Beyond Red & Blue Arrows:
Effective Natural Ventilation in Large Scale Buildings

>> **Calling all 21st century designers!** Your generation has the opportunity to reduce the built environment's energy demands, address issues of climate change, and lessen carbon emissions. In regards to the Holcim Foundation's sustainable objectives, naturally ventilated buildings can decrease energy used on cooling loads, improve indoor air quality, and increase occupancy comfort. When used in large-scale buildings, such as offices which are typically sealed air-conditioned boxes, the energy savings through natural ventilation can be significant. The design of large-scale, naturally ventilated buildings can be optimized through improvement in two areas: building simulation techniques and postoccupancy evaluation.

>> Building Simulation

The multiple iterations required to optimize natural ventilation design requires an informed dialogue between the architect and engineer. At the present, there is a suboptimal architect/engineer relationship in which the architect lacks simple tools for initial design analysis and lacks understanding of the constraints of the engineer's analysis process. Building simulation tools offer some assurance in the design of large-scale naturally ventilated buildings. Building simulation is often avoided because it is time consuming, requires expensive software, and necessitates a skilled, experienced engineer in order to achieve meaningful results. A few leading architectural and engineering firms have established a smooth design process including building simulation. Through interviewing prominent architecture and engineering firms about their use of building simulation techniques, a variety of strategies and purposes emerged. [1]

The main finding regarding the use of building simulation in design is that there is no standard process or testing method used by all firms. In fact, while the use of thermal modeling software is relatively uniform, opinions vary widely on the purpose and usefulness of computational fluid dynamics (CFD) and physical testing (such as wind tunnel or water-bath models).

The following three responses reflect the variety in opinion of CFD modeling.

• CFD's accuracy is best at a very small scale, for example, in showing the airflow near a window boundary condition, not at an entire building scale. Water-bath models are more accurate in simulating the buoyancy-driven flow within an entire building.

• CFD is used to test areas of a building that are unusual or new to the design team. More standard parts of the building do not require CFD modeling and are designed based on experience and numerical calculations via spreadsheets.

• CFD is used at all scales, although is most accurate at smaller scales, requiring the most accurate data input. It is starting to be used in modeling external conditions, using wind tunnel tests to identify areas to focus on with CFD.

>> Post occupancy evaluation

Often times, when a building is completed, the designers move on, assuming the building is functioning as expected. Because of its automated and user-operated features, a naturally ventilated building may require more attention through post occupancy evaluation for optimal performance. The major barrier to this evaluation is lack of funding for the equipment and time required to evaluate data, as well as liability issues. The leaders in the field of postoccupancy evaluation are William Bordass and Adrian Leaman, based in the UK. Interviews with them and other UK architects and engineers revealed the usefulness of monitoring physical performance and disseminating information on building use.

Is there really a need for post-occupancy evaluation? The two most common causes of failure in a natural ventilation scheme are 1) a physical breakdown of operable parts and 2) lack of operator know-how.

In the case of a physical breakdown of moving parts such as window actuators or dampers, a simple monitoring solution will suffice. A very basic yet effective way to monitor a building is to track its temperature, noting its diurnal swings to understand if the various features (such as natural ventilation or thermal mass) are working as expected. Temperature fluctuations outside of the expected range may warrant further investigation by the designers or building managers to remedy the situation.

In speaking with architects and engineers who design naturally-ventilated buildings, one word continually arose: simplicity. The system should be intuitive, require little instruction, and allow the users to have control over their immediate environment. When prompted as to how to disseminate information on how to use the building, designers responded creatively. For example, the design team could disseminate instructional cards outlining how best to use the building. Alternatively, installing displays where occupants can see energy consumption in real time, could motivate users and make them aware of their actions.

Large-Scale Naturally Ventilated Buildings & Airflow Simulation


image: Metropolis, Aug 2002

Swiss Re Headquarters, London, UK

Architect: Foster and Partners
Ventilation Engineer: Hilson Moran

Six-story spiraling atria with automated windows use wind-induced pressure differentials as well as buoyancy effects to allow for natural ventilation during forty percent of the year (predicted). CFD assisted in determining the direction of the spiraling atria, the placement of the cellular offices, and the design of the transom vent on the facade. Wind-tunnel tests drove the aerodynamic, tapering form, which decreased pedestrian level winds as compared to a rectangular building shape. Six weather stations feed data to control the building management system. Monitoring of energy consumption and ventilation performance began in June 2004.


photo: Wendy Meguro

New Parliamentary Building (Portcullis House), London, UK

Architect: Michael Hopkins and Partners
Ventilation Engineer: Ove Arup

The dynamic building façade has a unique combination, integrating the window components with a ventilation shaft and shading elements. Although the report on its performance is confidential, the building's energy consumption is being monitored. Michael Hopkins and Partners also designed Jubilee Campus, where post-occupancy monitoring is being carried out by the student researchers who inhabit the campus.


image: morphosis.com

San Francisco Federal Building, CA, USA

Architect: Morphosis
Ventilation Engineer: Arup

The San Francisco Federal Building utilizes cross-ventilation across a shallow floor plate where air flows up and over sealed office modules in the center of the office plan. The building management system relies on a series of algorithms which were fine tuned when the designers inhabited and monitored the building before client occupancy.

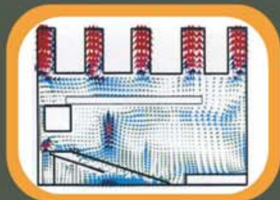
image: Architecture Today, June 1999

Contact Theatre, Manchester UK

Architect: Alan Short & Associates
Ventilation Engineer: Max Fordham

Contact Theatre uniquely cools its large interior volume by bringing fresh air in via an under-floor labyrinth (to avoid transmission of particulates and sound). The buoyancy-driven system exhausts hot air through H-shaped chimneys designed to maximize airflow while keeping out rain and noise. Building simulation in the form of thermal modeling as well as CFD verified the designers assumptions.

[1] Special thanks to firms interviewed:
Feilden Clegg Architects
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