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Air Temperature Stratification:
a post-occupancy study of the 12|West/ZGF office

by Justin Wells, Matt Sedor, Corey Griffin

Introduction

Completed in 2009, 12 West is a LEED-platinum mixed use 22-story highrise located in the West End of downtown Portland. The building houses ZGF's headquarters, with approximately 200 employees on floors 2 through 5, each floor being about 20,000 ft². A hybrid heating/cooling and air ventilation system is used. The heating and cooling system is comprised of an underfloor air distribution system (UFAD), utilizing an open cavity with regularly spaced floor vents.

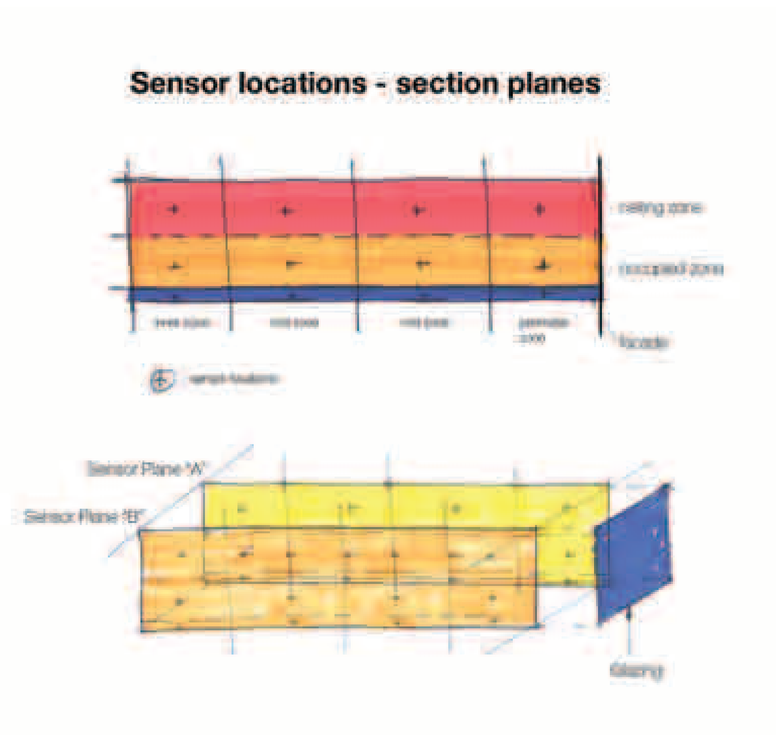
This project details a post-occupancy evaluation targetted to provide a better understanding of how the building's innovative HVAC systems perform. Although the engineering firm GLUMAC created detailed CFD models of heat and air flow in the spaces, no post occupancy studies had been done.

Methodology

The primary method for cooling is through the ventilation system during winter. HVAC studies were done using computational fluid dynamic models by the engineers. They predict that heat will be transported by convective air currents that rise from the floor, through an "occupation zone" to the ceiling and then exhausted through the ceiling air plenum. Although the air is distributed relatively evenly through floor-mounted diffusers, it is unknown how evenly the heat flow through the office space is actually functioning. Therefore, a distributed network of sensors was found to be the best approach to sample air temperature from many points in space.

The most important aspect of this post occupancy evaluation and data collection methodology was the establishment of the sensor grid. Air stratification is commonly measured using air temperature and humidity sensors that take measurements at different heights in a space. By collecting data at several floor heights in the occupied space, it can be determined whether the air is in fact stratified or if general mixing is occurring.

A study area was chosen along the southern exposure of the office - see figure 1
Two sensor planes were arrayed in the space to provide redundancy and to compare data. See figure 2. Each sensor plane sampled temperature and relative humidity data in a 2x4 grid in the space on 15-minute intervals, providing a cross-section of air stratification in the office - see figure 3.



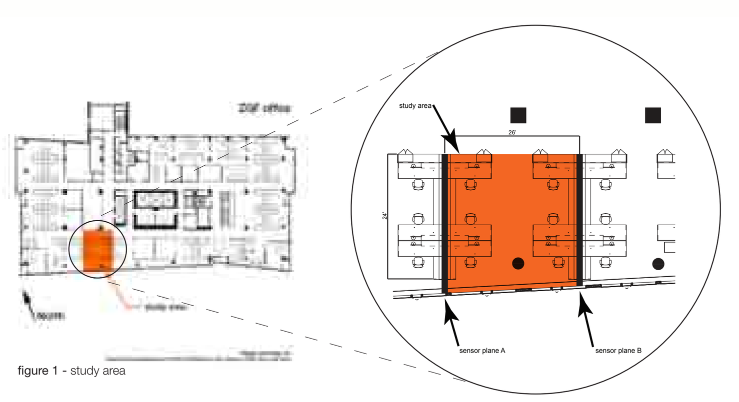


figure 1 - study area

figure 2 - section plane locations

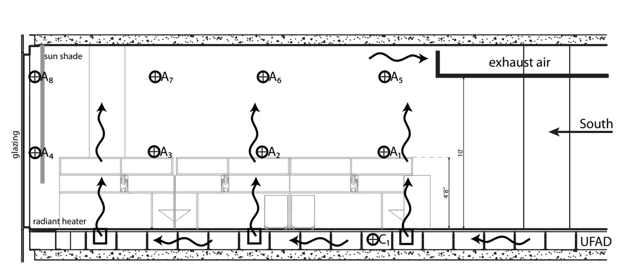
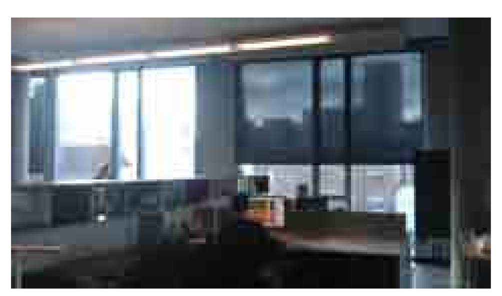


figure 3 - office section with sensor positions - plane "A"



