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Yuri Starodubtsev
Yuri Starodubstev manages the design of supertall projects for the Capital Group. He oversees the work of design architects and coordinates architectural and planning decisions with other aspects of the development. Mr. Starobubstev is also currently overseeing multifunctional complex on MIBC's Plot 16 designed by SOM, USA. He had participated in the design of a wide array of challenging building projects including Moscow embassies in Australia and the United States, factory facilities for Philip Morris in St. Petersburg and for Nestle in Moscow.

Joey Myers
Joey Myers led the design of the Capital City Towers project. He had worked on some of the NBBJ's most important projects, including Europe's largest wireless headquarters for Telenor in Oslo which received the FIABCI Prix d'Excellence. With 18 years of experience working in 18 countries, Mr. Myers specializes in the design and planning of large, complex projects and has created award-winning buildings in various market sectors.

Larry Goetz
Larry Goetz specializes in managing architecture teams in the design and delivery of complex developments with innovative engineering possibilities. Previous projects include Seattle's Safeco Field, the LEED® Silver Seattle Justice Center and an expansion to the Seattle-Tacoma International Airport. Mr. Goetz moved to Seattle in 2010 to work on NBBJ's Advanced Design Technology changes and advanced BIM development. He was named Principal in 2008.

"As a pioneering project in Moscow, Capital City has forged many new pathways for the city's real estate and construction industries. Through its integrated design and engineering, the project provides a model for mixed-use development, which remains rare in the city, and further establishes a new identity for Moscow."

After more than a decade in the planning, Moscow City, a new mixed-use business district rising 4 kilometers (2.5 miles) west of the Kremlin, is a symbol of Russia's ascent in the global economic playing field. The Capital City mixed-use development (see Figure1), completed in 2010, is the fourth to be realized among more than 20 projects which comprise Moscow City and, at 302 meters (989 feet) in height, it is currently the tallest building in Europe. With its iconic form that recalls Constructivist geometries, Capital City also captures modern Moscow. Its two slender, yet bold residential towers, joined by an office and retail base, are international in quality and performance but still rooted in Russian culture.

With its compressed schedule, achieving this unique structure at this point in Moscow's history required innovation and collaboration. The design introduced advanced engineering and design capabilities while building upon local construction expertise. Developed by Capital Group, a Moscow-based company responsible for more than 5 million square meters (53.8 million square feet) of residential, commercial and mixed-use development, Capital City's completion represents an exchange of high-rise design and construction expertise that will influence future construction and building standards in Russia.

Figure 1. Capital City Towers © NBBJ

Anchoring a New District

Capital City's mix of residential, office and retail distinguishes Moscow City from precedents like Canary Wharf in London and La Défense in Paris, which were planned primarily as commercial districts and are only now working to increase their residential components. Set on the Presnenskaya embankment overlooking the Moscow River, Moscow City was envisioned from the outset as a place for business, living and leisure. More than 3 million square meters (32.6 million square feet) of residential, office, hospitality and entertainment uses – including Capital City's 288,000 square meters (3.1 million square feet) – are planned for the 60-hectare (247-acre) district. Similar to London and Paris, Moscow City is intended to provide a vitalizing expansion of commercial office space while preserving the character of Moscow's historic center.

The idea of a new business district in Moscow first emerged after the completion of the Expocenter in 1980. With the Expocenter drawing new activity to the area, attention turned to the adjacent site, then a declining industrial area. By 1990, a master plan for a new international business center was in place, but it would take the sustained economic growth of the past decade to finally catalyze development.

The plan organizes 20 development plots around a central core serving the entire district. Currently under construction, the central core includes a hotel, retail-entertainment complex and concert hall. Below grade, a retail mall, vehicle access, 2,750 parking spaces, a multi-modal transit hub, and pedestrian walkways will link the central core with surrounding developments and the city beyond. In addition to the completed mini-metro link to the main metro system, future plans include two new metro stations and a high-speed rail connection to the Vnukovo and Sheremetyevo airports.

