Autodesk® Revit software
Autodesk® BIM 360

Build better healthcare buildings with BIM and CFD

The Building Information Modeling process offers healthcare organizations and building professionals the opportunity to use data-rich models to simulate real-world performance of designs, and computational fluid dynamics tools help to quickly and easily evaluate design options. Ultimately, using BIM and CFD can enhance building performance—helping to mitigate healthcare-associated infections, reduce energy consumption, and improve patient comfort.

Building information modeling (BIM) is an intelligent model–based process that helps owners and service providers achieve business results by enabling more accurate, accessible, and actionable insight throughout a project lifecycle. Healthcare organizations and building professionals alike are increasingly recognizing the role that BIM can play in bringing predictability into the design and construction process. BIM helps design and construction teams create more accurate, coordinated designs faster; improve collaboration and data management; speed decision making among stakeholders; and better manage schedules. Because healthcare buildings are among the most complex project types, working with coordinated, accurate BIM data during the design and construction process can result in substantial cost and time savings.

Beyond design and construction, BIM can also help improve the performance of buildings over their lifecycle, supporting improved patient care and reducing operating expenses. The tight integration of BIM and simulation technology from Autodesk now makes it easier and more cost-effective for healthcare organizations and building design professionals to maximize their investment in BIM. More accurate, data-rich building information models produced by Autodesk® Revit® software for BIM enable healthcare project teams to use advanced simulation tools to help explore the real-world performance and cost of design scenarios early in the design process to achieve more optimal design solutions. In particular, Autodesk® BIM 360 simulation capabilities that support the use of computational fluid dynamics (CFD) can help provide insight into critical environmental factors of healthcare facility designs that influence care and operations, including airflow, thermal comfort, and temperature influences.

This paper summarizes specific healthcare applications for CFD simulation enabled by BIM that can help mitigate healthcare associated infections, improve patient comfort, and reduce operating expenses over the building lifecycle.

CFD for infection control

The control of healthcare-associated infections (HAIs) presents challenges with severe health and economic consequences for healthcare institutions. According to the Centers for Disease Control (CDC), 1 in 20 people will contract an HAI during the course of receiving treatment at a healthcare facility.[i] Approximately 99,000 people who contract an HAI will die from that infection.[ii] The resulting economic burden HAIs place on the U.S. healthcare system is estimated to cost a minimum of $35 billion annually.[iii]

Building design and engineering professionals can play a key role in preventing HAIs through design considerations they undertake before construction begins. Hand-washing is recognized by the CDC as the single most important measure to prevent the spread of infection in healthcare buildings. However, given that an estimated 10 to 20 percent of HAIs are transmitted by the airborne route, building ventilation systems can play a significant role in preventing the spread of airborne microbial contaminants.[iv] Immune-compromised patients who stay in healthcare facilities for prolonged periods of time face the greatest risk of infection and mortality from airborne infections. As an example, mortality rates reported from *aspergillosis*, an airborne fungus, due to construction activities in healthcare facilities have been reported as high as 95 percent in bone marrow transplant patients, 13-80 percent in leukemia patients, and 8-30 percent in kidney transplant patients.[v]

Controlling air quality is critical to minimizing infection in operating rooms and other areas of the hospital that support immune-compromised patients. External air supply, operating room staff, and the space itself can all be sources for infections in operating rooms. Aerosol transmission of microorganisms is affected by factors such has increased humidity, temperature, population density, ventilation rate, and room airflow. Room air flow is governed by a combination of air movements caused by ventilation, differences in temperature, moving bodies, and the location and operation of equipment. By designing room airflow to ensure sterility at the surgical site, the risk of post-operative infection can be minimized.

Simulation using CFD tools can help building design teams model designs, such as operating rooms, to visualize and analyze room air flow and temperature distribution to minimize the risk from aerosol-transmitted infections. BIM enables design teams to model equipment and room variables, such as hospital staff, in realistic levels of detail to support more accurate simulations of air flow. Using CFD, project teams can easily test multiple design options to help achieve optimal air flows, humidity levels, and temperature distribution before construction begins.

A study undertaken in Australia validated that fine-tuning a design using CFD can lead to a safer environment for patients and more cost effective ventilation solutions. The study noted that traditional air distribution in operating rooms has not always resulted in the optimal supply of sterile air to the surgical site. Key objectives for controlling the operating room environment are: ensuring sterile air reaches the patient without mixing with air flows over staff and equipment; creating streamline or laminar air flow over the operating area;

making sure temperature is controlled and air velocity and temperature do not adversely affect the condition of the patient.[vi]

The study found that CFD simulation enabled the design team to model a proposed operating room air distribution system, to test each of the variables to help identify flaws in the air distribution, and make adjustments to achieve the optimum flow and temperature conditions. By using the visual results of CFD simulations, the project team gained a better understanding of how the placement of HVAC system components and equipment affects the environmental conditions in operating rooms. Through simulations, the project team was able to make a positive improvement in the air quality in operating rooms and assist in the reduction of post-operative infection rates.[vii]

