Case Study: Greenland's Suzhou Center, Wujiang

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Greenland’s “Breathing Tower” in Wujiang

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A Unique Collaboration Results in “Breathing” Tower

The latest project in the long partnership between Skidmore, Owings & Merrill and the Greenland Group, a 358-meter tower in Wujiang, incorporates passive ventilation techniques into the design to create a unique interior "lung."

In today’s world of increasingly sophisticated design technology, it is rare to find an established architect/client partnership that has consistently advanced the innovation of tall building design. Capitalizing on their successful collaboration on Zifeng Tower (formerly Nanjing Greenland Financial Center), the architecture, engineering, interior design and urban planning firm of Skidmore, Owings & Merrill (SOM) has since partnered with Shanghai’s Greenland Group on several important, high-profile additions to the Greenland portfolio: Zhengzhou Greenland Plaza, Jiangxi Nanchang Greenland Central Plaza Parcel A, Jiangxi Nanchang Greenland Zifeng, Greenland Center Dawangjing and Greenland Group Suzhou Center, as well as several design competitions (see an overview of these projects at the end of this article). These towers are designed to anchor large developments and act as world-class monuments within these new districts, while also introducing new technologies that are setting precedents for the design of tall buildings in China and throughout the world.

This paper focuses on the most recent addition to the team’s collaborative portfolio. At 358 meters, Greenland Group Suzhou Center marks the Wujiang waterfront with an aerodynamic form that has a unique presence, while accommodating its program with economy and efficiency. The design incorporates passive ventilation techniques through a unique interior “lung,” creating an efficient “breathing” tower.

Site and Context

With a total building area of more than 284,000 square meters, Greenland Group Suzhou Center will become the defining visual landmark for the new Wujiang lakefront development and, by extension, for the city as a whole. Sited prominently along Lake Taihu...
in the Jiangsu province of China (see Figure 2), the building's dynamic tapering form effectively unifies its office and residential uses within a gently curved volume that culminates in a 30-story tall opening which marks the tower's presence on the city skyline.

Like many of the SOM towers now being designed for Greenland, this building is in the first phase of a new development that encompasses many city blocks. It needs to be the catalyst that encourages other developers to follow. Since the adjacent blocks have yet to be developed, the Suzhou Center will function as a "city within the city." With office, retail, residential and hotel uses, the complex is active throughout the day. Although housing a mix of uses within a tower is a complex task to design and construct, by stacking the uses and providing shuttle elevators to access sky lobbies for each program, the core works efficiently. At ground level, separate lobbies ensure that each use can operate independently.

Shaped by the prevailing views, prominent wind direction and environmental performance factors, the design and positioning of the tower contribute to defining a place of memorable and lasting value. The design takes full advantage of its unique and dramatic location immediately adjacent to the lake as well as the pedestrian promenade which defines the heart of the Wujiang central business district. The designers' decision to orient the tower in the east-west direction is in direct response to two environmental factors—the wind and sun. Elongating the tower in the east-west direction takes advantage of solar radiation at the times of the day when it is most beneficial, while minimizing the impact when it is least advantageous.

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**Site and Context**

1. Lake Taihu
2. Regional Bus Depot
3. Primary Pedestrian Paths
4. Panoramic View to the South
5. Retail Podium
6. Local Elevated Train Stop
7. Central Retail Plaza & Media Wall
8. Ballroom Drop-off
9. Hotel Drop-off
10. Office Drop-off
11. Retail Drop-off
12. Panoramic View to the North
13. Local Bus Stop
14. Prevailing Summer Wind
15. Primary Development Axis

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Figure 1. Greenland Group Suzhou Center, Wujiang, © SOM

Figure 2. Suzhou Center contextual plan. © SOM
The Breathing Tower

The formal language of the tower is rooted in a direct functional expression of the development brief wedded to a plan geometry and a tower superstructure that is both efficient and economical to construct. Continuity of the vertical form is emphasized in the curved and inflected surfaces that comprise the main building elevations. This is done in concert with the tower’s atrium opening which celebrates its programmatic differences and is a memorable visual emblem for the City of Wujiang.