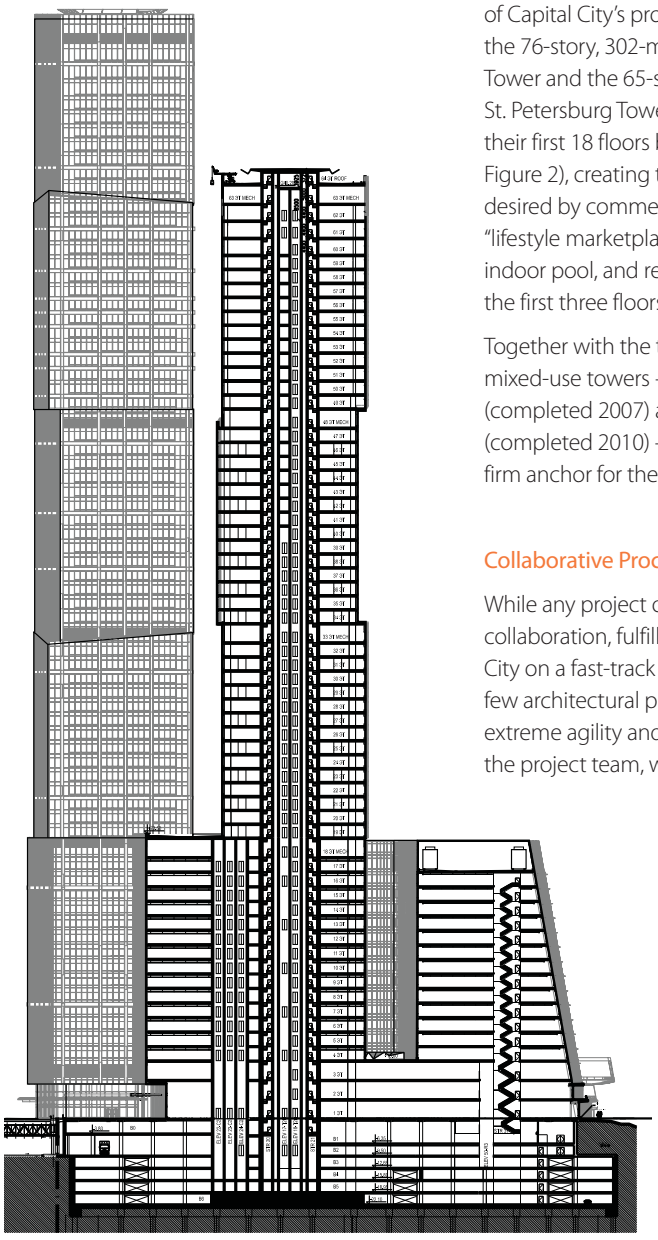

Figure 2. Building Section © NBBJ

The luxury residences that comprise the bulk of Capital City's program are contained within the 76-story, 302-meter (989-foot) Moscow Tower and the 65-story, 257-meter (843-foot) St. Petersburg Tower. Both are joined through their first 18 floors by a podium building (see Figure 2), creating the larger floor plate desired by commercial office tenants. A "lifestyle marketplace," a fitness spa with indoor pool, and residential lobbies occupy the first three floors.

Together with the two other completed mixed-use towers – the Naberezhnaya Tower (completed 2007) and Imperia Tower (completed 2010) – Capital City provides a firm anchor for the nascent Moscow City.

Collaborative Process

While any project of this complexity requires collaboration, fulfilling the vision for Capital City on a fast-track schedule in a district with few architectural precedents required extreme agility and innovation on the part of the project team, which spanned 11 time zones from Seattle, to London, to Moscow.

Another complication was the absence of applicable local building codes. When the development of Moscow City began, local building codes dated back to 1950, when the average building height did not exceed 75 meters (246 feet) and codes for high-rise housing did not exist. In order to address the structural and life-safety requirements for Moscow City's tall buildings, rigorous codes modeled after British standards were adopted for all projects in the new district, including Capital City. These codes establish high standards for fire safety, and include 4-hour structural fire resistance, the use of 30-minute fire-rated glass, ample refuge areas, redundant fire elevators and exit stairs, and rooftop platforms for lightweight refuge cabins that can be delivered by helicopter.