CFD for energy savings

Hospitals consume more total energy than any other commercial building type, and are second only to retail food establishments in their energy use per square foot. This energy consumption comes at a staggering cost. According to the U.S. Green Building Council, hospitals spend nearly $8.8 billion annually on energy. Given that 1–3 percent of the average hospital budget is spent on energy, reducing operating expenses through energy savings can have a substantial impact on a hospital's bottom line.[viii] According to Energy Star, every $1 a nonprofit healthcare organization saves on energy is equivalent to $20 in new revenues. For-profit hospitals can boost earnings per share by a penny by reducing energy costs by 5 percent.[ix]

Government support for energy reduction can aid hospitals in initiatives to improve the efficiency of existing facilities. The Nonprofit Energy Efficiency Act (S.3535) recently introduced into legislation provides nonprofit organizations such as hospitals with reimbursement for 50 percent of energy retrofit costs, up to $200,000. Eligible activities include updating or replacing HVAC systems and installing renewable energy generation or heating systems, and any other measures to make the building more efficient.[x]

Healthcare organizations are increasingly embracing energy efficient solutions. In fact, 84 percent of hospitals rated energy efficiency as an important attribute of requests for proposals they evaluate.[xi] As such, building project teams are turning to simulation solutions such as CFD to help design higher-performing, more sustainable buildings. The seamless integration between design software applications that support BIM and CFD tools helps building project teams incorporate energy efficiency into the design process.

In one use case, BIM and CFD were used in the redesign of a lab space. The project team's goals were to control air flow, reduce energy consumption, and abate contaminants and spills. By using CFD to simulate design options of the lab model, the project team was better able to determine the optimal HAV system for the space, improve air flow design, and reduce the number of air changes per hour, resulting in a $500,000 savings per year in energy costs.

By simulating airflow within existing building spaces and proposed designs, CFD can help expose air circulation issues that result in wasted energy and higher operating expenses. CFD enables air flow to be readily visualized in design models, helping project teams evaluate design options to achieve optimal, energy efficient air flows.

CFD for patient comfort

Simulation can also help project teams design more comfortable healthcare spaces for patients and visitors. Healthcare design teams are increasingly exploring innovative design concepts like underfloor air distributions, displacement ventilation, radiant panels, chilled beams, and different diffuser types. CFD enables exploration of creative design solutions virtually to help teams validate or eliminate them as viable options. This process helps to better ensure the comfort of occupants and visitors in spaces throughout the hospital—lobbies, patient rooms, common areas, atria and dining areas—in a low cost and sustainable way.

Conclusion

Healthcare building project teams can take advantage of BIM design data to perform more realistic simulations of building performance, early in the design process. Using simulation technology for CFD, building project teams can evaluate multiple design options based on various scenarios and environmental conditions, such as temperature and humidity levels.

Now, the more seamless integration of Autodesk Revit software for BIM and new cloud-based CFD simulation tools provided by Autodesk BIM 360 enables project teams to harness the flexible, scalable computing power of the cloud to run an unlimited number of simulations simultaneously and compare results side by side. By offloading computationally intensive studies from local computers, project teams can compress the analysis phase of projects while finding optimal design solutions.

When combined, BIM and CFD tools can offer significant value to healthcare building project teams in helping them plan, visualize, and validate designs. By incorporating simulation early and often in the design process, project teams can help reduce infections, maximize energy efficiency, and create more comfortable spaces for patients.

Learn more about Autodesk BIM and CFD solutions by visiting www.autodesk.com/healthcare or contacting healthcare@autodesk.com.

[i] Klevens, Monina R., et al. 2002. “Estimating Health Care-Associated Infections and Deaths in U.S. Hospitals, 2002.” Centers for Disease Control and Prevention. http://www.cdc.gov/HAI/pdfs/hai/infections_deaths.pdf
[ii] Klevins, 2002.
[iii] Scott, R. Douglass, II. 2009. “The Direct Medical Costs of Healthcare-Associated Infections in U.S. Hospitals and the Benefits of Prevention.” Centers of Disease Control and Prevention. http://www.cdc.gov/HAI/pdfs/hai/Scott_CostPaper.pdf
[iv] Memarzadeh, Farhad. 2011. “The Environment of Care and Health Care-Associated Infections: An Engineering Perspective.” American Society for Healthcare Engineering.http://www.ashe.org/resources/management_monographs/mg2011memarzadeh.html
[v] Memazadeh, 2011.
[vi] Colquhoun, John and Lester Partridge. 2003. “Computational Fluid Dynamics Applications in Hospital Ventilation Design.” *Indoor Built Environment* 12:81-88.
[vii] Colquhoun 2003.
[viii] United States Green Building Council, “Hospital Energy Efficiency Gets Some Help from Capitol Hill.” Accessed Nov 2012 https://new.usgbc.org/articles/hospital-energy-efficiency-gets-some-help-capitol-hill
[ix] Energy Star, “Leaders in healthcare tap the power of superior energy management.” Accessed Nov 2012. http://www.energystar.gov/ia/business/healthcare/factsheet_0804.pdf?26dd-883f
[x] United States Green Building Council 2012
[xi] Johnson and Johnson, “the Growing Importance of More Sustainable Products in the Global Health Care Industry.” Accessed Nov 2012. http://www.jnj.com/wps/wcm/connect/ef4195004cca13b8b083bbe78bb7138c/JNJ-Sustainable-Products-White-Paper-092512.pdf?MOD=AJPERES