Gently curvilinear in shape, the tower houses its mixed-use program of hotel, serviced apartments and offices via a stacked central atrium at the core of the building’s residential and hotel zones (see Figure 3). Defined by a 30-story operable window, this public space is both experientially remarkable and functionally intelligent. Acting as the “lung” of the building, it invites cool air flow during the summer months while also flooding the interior spaces with natural light (see Figure 4).

The shape of the tower was determined through highly advanced use of aerodynamic modeling techniques, many of them initially developed by SOM’s engineers and designers for earlier Greenland projects, particularly Jiangxi Nanchang Greenland Central Plaza Parcel A (The Twins) and Wuhan Greenland (see “Selected Projects from the SOM/Greenland Portfolio”). Typically towers of this height are subjected to wind tunnel testing in the later phases of design to insure that the assumptions for structural loading and behavior are correct. In the case of Suzhou Center, the design team put the tower through a series of digital wind tests that allowed designers to fine tune the form. The convex primary façades, combined with the concave short façades, are shaped in a manner that decreases the building’s structural loads while simultaneously increasing the flow of natural ventilation through the windows on the east and west elevations of the tower. Patterns will vary with changes in wind from season to season, even hour to hour, but a high performance system of digital controls will meter and direct the

![Figure 4. Suzhou Center wind study. © SOM](image)

![Figure 5. Suzhou Center atrium façade. © SOM](image)
flow of air into the atrium depending on specific climactic conditions (see Figure 5). This sophisticated system will direct the opening and closing of windows throughout the building and enhance the atrium’s functioning as the building’s “lung.”

Environmental Strategies

The design of Suzhou Center minimizes the building’s environmental impact, with a specific focus on reducing energy consumption and conserving water. Anticipated to achieve LEED-CS Silver status, the tower incorporates a series of high efficiency measures with the objective to achieve significant savings in energy consumption from an ASHARE 90.1 2007 baseline.

The atrium’s façade maximizes daylight penetration, facilitates mixed mode ventilation in the lobbies and public spaces, and acts as a fresh air supply source for the hotel and serviced apartments (see Figure 6). Like many expanding cities, poor air quality presents an environmental challenge in

“The Suzhou Center stands at the confluence of contemporary form and function, adapting techniques from the world of high-performance automobile design to facilitate environmental concerns within a singular architectural form.”
Wujiang. Since the greatest concentration of pollutants can be found at lower elevations, fresh air will be supplied through enormous openings at the top of the tower. Dynamic control of the atrium façade will modulate fresh air intake to directly cool apartments and hotel rooms during the summer months, while also facilitating mixed-mode ventilation in lobbies and other public spaces (see Figure 3). When natural ventilation is not favorable, the hotel guest rooms, serviced apartments and office units will be conditioned by variable-speed fan coil units. In the winter months, the vertical stack generated in the atrium will help maintain a warmer interior temperature and reduce heating usage, which is otherwise met by the fan coil units with supplemental under-floor radiant heating.

Wujiang’s seasonal prevailing winds will be harnessed at the east and west façades of the atrium to assist the natural ventilation strategies. Based on meteorology data, these winds move either from the northwest through northeast or east through southeast throughout the year, with predominant southeasterly winds occurring in summer (see Figure 7). In these months, the wind flows deflected around the tower during prevailing southeasterly winds will also assist the natural ventilation mode for the southerly office spaces. In order to predict the atrium’s vertical climate while mechanically ventilated (with openings at the top and bottom of the atrium open and controlled), the CFD simulated wind pressure coefficients were coupled with hourly meteorology data.

Other major energy saving strategies include a high performance façade, natural light harvesting using daylight responsive controls, energy recovery systems and lighting energy optimization using efficient fixtures and occupancy controls. Water management, conservation and reuse strategies include efficient building fixtures, rain water harvesting, condensate recovery and an efficient use of processed water. Site wide potable water savings are projected to be 50% when compared to the Energy Policy Act of 1992 fixture performance criteria.