To begin construction on schedule, NBBJ and Arup elected to complete the structural design while the architectural design was still in process. The superstructure and raft foundation design was developed on a fast-track schedule that was locked in place after early design development, allowing architectural façade design to continue while detailed structural design was completed. Refuge floor locations in the two tall towers were finalized along with vertical mechanical and fire separations to allow structural design of the superstructure to be coordinated quickly with the design of the structural out-riggers and core.

After working closely together to develop highly efficient and integrated structural and mechanical systems, the design team worked with Moscow authorities to verify that the project would fulfill the new building codes. Expert panels in structural engineering and life-safety reviewed the proposed design.

Design Concept

Capital City's bold architectural form takes as its conceptual inspiration "Corner Counter Relief" of 1914 by Vladimir Tatlin, often heralded as the father of Russian Constructivism. Tatlin's experimental work in the early 20th century marked an attempt to redefine sculpture's relationship to built space. Slung between two perpendicular walls, Corner Counter Relief breaches the orthogonal shape of a typical room in order to introduce a taut, interstitial geometry. A similar effect is created by the offset rotation of Capital City's tower segments which

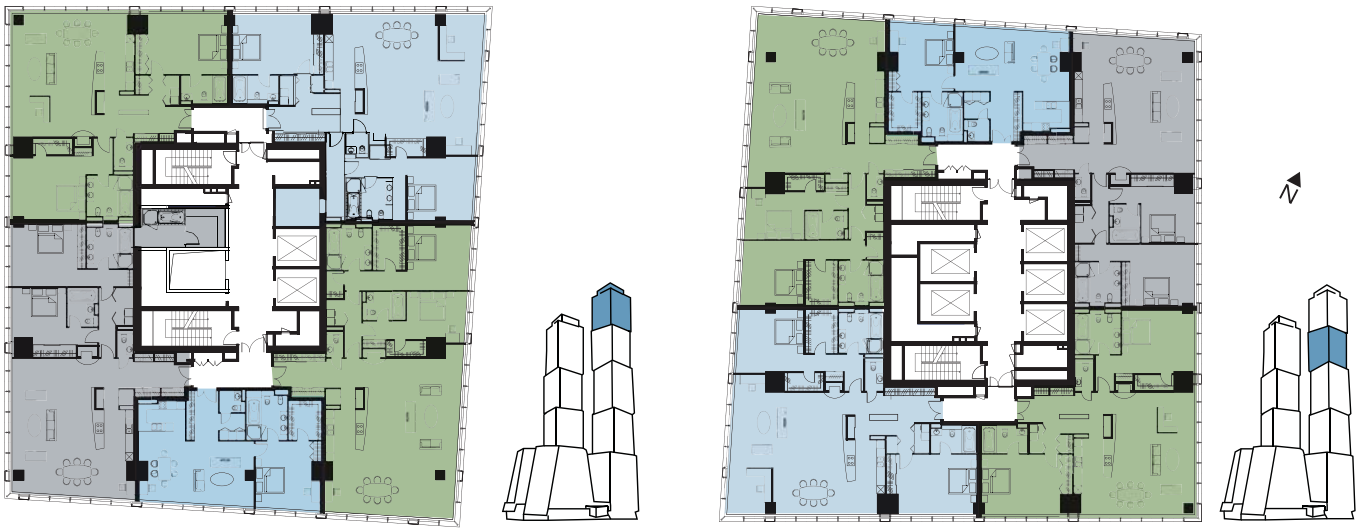

Figure 3. Typical residential plans © NBBJ

create a dynamic departure from the stability of a square (see Figure 3).

This rotational effect, achieved through a slight cantilever on only two façades of each vertical segment, does not compromise the regularity of the towers' structure. A mechanical floor demarcates each 15-floor segment and integrates the structural system. The Moscow Tower contains five such segments while the St. Petersburg Tower contains four.

The two-tower typology had several benefits over a single tower of the same square footage. It allowed for a slender, elegant massing that maximizes the perimeter-to-floor plate ratio, enhancing access to breathtaking views and daylight. It also eliminated corridors and provided a more intimate relationship between the elevator lobby and the five to six units per floor, a scheme more suitable for high-end luxury residences.

