Brussels'tainable

The State Administrative City in Brussels was completed in 1983 and is now largely unused.
Photo courtesy Michael Uyttersprot.

Simulation helps to determine potential environmental impact in preparation for a massive renovation in Brussels.

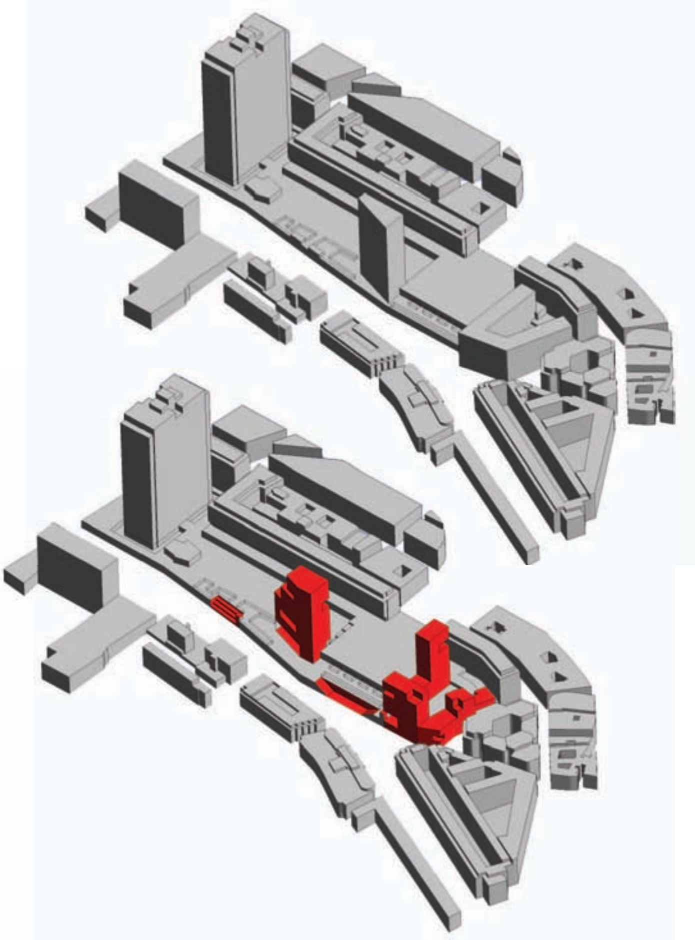
By Tin Meylemans, Architectural Engineer, and Jean-Pierre Demeure, Head of Urban Planning, City of Brussels, Belgium

Arnaud Boland and Quentin Hamoir, Support Engineers, ANSYS, Inc.

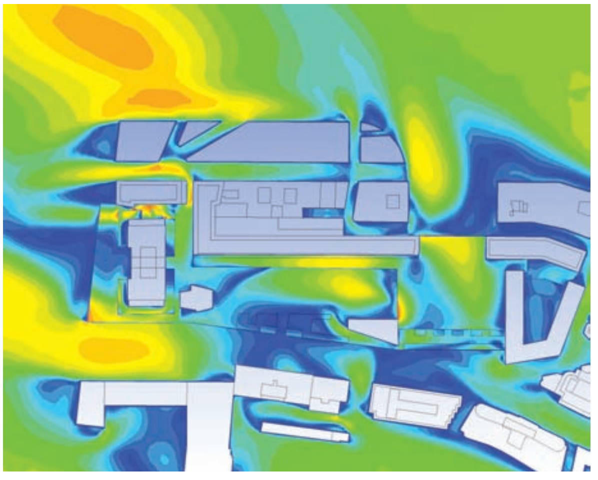
In 1992 during the Earth Summit in Rio de Janeiro, 200 countries — including Belgium — adopted Agenda 21, an action program for the 21st century to enable globally sustainable development on the planet. Among the program's main objectives is responsible management of natural resources and harmonious urban development. As the federal capital of Belgium and an administrative center of the European Union, the City of Brussels has been a leader by example. It is also a prime contributor to generating awareness of how large cities can naturally evolve to environmentally friendly urban growth.

Guided by Agenda 21 and targeting urban revitalization, the city undertook renovation of the State Administrative City, or CAE (Cité Administrative de l'Etat), an important site in downtown Brussels. Often recognized as the finest architectural achievement in Brussels since World War II, CAE is nevertheless an urban planning defeat, as it eliminated an entire district and broke the urban fabric with its 140,000 square meters of office space. As the Belgian federal government evolved, the administrative city has not been used since the early 2000s, leaving this huge site unoccupied. Its renovation had become a city priority. Today the site is undergoing a massive renovation project that combines housing, offices, shops, parks and a school.