**The Hollowed Structure**

In a typical high-rise, the structural core is built around the building’s elevator systems and other spaces dedicated to the vertical distribution of building services. As the structure rises, elevators servicing the lower levels terminate, and the core typically tapers to encompass the reduced area of the core components. However, on Suzhou Center, the design team elected to address the reduced core area requirements at the upper levels by hollowing out a portion of the building’s core, essentially eroding it from the inside out. This approach results in a higher stiffness and structural efficiency of the core, as the outer geometry of the core is maintained through the full height of the tower. The office program demands deep floor plates that are continuous around the building core. The hotel and residential program require shallower floor plates and less supporting core area. In Suzhou Center the surplus core area is removed in the upper part of the tower, increasing the efficiency of the tower and tailoring the lease area to the program. By bisecting the tower’s hotel and apartment levels with the atrium, designers efficiently addressed the programmatic aspects of the tower, eliminating extraneous area in the hotel and apartment levels while also allowing for efficient core geometry.

Although the inclusion of the atrium increases the geometry of the structural core in the upper levels of the tower, the design of the openings on the east and west façades means that the core is essentially split into two halves. The overall performance of the two halves is greatly diminished in this configuration, so the structural engineers used steel bracing to lace the two slender cores of the tower together, allowing the core to behave as one overall structural element, and still preserving the transparency of the east and west façades (see Figures 8 and 9).
The bracing transfers shear between the two sides of the tower core, acting in a similar manner as the diagonal members of a trussed bridge, which couple the main top and bottom chord elements. Articulated skybridges in the upper stories allow for pedestrian circulation between the two parts of the core, while accommodating relative movement between the two cores. Outrigger trusses engage megacolumns on the tower’s perimeter and supplement the stiffness of the core.

The tower rises from three basement levels and is built on a pile-supported mat foundation. A secondary wind and seismic force resisting system is provided by perimeter moment resisting frames that consist of steel perimeter beams and columns that are round, concrete-filled steel tubes. The round steel tubes ideally facilitate the continual variation in the geometry of the tower, as they can be cut at an angle and mitered together to adjust the trajectory of the column in any direction and by any angle.

Since the tower is located in a low to moderate seismic region, wind loads ultimately controlled the size of the building’s structural elements. Elliptical in plan, the tower’s configuration and its tapered section help to minimize vortex shedding, the phenomenon where eddy currents in the flow of air around the tower can induce motions perpendicular to the direction of the wind, and which can be the dominant wind effect in the design of high-rise towers.

**Conclusion**

A collaborative interdisciplinary practice has made possible the innovative design of Suzhou Center. Typically the engineering disciplines are considered “consultants” and are brought in after a design has been developed. But for Suzhou Center the critical input of structural and mechanical engineers, environmental planners, technical specialists, and urban designers was integrated at the beginning of the design process. Careful analysis initiated a process whereby the tower’s form was optimized to harness natural forces in and around the site. Today the spectacular buildings that are being realized in China have attracted the attention of the world. The experimentation with forms at a grand scale is unprecedented. This solution for a high-rise mixed-use tower has a unique form that is derived from a functional elucidation rather than arbitrary form-making. The sophistication of this tower marks a new chapter in a design portfolio that continues to challenge conventional answers.

**Project Data**

- **Height to Architectural Top:** 358 meters
- **Stories:** 75
- **Total Area:** 284,828 sq m
- **Building Function:** residential / hotel / office
- **Owner:** Greenland Group
- **Design Architect:** Skidmore Owings & Merrill LLP
- **MEP/Structural Engineer:** Skidmore Owings & Merrill LLP
Selected Projects from the SOM/Greenland Portfolio

SOM and Greenland Group have enjoyed a close, collaborative partnership for almost a decade, resulting in a variety of distinctive tall buildings. Beginning with Nanjing’s 450-meter tall Zifeng Tower through the recent competition design for the 600-meter Wuhan Greenland, the relationship of architect and client is transforming the look of major Chinese cities through these iconic projects. Each is the result of a simple mission statement as declared by SOM: “To provide Greenland with something that has never been seen before.”

Each building design is instantly recognizable – from Zhengzhou’s carefully controlled interior solar shading mechanism to The Twins gracefully dancing ballet on Nanchang’s skyline, from Gaixiu’s city-scaled “window” to Beijing’s intricately faceted face. The most recent project, featured in the previous case study, is Greenland Group Suzhou Center – a 600-meter tall tower which incorporates passive ventilation techniques via a unique interior “lung.”

Each of these projects is innovative in unexpected ways, while setting new standards for techniques and technologies. Recurring themes define these investigations, which explore different aspects of natural lighting, passive ventilation and the manipulation of air around and through these high performance buildings.

