Wind Study Equips Unique Structure, Tower to Withstand Wind Loads

Children's Mercy Research Institute

BSA

Wind Study Equips Unique Structure

Tower to Withstand Wind Loads

Designing and engineering an iconic nine-story structure to withstand high winds and maintain the highest degree of air quality standards possible for its occupants – pediatric researchers and their patients – was the impetus behind Children's Mercy Research Institute (CMRI) architect BSA LifeStructures' (BSA's) and Bob D. Campbell & Co. Structural Engineers' (BDC's) decision to commission a site-specific wind study.

CPP Wind Engineering joined the project team in May 2017 to pair with BSA on CMRI, a 400,000-square-foot pediatric medical research institute located on Hospital Hill in Kansas City, MO that will reach substantial completion this fall. The institute is in proxim¬ity to several other medical facilities. Floors one through five of the new building adjoin existing floors of Children's Mercy Adele Campus.

BSA commissioned the wind study based upon guidance from structural engineer BDC and Brack & Associates, the project's mechanical-electrical-plumbing engineer. BSA LifeStructures Director of Architecture Jacqueline Foy, LEED, AP, said the design team explored the need for a localized, specialized wind study due to the unique geometry of the research tower. Foy said the wind study performed specific to the design of CMRI is not one that would normally be done to design and build a standard brick and mortar healthcare facility.

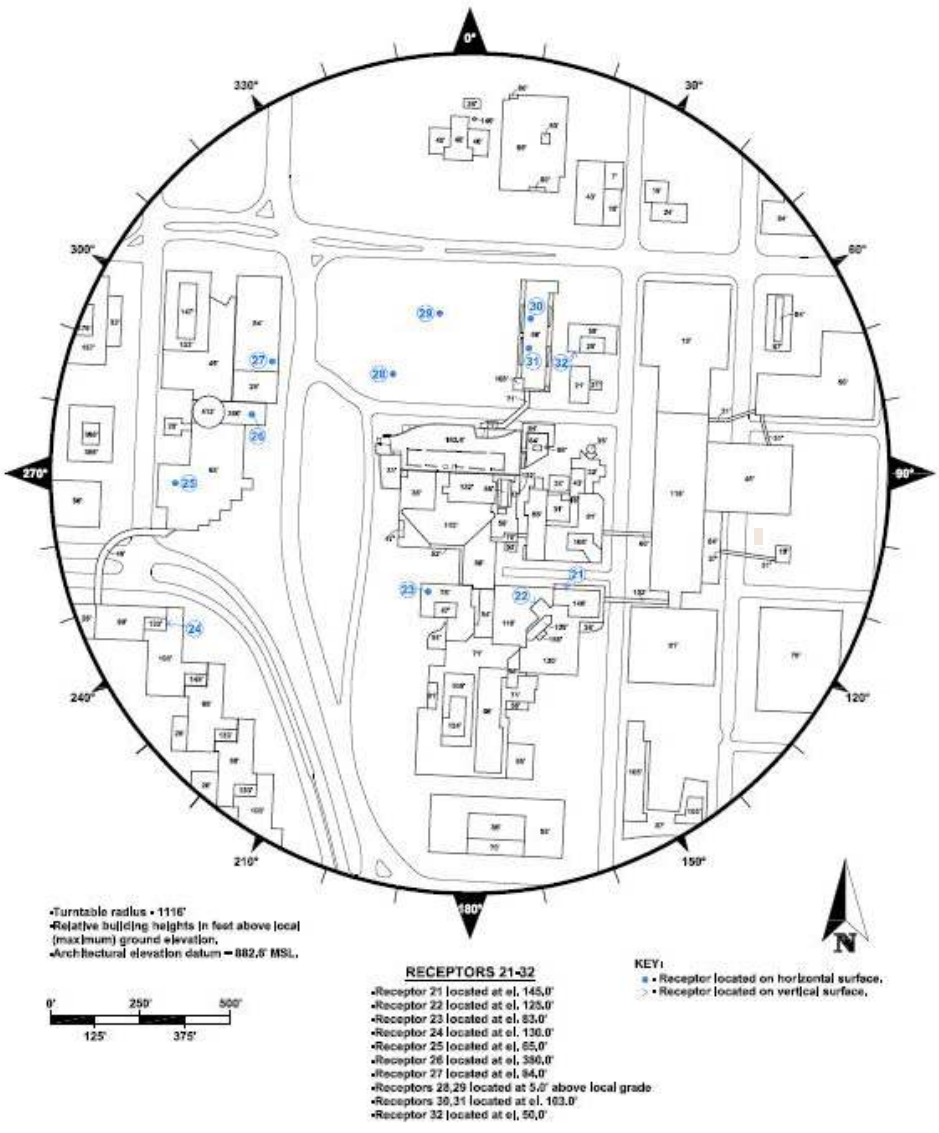
The research tower's shape has become sensitive to wind pressures and this is particularly true at the iconic stair tower and the fly-by curtain wall.