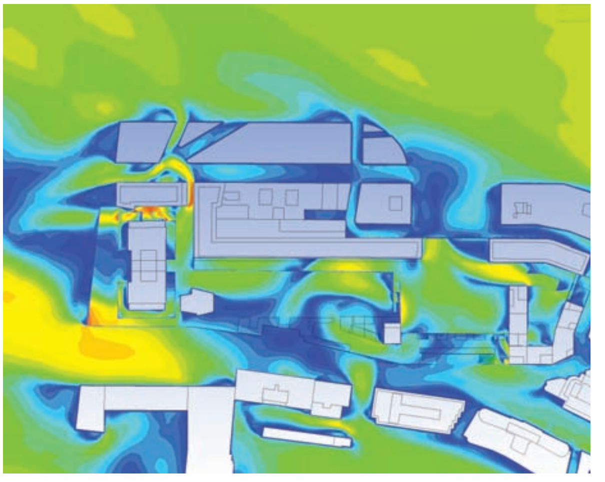
Before any major project is constructed, Belgian law requires an environmental impact study that includes economic and social factors, environmental assessments, mobility studies, health influences and noise level effects.



Initial (top) and modified (bottom) geometries of Brussels' CAE



Initial design



Recommended revision

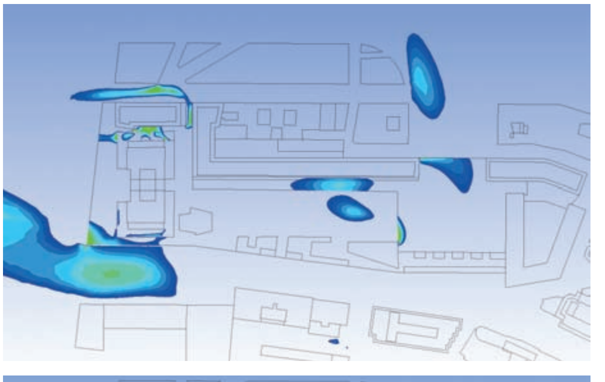
Engineering simulation was performed to determine pedestrian comfort levels (with yellow and red indicating discomfort).

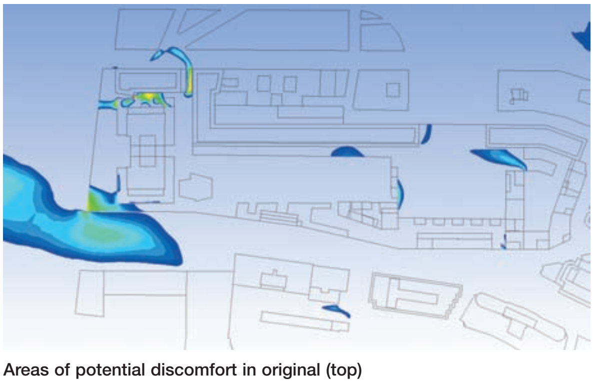
The City of Brussels selected the ANSYS office in Belgium to investigate wind flow patterns for the new site and compare different options for building locations — via engineering simulation.

Wind analysis is useful in studying many parameters related to a site's user comfort, in this case including high-rise buildings and green spaces. In some instances, the building acts as a screen and improves comfort, but in others the wind pattern could cause significant discomfort — and might even be dangerous — to pedestrians and occupants. Several important phenomena can occur, such as channeling and wedge effects, that lead to local wind acceleration and increased turbulence. These phenomena can contribute to discomfort for people located at ground level, terraces and balconies. The wind effects can also damage vegetation and generate unwanted pressure effects on buildings that cause whistling or material damage.

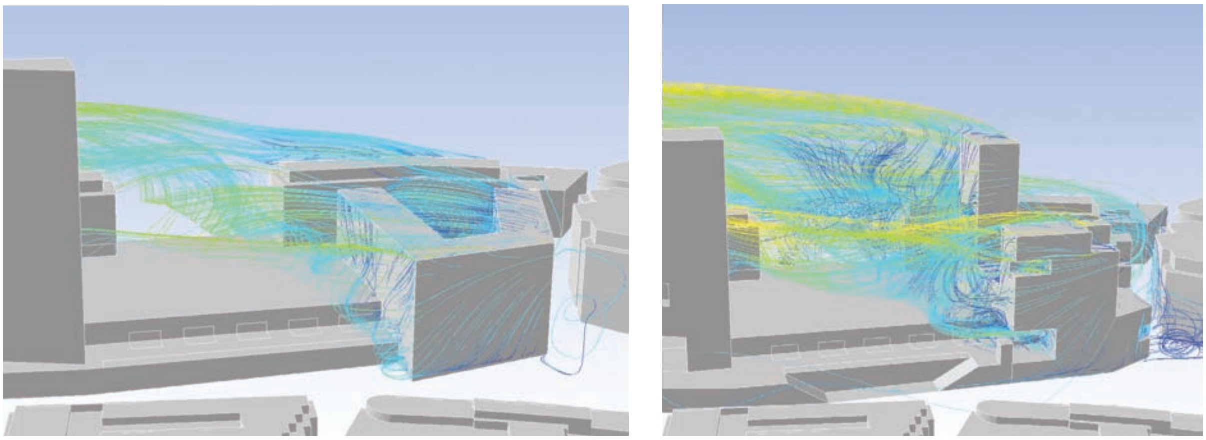
A typical comfort criteria from the TNO (an independent research organization in the Netherlands whose aim is to apply scientific knowledge to strengthen the innovative power of industry and government) requires that the wind speed in an area 1.75 meters above the ground should not exceed 5 meters/second for more than 220 hours per year. In identifying areas of discomfort, the standard must be expressed in terms of amplification factor (AF), the ratio between velocity without and with the building. A factor greater than 1 means the flow is accelerated by the buildings. Considering Brussels' meteorological data over the last 10 years, an AF of less than 0.88 satisfies the most-restrictive comfort criterion.

