Pharos University in Alexandria

Faculty of Engineering

Department of Architectural Engineering

# Influence of Building Envelope on Thermal Comfort

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*Submitted by*

**Mayar Mahmoud Abdel-Aziz Ali**

B.Sc. of Architectural Engineering

Faculty of Engineering, Pharos University in Alexandria (PUA)

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# Abstract

The building sector is currently responsible for a significant portion of global energy consumption, a major part of which is attributed to maintaining indoor thermal comfort. Traditional building envelopes, historically effective through passive design strategies, are predominantly static. They lack the capacity to respond to dynamic changes in meteorological conditions and fluctuating internal occupancy loads, leading to excessive reliance on mechanical heating, ventilation and air conditioning (HVAC) systems. As climate instability increases and energy regulations tighten, the transition from static to adaptive building skins becomes a critical necessity for sustainable architecture.

This research investigates the potential of Smart Building Envelopes to bridge the gap between user comfort and energy efficiency. The study provides a comprehensive taxonomy of adaptive systems, ranging from smart facades that mechanically regulate solar gain to advanced smart techniques which intrinsically modulate heat transfer. By analyzing the limitations of traditional strategies such as thermal mass and shading, the study highlights the necessity of responsive systems that can alter their thermo-optical properties in real-time.

This thesis employs a comparative analysis of state-of-the-art envelope technologies, evaluating their applicability in hot-arid climates. The research integrates theoretical guidelines of smart architecture with performance analytically to assess the energy-saving potential of these systems.

The findings demonstrate that integrating smart techniques and smart materials can significantly reduce cooling loads and improve daylight autonomy compared to static baseline models. The study concludes design guidelines for implementing adaptive envelopes that do not merely resist the environment, but actively negotiate with it, reimaging the building skin not as a barrier, but as a metabolic filter that actively negotiates with its environment.