"The building's unique design and shape led to this project-specific wind study," said Foy. "The research tower's shape has become sensitive to wind pressures and the harmonic response of the structure to those wind pressures. This is particularly true at the iconic stair tower and the fly-by curtain wall," Foy said. "The team recommended to Children's Mercy Research Institute that a site-specific wind study be completed to accurately assess the actual wind pressures that will act on the tower. This study also included a dynamic analysis of the stair structure to ensure this shape does not introduce harmful vortices shredding (via whirlwinds) that could excite the structure and lead to large, rhythmic deflections that could damage the stair or render it unusable."

Foy added that the wind study also contributed to efficiency and economy in the design of the structure's curtain wall framing.

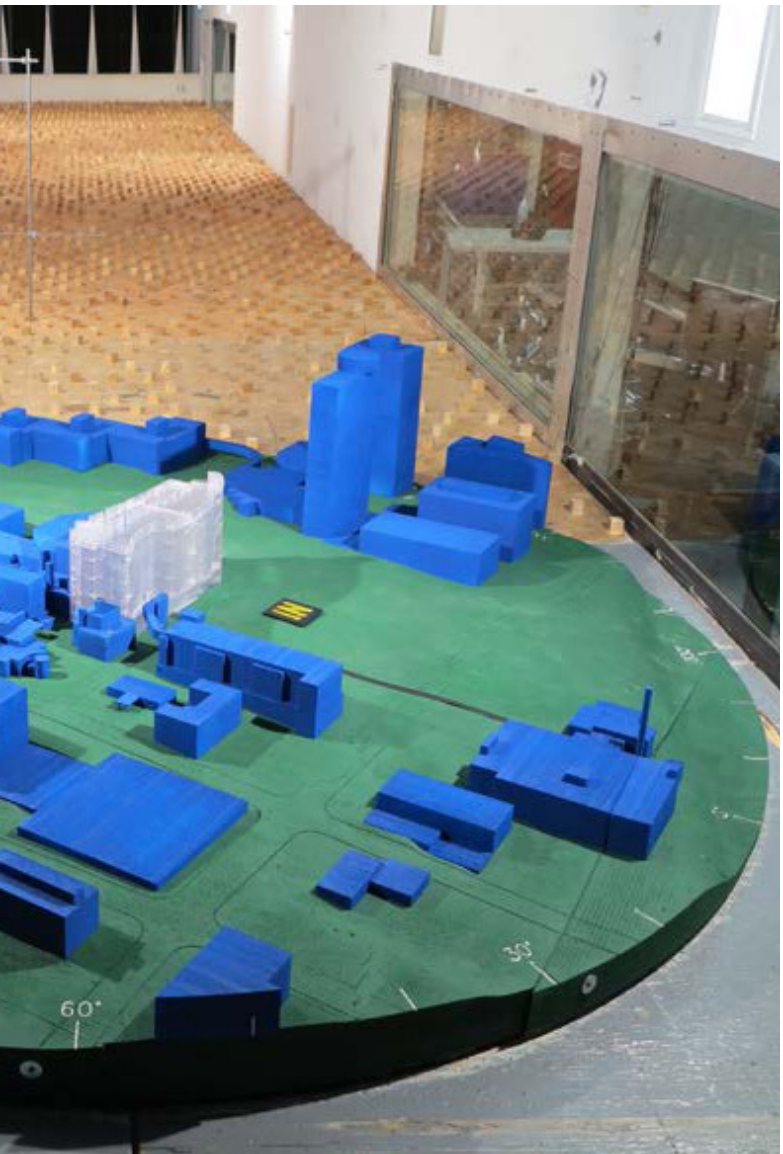
CPP Wind Vice President Roy Denoon led the structural wind loading team and directed an intricate wind study of the project. Physical modeling was a critical part of the work, as engineers worked in