Zhengzhou Greenland Plaza

The 280-meter tall Zhengzhou Tower’s circular form, wrapped by sun-shading screens, is an essay in the manipulation of natural light. The building was designed in 2006. Natural lighting provides multiple benefits – reducing the building’s energy costs, improving worker productivity and making a more pleasant interior environment for occupants. The exterior skin is protected by an intricate screen that gives the 56-story building a stacked form that subtly invokes the architecture of traditional Chinese tower structures while filtering daylight for the interior spaces. The building’s atrium space is crowned by the building’s most technically advanced feature – a motor-driven heliostat. This computer-controlled solar reflector focuses sunlight within the building’s core according to carefully considered parameters. Extensive day lighting studies allow the innovative device to maximize natural light by focusing it through sunshade louvers driven by dimmer switches that modulate light levels. The atrium is bathed in glare-free natural light, optimizing indoor environmental conditions while saving energy.

Status: First phase completed, 2012

Jiangxi Nanchang Greenland Central Plaza Parcel A

These two bold towers will dance across Nanchang’s skyline in an inspiring ballet between 289-meter-tall buildings. The fluidic forms at the center of the new 110,000-square meter mixed-use complex were inspired by the organic form of the city’s flower, the Chinese Rose, but the final shape was derived from SOM’s cutting-edge investigations into the aerodynamic performance of tall buildings and the cladding technologies of cold bent glass. The 59-story-tall twisting profiles, with no sharp edges, aid in vortex shedding – the primary external force on contemporary buildings at this scale. Their execution utilizes cold bent glass to provide a cost-effective solution to produce the highly varied warped patterns necessary to achieve the overall form. The towers’ reflective and luminous surfaces will be a new icon for Jiangxi and the region – as the two buildings will be the tallest in central China when completed.

Status: Under construction

“Each building design is instantly recognizable – from Zhengzhou’s carefully controlled interior solar shading mechanism to The Twins gracefully dancing ballet…”
Jiangxi Nanchang Greenland Gaoxin

The 268-meter-tall Jiangxi Nanchang Greenland Gaoxin features a distinctive diagrid-patterned aluminum sunshade system that reduces solar loads while making a strong aesthetic statement on Nanchang’s skyline. The top third of the 54-story tower is articulated as a recessed “great window” that faces the old city to the west. The window also denotes the location of the hotel portion of the 264,250-square meter program; lower floors and a podium structure house office and retail functions. The triangular-shaped 750-millimeter deep fins are part of the insulated glass unitized curtain wall that incorporates low-e and silver reflective coatings to enhance sustainability. The building’s singular identity is intended to create a new beacon for Nanchang, linking the city’s storied past with its future in the Gaoxin district.

Status: Under construction

Beijing Greenland Dawangjing Tower

The boldly elaborate façades of the 285-meter-tall Beijing Greenland Center are designed to create the world’s first “self-shading” supertall structure. Developed to demonstrate Greenland Group’s commitment to environmental efficiency, interlocking glass trapezoid window panels balance solar gain and self-shading while providing a distinctive building skin that will be an icon for the emerging financial district located in northeastern Beijing, close to the city’s international airport. The 170,905-square meter structure is paired with a four-story retail building that uses an asymmetrical composition of translucent and transparent glass to provide a complimentary aesthetic to the tower. Beijing Greenland Center is one of the first projects to utilize SOM’s proprietary High Performance Design (HPD™) application to meet the firm’s performance design goals.

Status: Under construction

Wuhan Greenland

SOM’s competition design entry for Wuhan Greenland Tower develops aerodynamic themes initially pioneered by the firm in Nanchang’s Twins. Gently curved concave and convex curves sheath a cruciform plan based on the upper floors of SOM’s iconic Willis (formerly Sears) Tower in Chicago. The basic plan shape provides a well-tested, structurally stable solution for office and residential uses that extend more than 600 meters into Wuhan’s sky. The complex interplay of curves, coupled with notches at various intervals, were informed by extensive aerodynamic testing and allow for the most structurally efficient solution. High performance glass curtain walls sheathe the building, culminating in a series of open steel parabolic arches at the building’s crown. A bold, singular statement on the banks of the Yangtze River, Wuhan Greenland Tower was intended to become a recognizable icon throughout China.

Status: Competition Entry