

CE 41300 Building Envelope Design and Thermal Loads

Sem. 1 or Sem. 2, Lecture 3, Cr. 3.

Restriction: Junior or higher standing in the College of Engineering.

Prerequisites: CE 31100 Architectural Engineering or instructor permission

Description: This course discusses the basic thermal processes in buildings and presents comprehensive methods for thermal design of envelope assemblies in commercial and residential buildings. The first part of the course includes steady-state and transient conduction through envelope assemblies, convection and radiation heat transfer in buildings, solar radiation and solar gains, thermal performance of windows, internal gains, ventilation and infiltration. The second part of the course considers surface and room energy balance equations and presents analytical and computational models for calculation of hourly heating and cooling loads throughout the year. Climatic-based standards, passive solar design, advanced energy guides, and innovative technologies for high performance buildings are discussed. The course also includes a design project on analytical heating/cooling load calculations for a commercial building.

Level: Undergraduate Level

Course Instructor: Athanasios Tzempelikos

Course outline:

- **Building systems and the built environment** – Energy use in buildings; urban microclimate; introduction to building science; building systems and domains; atmosphere and climate and their effect on buildings and occupants (1 week)
- **The building envelope** –Wall construction types and materials; cavity, barrier and mass walls; facades; foundation and basement wall thermal details; roof construction thermal design; curtain wall details; thermal bridges; residential envelope construction and the role of insulation; test methods for heat, air and water leakage (2 weeks)
- **Steady-state and transient heat conduction through building opaque sections** – Prediction of steady state heat flow and temperature gradients in single and multi-layered walls; parallel heat flows in real wall assemblies with thermal bridges; heat transfer through doors, ceilings, roofs, attic spaces, basements, window frames, pipes; Transient RC networks for heat transfer through walls; performance design tables and introduction to ASHRAE energy design guides (2 weeks)
- **Convection and radiation heat transfer in buildings**- Internal and external convective surface coefficients; grey surfaces; long wave radiative heat exchange between building surfaces; view factor calculations; exterior surface radiation models (2 weeks)
- **Windows** - Solar and optical properties of windows; coatings; combined convection and radiation film coefficients; window overall thermal resistance and conductance calculations; performance metrics and specification tables (1 week)
- **Solar radiation in buildings** - Solar geometry; direct and diffuse solar radiation models; solar irradiance on exterior building surfaces; transmission through windows; shading

calculations and design methods; solar heat gain coefficients and performance design tables (2 weeks)

- **Infiltration and Heating load calculation**– Air leakage calculation methods; infiltration conductance calculation; energy cost of infiltration; climatic data and heating design information; calculation of peak heating load for residential and commercial buildings (1 week)
- **Energy balance equations and building cooling load calculation**- Calculation of energy flows in rooms; thermal storage; room energy balance; transient thermal network approach; cooling climatic design information; internal gains; semi-transient models and the heat balance method; peak loads (2 weeks)
- **Building simulation, energy guides, and advanced technologies** – Basic modeling methods; building simulation software; ASHRAE energy design guides and ASHRAE Standards; passive solar design; high performance windows and walls; renewable energy technologies in buildings; daylighting and lighting controls; smart buildings (2 weeks)