kW for heating.

Another innovation of renewable energy use for Shanghai Tower is installing wind turbines on the top of the building. The wind field analysis shows that there was 2 to 3 times more wind power at the top of the tower than at ground level. That means the wind speed at the top of Shanghai Tower will reach more than 6m/s because the wind speed is 3m/s average at the ground level in Shanghai, which is very good for generating wind power. In order to make full use of this renewable energy, 270 wind turbines with the total capacity of 135kW are installed on top of Shanghai Tower which will produce more than 150,000kWh electricity generated per year, and are expected to generate power for exterior lighting and public spaces.

### Grey Water and Rainwater Use

For the effective conservation of water resources, the water treatment system is optimized to recycle the bath wastewater from the hotel area, the toilet wastewater from the office area and the rainwater collected by buildings to flush the toilet of office at low zone, podium and basement; supplement the outdoor landscape, irrigate plantings and wash the outdoor road and the garage floor.

There are two sets of water collection and treatment systems located in 66F and B5 of the Shanghai Tower respectively, the process of water treatment is designed as:

- Wastewater
- Grille wells
- Collect pool
- MBR membrane bioreactor
- Disinfection
- Water tank
- Recycle use

The quality of recycled water should meet the requirements of water quality standard of China. According to the system design, there are 237,000 m<sup>3</sup> of grey water, including 8700m<sup>3</sup> of rainwater, that will be collected, treated and recycled in the buildings every year. The use of recycled water resources is up to 24% (Tongji University, 2012).

### Structural System

Shanghai Tower is very high and its structural safety rating is also high. The structural component will bear great lateral and vertical forces. In order to reduce building component size, save material, shorten the construction time, and improve the quality of building operation and comfort, Shanghai Tower designers carried out a comprehensive optimization analysis to select

- 生活废水
- 格栅井
- 调节池
- MBR膜生物反应器
- 消毒
- 中水箱
- 回用

中水的水质满足相应用水水质标准要求。根据设计资料,大楼年设计中水用量为23.7万m<sup>3</sup>,其中雨水收集量为0.87万m<sup>3</sup>,中水利用量占建筑全年用水总量的比例达到24%以上,节水效果相当明显(Tongji University, 2012)。

### 结构体系优化

上海中心大厦高度超高,结构安全等级也较高,建筑结构构件将承受很大的侧向设计荷载与竖向设计荷载,为减少建筑构件尺寸,节省材料用量和施工时间,提高建筑物运营品质和使用舒适度,上海中心大厦的设计者通过高强材料的选用、抗侧力体系的选取、外伸臂体系和塔楼筏板、SRC巨柱、建筑外形与建筑舒适度改善优化等对建筑结构进行了系统全面的优化设计分析(Thornton Tomasetti Inc, 2009)。

根据分析结果,上海中心大厦混凝土最终确定为:1~3区巨柱混凝土选用C70、4~6区选用C60、7~8区为C50,剪力墙与连梁混凝土选用C60、基础混凝土选用C50。外伸臂桁架、环形桁架和径向桁架选用Q345GJ钢材。巨型结构体系最终采用“巨型框架——核心筒——外伸臂”结构体系,外伸臂选用六道方案,而通过引入八道翼墙将筏板厚度由原先的7.4m减少为6m,大大节省了混凝土的用量。SRC巨柱含钢率也因从最初设计的6%~8%优化为4%~6%而节约钢材约13000吨。建筑外形旋转角度则因通过风洞试验优化为120度而降低约24%的风荷载,通过在屋顶安装TMD成功将塔楼顶部的加速度减少40%左右,建筑舒适度得到明显提升。

### 绿色施工管理

为最大限度节约资源和减少项目建设对周边环境的负面影响,上海中心大厦明确提出了绿色施工要求,对项目土方平衡、土壤保护和施工道路后期运营及施工过程中的噪声、扬尘、水和光污染等污染进行有效控制(见图2.19),注重本地化材料、环





Figure 2.19. The environmental control during the construction process of Shanghai Tower (Source: Shanghai Research Institute of Building Sciences.)

图2.19上海中心大厦施工过程环境影响控制 (来源: 上海市建筑科学研究院(集团)有限公司)

high-performance materials, design of the lateral system, outrigger system, mat foundation, Super Columns, and improve the shape and comfort of the building (Thornton Tomasetti Inc, 2009).

According to the analysis results, many kinds of high performance materials were selected for the Shanghai Tower. For example, Concrete C70 is selected for the super columns in zones 1~3, C60 in zones 4~6 and C50 in zones 7~8, C60 is also used for the concrete shear walls and beams, and C50 used for the foundation. The Q345GJ steel is used by the outrigger trusses, belt trusses and ring radial trusses. The lateral system of Shanghai Tower is designed as “Core-Outriggers-Mega Frame” and six sets of outrigger trusses are selected. The thickness of the mat foundation is decreased from original 7.4m to 6m by the introduction of eight wing walls to save great amounts of concrete. The steel ration of the steel columns embedded in the super columns and diagonal columns were optimized from 6%~8% to 4%~6% and saved about 13,000 tons of steel. Architectural appearance is designed by using wind tunnel tests to rotate the optimization angle of 120 degrees to reduce the wind load by about 24%, and the building comfort improved by mounted a TMD on the roof that can slow the acceleration on the top of building reduced by about 40%.

### Green Construction Management

To save the resources and lower the negative influences of the project on the surrounding environment as far as possible, the green construction management addressed soil balance, construction road use, noise, dust, water, and light pollution (see Figure 2.19). The use of local materials, environment-friendly materials, high-performance materials, recycled materials, embedded waste materials and recycling the construction solid waste were requested in the construction process of Shanghai Tower.

The construction monitoring and management data shows that the measures to control dust, noise and light pollution are effective and meet the requirements of China’s green construction standard. According to the statistical results of the material use during the construction period, the ratio of local materials is 83.1%, the ratio of the high performance concrete is 69.4%, the high strength steel is 77.4%, the recycled of construction solid waste is 39.8%. And the BIM technology was also introduced in Shanghai Tower to remove the potential risk of the collision during the construction effectively and reduce the implied probability for reworking or repairing of the project.

保材料、高性能混凝土、高强度钢筋、可再循环材料和废弃原材料生产的建筑材料等的使用，强调回收利用施工过程中产生的固体废弃物。BIM技术的应用则有效降低了项目施工过程中潜在的碰撞风险，成功减少了施工返工率。

施工监测管理数据显示，上海中心大厦自开工以来，对施工噪声、扬尘、光污染等的控制措施有效，全部符合中国绿色施工标准要求。根据施工期材料利用统计结果，截至目前上海中心大厦本地化材料利用比例为83.1%，高性能混凝土比例为69.4%，高强度钢筋比例为77.4%，施工废弃物处理及材料回收利用率达到39.8%，满足项目的绿色建筑要求。

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