BELOW | *Plan view of the area modeled on the turntable with building heights and surrounding receptor locations.*
BELOW RIGHT | *Completed model in the wind tunnel; View from northeast, simulating southwesterly wind.*



tandem with BSA to design and engineer a resilient structure. Simulating and calculating potential wind pressures on the future structure via a customized approach – and at standards exceeding normal building code requirements – was necessary.

"There are two ways of calculating wind loads on structures," said Denoon. "First, you can utilize existing, generic building codes and standards outlining typical wind forces on your building. The other option is to use wind tunnel testing and engineer wind load resistance based upon criteria specific to your building and project site. For the CMRI project, the project team chose the second option."



Denoon said examining factors such as how much the contemporary high-rise structure might move in the wind, potential wind impact on the top-to-bottom, helix-shaped monumental stair and the level of resistance based upon the building's contemporary glass and metal façade were all unique structural engineering wind load considerations.

"For the monumental stair, we performed a separate set of wind studies just on that feature," he said. "It's a feature of the design that standard building codes could not have accommodated. This particular study evaluated any potential wind pressures that would cause this iconic stairway to move or vibrate from within and engineered a solution for that."

Studying how wind loads might impact specific, localized portions of the future CMRI building – such as where the curtain wall connects to both the building slab and the monumental stair – also formed part of CPP Wind's analysis to ensure the integrity of the building envelope. According to Denoon, the wind engineering team spent a total of nearly eight weeks performing the wind load testing and analysis, from designing and building the test models to testing in the wind tunnel, to analyze the results.

"For the CMRI project, we established 550 locations over the building where we measured the surface pressures," he said. "More holes were used close to the corners of the models than in the building's center, as these are the areas where the highest pressure is generally found but also where the pressures change most quickly."

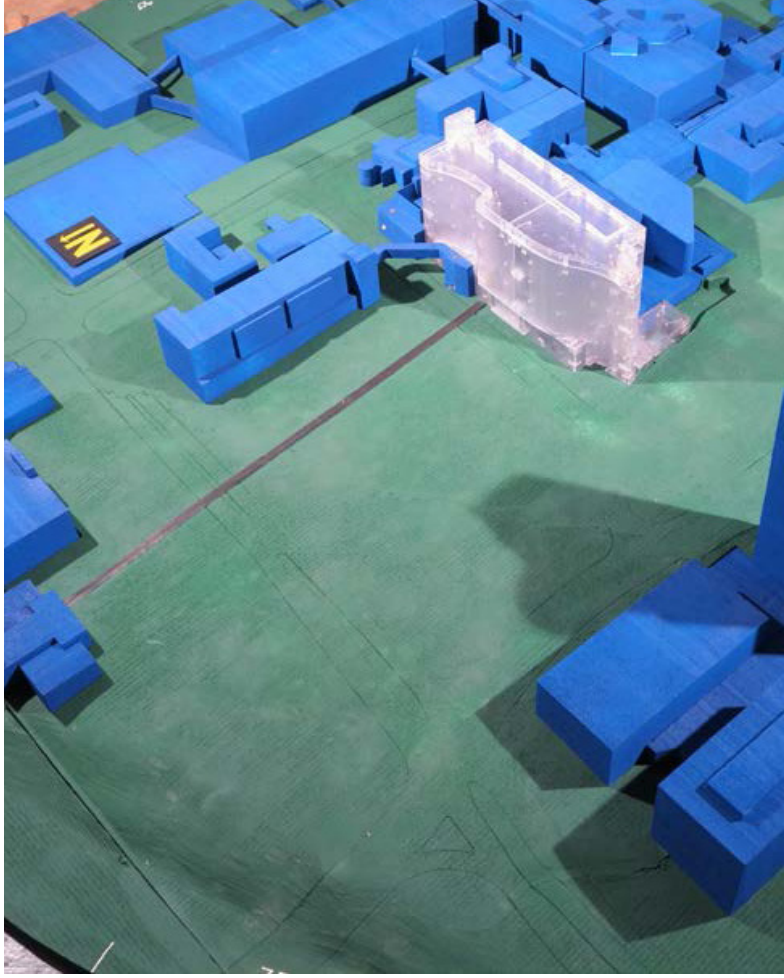
Inside the wind tunnel, the model was installed on a turntable; this was rotated, and measurements were made at 10-degree increments to simulate the effects of different wind directions. A six-foot-long, flexible