Unlike typical real estate practices in Moscow, where residential units are typically delivered unfinished, nearly all Capital City's 474 rental apartments are fully fitted out with finished interior walls, stone and parquet floor, high-end appliances and fixtures, HVAC, operable windows, and security system. This change in practice allowed residential units to be leased ready for immediate occupancy and eliminated any reduction in lift service that could occur during a simultaneous fit-out of so many units once the building began to be occupied.

In contrast to the rectilinear tower segments, the 18-story podium building has inclined façades and a curvilinear ground plan (see Figure 4) that alludes to Moscow's concentric ring roads and creates a welcoming space for the public amenities on the first three floors. Upon entering from the porte-cochere, visitors are welcomed into the lifestyle marketplace on the first two levels and a world-class fitness spa and pool facility on the third. Organized around a central north-south pedestrian axis that defines a "main street" of shops and restaurants, the retail floors culminate in an expansive, day-lit atrium near the base of the towers (see Figure 5).

The upper levels of the podium are dedicated to office space and are organized in a bifurcated, H-shaped plan. This configuration allows more natural light to penetrate the office floor plates and to reach down to the spa and retail floors, which are enclosed in a continuous, undulating curtain wall that extends from the building façade above and folds over the main retail atrium to the north and the spa pool area to the south, to define the porte-cochere.

...drive for height

> "The drive for height is driven by the desire to increase land value, and one role of planning is to balance the individual property owner's desire to cram as much development on their parcel as possible with the impacts on neighbours and on the city as a whole."
>
> *Hank Dittmar, Chief Executive of the Prince's Foundation for the Built Environment on the future of tall buildings in London. From "Building Community," Modus, March 2011.*

Integrated Engineering

Capital City's prominent riverfront location and current distinction as Europe's tallest building make the dramatic views from its residences one of the project's most notable features. The desire to capitalize on this valuable amenity while providing spacious,

Figure 4. The Towers' podium © NBBJ

open residences drove the building's structural design.

The imperative of providing large, open living spaces with full-height glazing precluded a conventional tube structure approach, which would have placed obstructive edge beams and columns at the building's perimeter and corners. The team instead chose a multi-pronged solution that combines a minimal building core with a mega-column structure to achieve enhanced structural efficiency and spatial quality.

The core was minimized by carefully integrating mechanical and structural systems and through the use a double-decker, high-speed elevator system. This system, which has an upper compartment for passengers and a lower compartment for service staff and equipment, is typically used in China and India to increase passenger capacity in high-occupancy office buildings. For Capital City's luxury residential program, this configuration obviates the need for a separate service elevator, thus reducing the core size. Although this system increased construction costs slightly, the improved efficiency provided a long-term benefit that outweighed the initial expense.

Running mechanical shafts seven floors above and below each mechanical floor, rather than serving each fourteen-story segment with a single shaft, resulted in further efficiency gains. Although this approach required special compartments separating mechanical equipment from the two shafts, in order to meet life-safety codes, the reduced dimensions of the shorter shafts increased the tower's efficiency.

Eight mega-columns – arranged to maximize open interior space and permit large windows in the façade – transfer loads for each tower segment through a series of connections. At each mechanical floor, the vertical load is transferred from the corner and central columns to the eight mega-columns through a perimeter belt truss that also connects to an outrigger structure. These outriggers in turn tie back into the core for wind load transfer.

Secondary reinforcement and connection between the central core and perimeter mega-columns is created through blade columns located on every other residential floor. Organized around the central core and concealed within the interior concrete walls along bathrooms and between units, these columns work in conjunction with the apartment floor beams to harness the stiffness of the perimeter columns for lateral loading while being relatively unaffected by differential shortening between the core and perimeter.

Finally, solid concrete slab floors supported on bi-directional shallow beams allow for higher than average floor-to-ceiling ratios within residences and offices, and permitted fast construction. The floors cantilever out beyond the mega-columns to the façade, allowing the form to shift with each vertical segment while the structure remains consistent. The cantilevered segment of each floor creates a dramatic, column-free area between the column line and the façade.

In response to more rigorous building codes, floors were detailed to accommodate the removal of a structural support, or to carry the weight of a collapsed area of the floor above, in the event of a localized but significant event such as a fire or explosion.

