

## Hygrothermal Interactions and Energy Consumption in Cold Climate Hospitals: Integrating Numerical Analysis and Case Studies to Investigate and Analyze the Impact of Air Leakage and Vapor Retarding

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**Abstract :** Moisture-induced problems are a significant concern for building owners, architects, construction managers, and building engineers, as they can have substantial impacts on building enclosures' durability and performance. Computational analyses, such as hygrothermal and thermal analysis, can provide valuable information and demonstrate the expected relative performance of building enclosure systems but are not grounded in absolute certainty. This paper evaluates the hygrothermal performance of common enclosure systems in hospitals in cold climates. The study aims to investigate the impact of exterior wall systems on hospitals, focusing on factors such as durability, construction deficiencies, and energy performance. The study primarily examines the impact of air leakage and vapor retarding layers relative to energy consumption. While these factors have been studied in residential and commercial buildings, there is a lack of information on their impact on hospitals in a holistic context. The study integrates various research studies and professional experience in hospital building design to achieve its objective. The methodology involves surveying and observing exterior wall assemblies, reviewing common exterior wall assemblies and details used in hospital construction, performing simulations and numerical analyses of various variables, validating the model and mechanism using available data from industry and academia, visualizing the outcomes of the analysis, and developing a mechanism to demonstrate the relative performance of exterior wall systems for hospitals under specific conditions. The data sources include case studies from real-world projects and peer-reviewed articles, industry standards, and practices. This research intends to integrate and analyze the in-situ and as-designed performance and durability of building enclosure assemblies with numerical analysis. The study's primary objective is to provide a clear and precise roadmap to better visualize and comprehend the correlation between the durability and performance of common exterior wall systems used in the construction of hospitals and the energy consumption of these buildings under certain static and dynamic conditions. As the construction of new hospitals and renovation of existing ones have grown over the last few years, it is crucial to understand the effect of poor detailing or construction deficiencies on building enclosure systems' performance and durability in healthcare buildings. This study aims to assist stakeholders involved in hospital design, construction, and maintenance in selecting durable and high-performing wall systems. It highlights the importance of early design evaluation, regular quality control during the construction of hospitals, and understanding the potential impacts of improper and inconsistent maintenance and operation practices on occupants, owner, building enclosure systems, and Heating, Ventilation, and Air Conditioning (HVAC) systems, even if they are designed to meet the project requirements.

**Keywords :** hygrothermal analysis, building enclosure, hospitals, energy efficiency, optimization and visualization, uncertainty and decision making

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