vinyl tube was connected to each hole and led back through the model, connecting to sensors underneath the wind tunnel where the pressure sensors were located.

“The wind tunnel model itself gave us approximately a 1,200-foot radius of the buildings around the CMRI building,” said Denoon. “The scale is determined by the heights of the surrounding buildings and the anticipated effect they will have upon CMRI’s structure. Taller buildings in proximity to CMRI can provide shelter from some directions or may actually increase the wind loads due to winds being accelerated around them.”

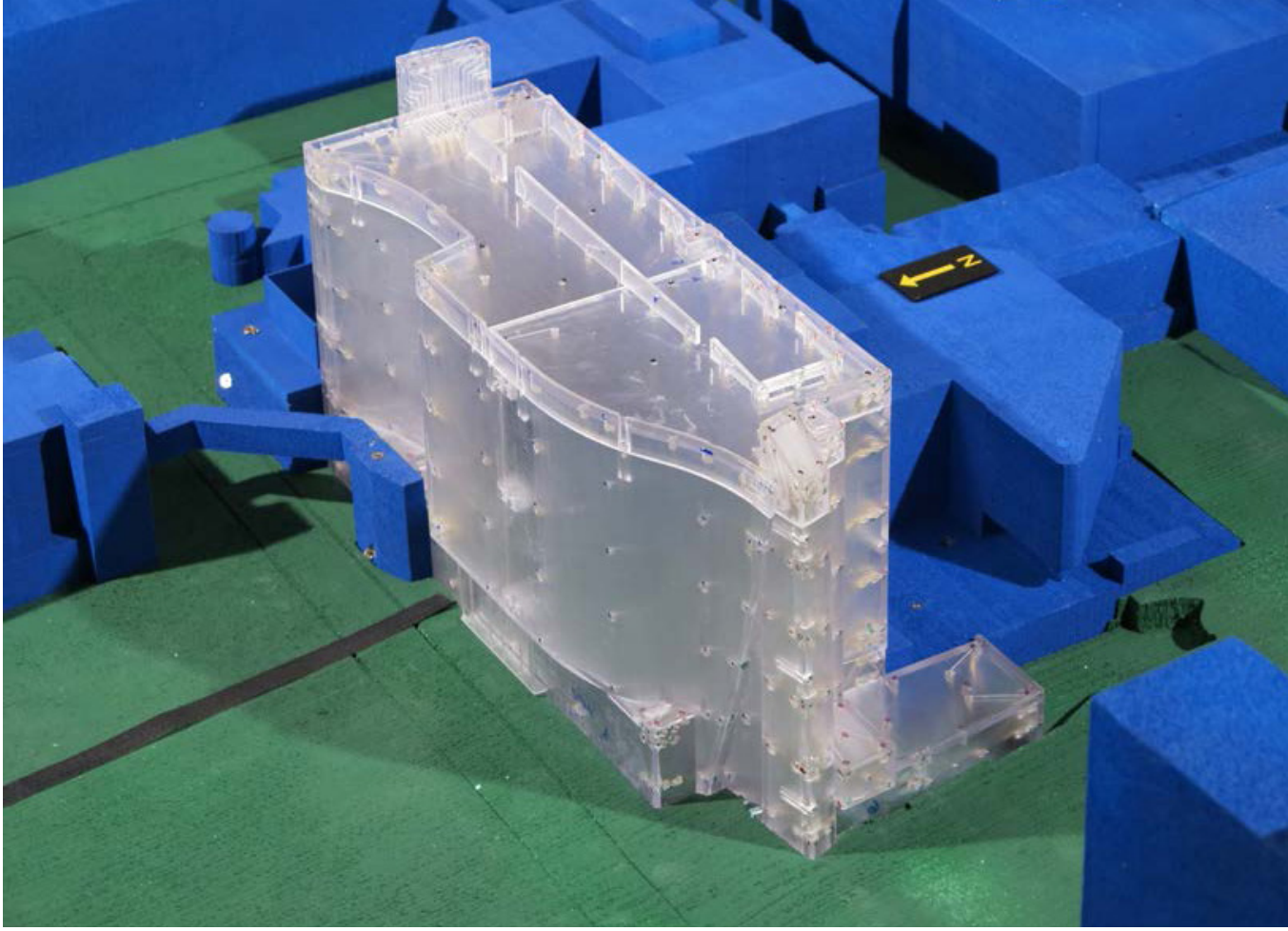
Modeling the characteristics of the wind – in addition to wind forces – was part of the scope. “Spires on the end of our wind tunnel, a trip board and blocks on the floor all simulated the effects of terrain for miles upwind of this site,” Denoon said. “The results of our wind study enabled project partners to design, engineer and build a one-of-a-kind pediatric research institute that will stand the test of time and that will operate as an efficient, sustainable building.”