Project engineers investigated two configurations for environmental impact along with a possible need to minimize the negative impacts of wind. The first configuration, called initial state, contained the layout of the project (the volume envelope prescribed by the City of Brussels in which the building must be situated to satisfy local planning regulations). A second configuration, called the modified geometry, was studied to quantify the impact of architectural changes, such as towers being built on stilts, or architectural details, such as carvings or openings placed on different levels/stories of the structure. Because plans for reuse of the area were not complete at the time of analysis, this study would show where changes could have an impact.





Areas of potential discomfort in original (top) and modified (bottom) designs

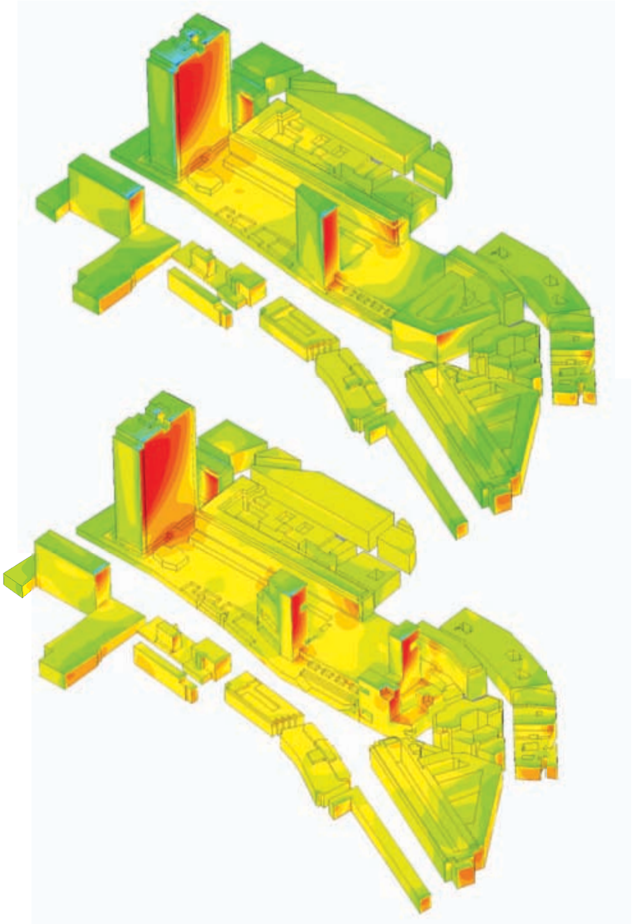


Pathlines showing wind trajectory colored by velocity magnitude for original (left) and new (right) designs provided increased understanding of wind behavior near buildings to determine areas of concern.

The ANSYS team determined the amplification factor at human height for both configurations, illustrating wind effects such as corner effects near tall buildings and channeling effects between closely spaced buildings. For the initial state, a map of the most-restrictive values (in which AF is greater than critical value) revealed areas where local wind speed was too high and would lead to pedestrian discomfort. The modified configuration reduced areas of discomfort by approximately a factor of three.

The team used ANSYS engineering simulation to determine airflow between the buildings, and these results were used to generate velocity vectors to identify specific points of interest, such as recirculation zones in which dust could accumulate. The details provided information that helped in adjusting the building design to avoid these types of zones. Pathlines of wind trajectory provided increased understanding of wind behavior near buildings, including turbulence, and identified areas where potential problems could occur. Finally, computing pressure contours on the buildings identified areas that would require special care during the design phase to avoid other concerns, including whistling problems due to insufficient insulation or damage to the facade.

This project demonstrates the use of engineering simulation for smart urbanization. Such analysis can provide comprehensive maps of airflow patterns, local wind velocities and local turbulence intensities — all useful in planning urban development projects. Simulation-driven building design provides information about how structures affect the environment, which can be an important part of discussions and decisions from a project's first stages.



Pressure contours for original and new designs identified areas that required special care during design to avoid insulation whistling problems or potential façade damage.