Integrating the tower structure with the podium building structure required significant analysis. Structurally separating the two towers would have necessitated placing a movement joint through an entire floor. More significant than loss of usable space, this approach would result in a compromised experience since the independent movements of the towers would be noticeable during windy conditions and interior finishes, exterior cladding and waterproofing would have to accommodate this movement.

Arup elected instead to treat the towers as a fully contiguous, single structure through the first 19 floors (including the podium building roof) and conducted complex dynamic analysis in order to determine the forces acting between the linked structures. The resulting structural analysis designated a slightly thicker, more reinforced slab at

Figure 5. Main atrium © NBBJ

Level 18, with lower floors also performing as continuous concrete diaphragms.

Foundation Construction

The ready availability and local production of concrete, coupled with a local building industry skilled in its use, gave reinforced concrete construction a significant advantage over other options. From an engineering and design perspective, it also allowed for minimal floor depth, maximum fire resistance, and adequate acoustic separation necessary in residential multi-story buildings.

Despite the common use of reinforced concrete in the region, critical portions of Capital City's concrete construction work were carried out in conditions that were anything but typical. The tower pile caps were each installed during continuous, 33-hour mid-winter pours in temperatures ranging from -32 to -34°C (-25 to -30°F, under a large heated tent to keep the concrete from freezing. Running five meters deep and measuring 6,500 cubic meters (230,000 cubic feet) and 6,000 cubic meters (212,000 cubic feet) for the Moscow and St. Petersburg Towers, respectively, the foundation utilized a relatively standard rebar cage and wooden formwork.

The foundation pile cap tops 215 piles beneath the Moscow Tower and 191 piles beneath the St. Petersburg Tower. An additional 76 piles for the combined-pile raft foundation support the podium building. Each pile measures 1.2 meters (47.25 inches) in diameter and 20 meters (65.6 feet) in length, and is drilled down through the site's thick layer of clay to the underlying limestone bedrock. The alternative – a shallow foundation at the bottom of the basement that would act as a big raft in the clay layer – would have required large stabilizing walls in the basement that would have significantly compromised circulation and the basement-level program. The six-level basement includes more than 2,200 parking spaces, electrical equipment and enlarged fire compartments.

The basement also accommodates an unusual site runoff management facility that responds to the limited capacity of Moscow's sewer system to absorb large surges of water. Rainwater collection tanks located in the basement temporarily retain runoff water before it is slowly discharged into the municipal system at a manageable rate. While such measures are unusual for Moscow, this system protects Capital City and the immediate site from flooding. Additionally, a water retention pond for fire defense minimizes on-site water and energy consumption.

Typical cast-in-place concrete construction utilizing pumps to move the concrete to upper floors was utilized for the towers and podium building and towers.

Curtain Wall

The design team collaborated with German curtain wall specialist Schüco to create a dynamic façade for the towers and podium

building. The towers are enclosed in a unitized panel system with four-sided structural-silicone glazing. The aluminum panels compose a shifting super grid that resonates with the towers' shifting blocks. The panels also shift in plan, some protruding outward while others are slightly inset to accommodate vertical LED lighting. Within this shifting grid, silver-reflected glass panels alternate between shadow box construction and ceramic frit coating to control solar heat gain. The curtain wall also integrates electronically operable windows in all apartments. These windows are designed for use in accordance with the mechanical systems, offering residents flexible control over their interior environment.

The podium building's façade establishes a more striking presence, utilizing two systems: a structural silicone stick system and a point-supported planar glass system. The main three walls to the south incline at a 10-degree slope and are constructed of a four-way glazing system with sunshades on the south side. The remaining vertical curtain walls are fabricated with flat and curved aluminum panels with vision glass that form a gently curving wall extending from south to north. The three retail and spa floors are denoted by a point-supported planar façade system with stainless steel spider supports and specially designed glass columns. Three automatic revolving doors with air curtains provide the primary means of entry.