Also, as part of the wind engineering firm’s scope of work, the project team – in tandem with Air Quality Consultants – performed a detailed air quality assessment of CMRI, ensuring that the design and construction allowed for safe and efficient dispersal of building exhausts. “Our analysis identifies the key areas from major pedestrian locations to air intakes on surrounding buildings,” said Denoon, “to ensure that there will be no ingestion of exhausts into fresh air intakes or concentrations in public spaces.”



ABOVE | *Photographs of the completed model in the wind tunnel. The wind study contributed to efficiency and economy in the design of the structure’s curtain wall framing. Simulating and calculating potential wind pressures on the future structure via a customized approach was necessary.*

Foy said owner CMRI will benefit from the design and engineering of an optimized exhaust fan system that minimizes risk to reintroduction of contaminants into outdoor air intakes and effects of adjacent facilities. “The air quality analysis identified the operating parameters of the variable air volume exhaust system,” she said. “Particularly because the initial build-out is limited to the lower floors, this analysis helped identify the low-end operating conditions which will ideally save operating costs, especially early on in the building’s life cycle.”



The CMRI wind tunnel exhaust system analysis also provides tangible benefit to the owner, Foy added, because it models the climatic condition effect on the exhaust systems. “This approach is more precise and may allow more economic operation of the building than applying more conservative building code recommendations,” she said.

As the new research institute building lies adjacent to several high-rise structures, the buildings collectively created a unique wind tunnel along Gillham Road. “The hill on which the building sits played an important role in this wind tunnel,” Foy said. “It also created some noticeable turbulence on the south side of the building that played into the height of the exhaust fans and their design.”

Author:
Jackie Foy
Architect, LEED AP
Director of Architecture
jfoy@bsalifestructures.com

BSA LifeStructures, a national, integrated design firm, creates inspired solutions that improve lives. BSA provides architecture, engineering, interior design and planning services for spaces that support and enhance healing, learning and discovery – facilities known as LifeStructures.

bsalifestructures.com
800.565.4855

ARCHITECTURE
ENGINEERING
PLANNING
INTERIORS
BSA

FRONT COVER | *A wind tunnel study of the Children's Mercy Research Institute was conducted to determine structural loads due to design-level winds. A scale model of the project was centered on a turntable in a boundary-layer wind tunnel. Replicas of surrounding buildings were constructed and placed on the turntable.*

BSA

BSA LifeStructures is an integrated design firm creating inspired solutions that improve lives through architecture, engineering, interior design, and planning services. With national expertise and regional leadership, BSA designs LifeStructures – innovative and inviting spaces that not only house the activities of healing, learning, and discovery but actually contribute to them – in order to make a difference for our clients and communities. As such, a LifeStructure is purposeful, a LifeStructure inspires, a LifeStructure delights and a LifeStructure improves lives.

bsalifestructures.com
800.565.4855