Energy Use Intensity as a Driver for Building-Envelope Design

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Abstract

As the principal interface between interior and exterior environments, the building envelope plays a primary role in the success or failure of a building's response to its climate. The design and subsequent performance of building-envelope systems can have significant impacts on the overall energy performance of a building during its lifespan. Design decisions about window-to-wall ratios, the placement and orientation of glazing and shading devices, the components of opaque wall assemblies, and the selection of facade materials, products, and systems each contribute to a building envelope's performance. To design high-performance enclosures, architects must understand the relationship between these parameters and their relative influence on energy consumption. This paper presents an approach in which building-envelope designs are evaluated in terms of resultant Energy Use Intensity (EUI) utilizing energy-performance simulation to optimize the enclosure system. As a metric, EUI conveys a building's annual energy use per unit area (in kBTU/ft2/yr or kWh/m2/yr), thus allowing easy comparison of buildings despite differences in size, type, and location. When EUI is measured at each stage of building-envelope development, from the earliest conceptual studies to the final design, the designer is empowered to evaluate design decisions from an energy-use perspective, which can be integrated into a design process alongside other technical as well as aesthetic objectives. To provide historical context, this paper begins by presenting research about the evolution of building-envelope requirements contained in the International Energy Conservation Code (IECC) over the last two decades. Changes to code guidelines—such as maximum window-to-wall ratios, minimum R-values, and maximum U-values—are tracked to illustrate the evolution of performance criteria for building envelopes. A design/analysis exercise from the author's graduate-level seminar on building-envelope design is then presented to demonstrate a process that builds the designer's understanding of how the parameters of façade design affect EUI, in addition to more specific metrics for heating, cooling, and lighting loads. Using cloud-based Sefaira software, designers follow a series of steps that evaluate energy performance implications for a range of design decisions: the area, size, placement, and orientation of window openings, the insulation value of opaque components, and the thermal, solar, and visual properties of various glass products. Designers learn the relative importance of each decision based on given parameters of climate zone and building type. This process develops and understanding of not only the quantity of energy consumed, but also where and how this energy is used and how design revisions can impact this. This process engages digital simulation tools but also develops the designer's intuitive knowledge of the relative impacts of numerous building-envelope parameters on overall energy use; both types of knowledge contribute to better understanding of how to intelligently design the envelope to optimize its energy performance.

Keywords: Structures, Energy + Systems; Pedagogy; Facades; Envelope; Design