One of the project's more complex curtain wall systems is the folded, angled curtain wall covering the retail atrium and spa pool and marking the main entrance (see Figure 6). The curtain wall's geometry tapers in plan and angles in section, allowing for water drainage and ice collection and removal. The glass panels are heated to adapt to Moscow's winter climate. This skylight system – an undulating, folding clear and translucent glazing – also resonates with the interior pedestrian "fashion street" at the ground level by creating a fashion/fabric analogy.

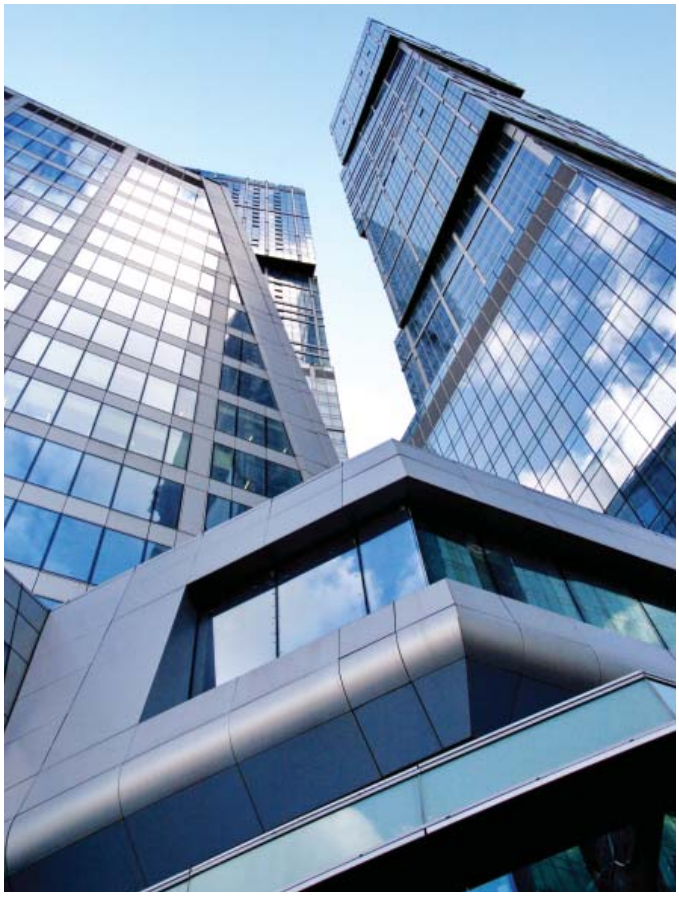

Figure 6. Angled curtain wall cladding © NBBJ

The realization of the curtain wall was a global effort. Designed in Germany, fabricated in Turkey, tested in England at Taylor Woodrow Technology Centre, supervised by US consulting firm Israel Berger & Associates, and assembled in Moscow by Aygun Aluminum; the curtain walls are one of Capital City's more complex elements and necessitated multiple iterations before finalization. Wind tunnel tests and computer analyses were performed to determine areas of positive and negative pressure, after which on-site mock-ups provided critical feedback dictating the use of thicker glass in certain locations. After several tests, the necessary thickness for the exterior glass on the upper floors of the St. Petersburg and Moscow Towers was deemed to be 8 millimeters (0.25 inches) and 10 millimeters (0.375 inches), respectively.

Conclusion

As a pioneering project in Moscow, Capital City has forged many new pathways for the city's real estate and construction industries. Through integrated design and engineering, the project provides a model for mixed-use development, which remains rare in the city, and further establishes a new identity for Moscow.

As much as the project demanded innovative solutions and processes, an equally important legacy of Capital City's development is the design, construction and procedural precedents it helped to establish in Moscow. The collaboration throughout the project – between the client, design team, and local engineering, construction and agencies – represents a foundation of exchange between the global and local tall building industries that paves the way for future advances. ■

Acknowledgements

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Project Data

Completion Date: December 2010
Height to Architectural Top: 302 m (989 ft) (Moscow), 257 m (843 ft) (St Petersburg)
Stories: 76 (Moscow), 65 (St. Petersburg)
Total Area: 288,000 sq. m. (3.1 million sq. ft.)
Primary Use: Residential
Owner/Developer: Capital Group
Design Architect: NBBJ
Structural Engineer: Arup
MEP Engineer: Arup
Main Contractor: Inrecon
Lift Consultant: KONE