



Effects of Pavement Albedo and Tree Canopy Transmittance on Pedestrian Thermal Comfort along Campus Walkways: University of Seoul Case Study

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The deterioration of outdoor thermal comfort under recurrent heatwaves has become a critical constraint on pedestrian activity. Campus walkways function not only as circulation routes but also as everyday spaces for rest and social interaction, which can prolong pedestrian exposure to thermal stress. Due to the combined configuration of pavements, tree canopies, building façades, and adjacent open spaces, campus walkways exhibit spatially heterogeneous radiative environments that cannot be adequately explained by single-factor thermal analyses.

This study investigates how combinations of pavement albedo and tree canopy leaf transmittance affect pedestrian thermal comfort under different adjacent spatial conditions, using a university campus as a case study. A continuous pedestrian axis within the University of Seoul campus was classified into two spatial types: a plaza-type walkway with high openness and a large proportion of artificial pavement, and a continuous façade-type walkway characterized by aligned building façades and continuous rows of street trees.

Urban microclimate simulations were conducted using ENVI-met (v5.6.1) and the BioMet module. The Universal Thermal Climate Index (UTCI) was calculated at pedestrian height (1.4 m) based on air temperature, humidity, wind speed, and mean radiant temperature. Simulations were performed for a representative summer hot day (27 July 2025) under three wind speed conditions (1.5, 2.5, and 3.5 m/s). Pavement albedo ($A = 0.12\text{--}0.55$) and canopy leaf transmittance ($\tau = 0.15\text{--}0.45$) were systematically combined into twelve scenarios, with existing site conditions defined as a baseline.

Results indicate that increasing wind speed generally reduced UTCI across both spatial types, while the relative effects of pavement albedo and canopy transmittance remained consistent. However, the timing of peak thermal stress differed by spatial type, occurring mainly around midday in the plaza-type walkway and in the late afternoon in the continuous façade-type walkway. Higher pavement albedo consistently increased maximum UTCI, particularly in the more open environment, whereas lower canopy transmittance reduced thermal stress. Combined modifications of pavement and canopy properties produced non-additive UTCI responses, indicating complex radiative interactions.

This case study demonstrates that thermal comfort responses along campus walkways are highly sensitive to spatial configuration and the combined properties of pavements and tree canopies, highlighting the need for context-specific thermal mitigation strategies in pedestrian environments.