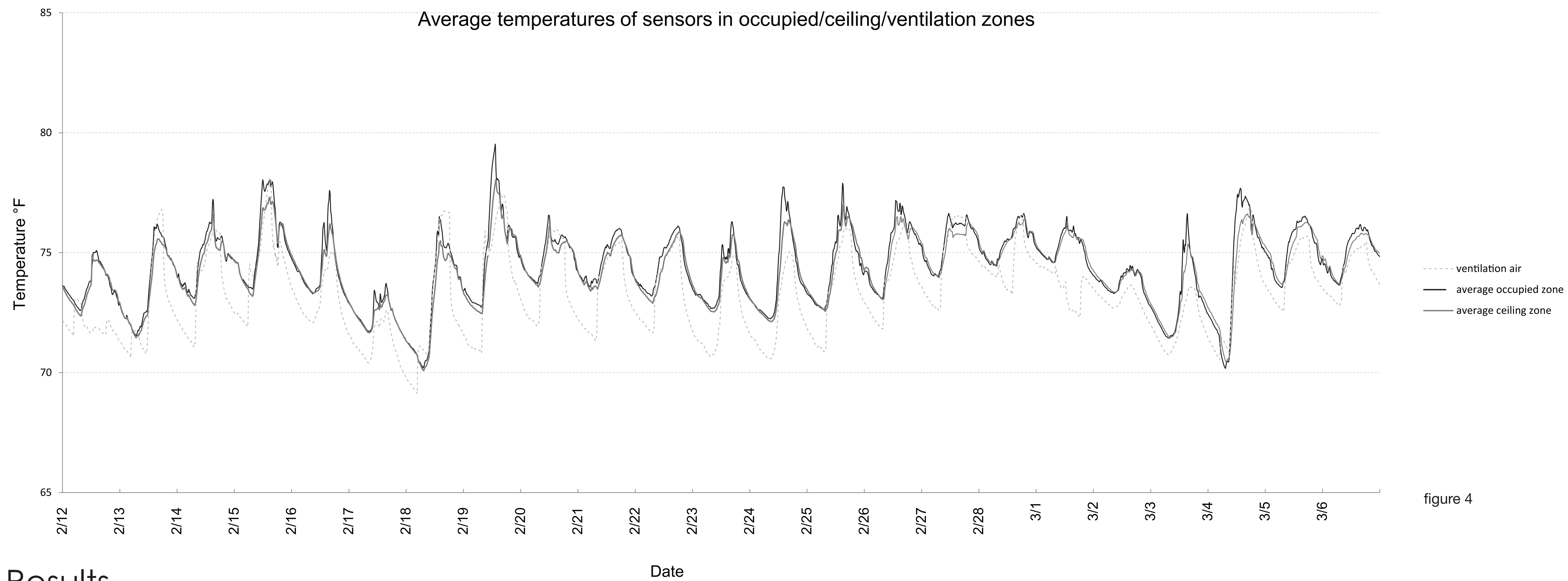


figure 4

Results

Data was collected between the dates of February 12th and March 6th, 2013. After analyzing the data, several interesting trends were identified. Analysis was focused on the data set "A." Two periods of data were analyzed; a period of February 12 through the end of March 6th, and February 25th through the end of February 26th. Figure 4 illustrates the cyclical nature of the air temperature as it heats and cools throughout the day/night diurnal cycle. The longer data set was used to determine trends and patterns through the full study period, and to identify anomalies; ie weekend patterns vs weekdays. The shorter period of two weekdays was used to allow much higher resolution to identify more granular changes in temperature, which would be lost on the longer data set.

Data from the sensors in plane "A" and "B" were almost identical, indicating that air stratification in the study area was extremely uniform throughout the space. In addition, peak high/low temperatures corresponded very closely with each other, suggesting that these are the result of solar gain or cooling by ventilation air, rather than internal loads from the occupants or equipment such as computers. Considering the open floor plan of the office and the fact that the two sets of sensors were only 26 feet apart, this was not a surprise.

The hottest air was measured in the occupied zone, not the ceiling zone. In general, the occupied zone averaged .5°F hotter than the air in the ceiling zone, with a higher peak temperature. This indicates that the air cooled as it rises and is drawn towards the return air plenum. Temperature lag in the ceiling temperatures were compared to the air in the occupied zone. Figure 5 illustrates the time lag and temperature profiles that are mirrored between the occupied and ceiling zones.
Air temperature measured in both the occupied and ceiling zones were all between 70°F to 80°F, with an average of 74°F. Likewise, the measured relative humidity excluding the window zone averaged 30%, with a range of 18% to 43%.

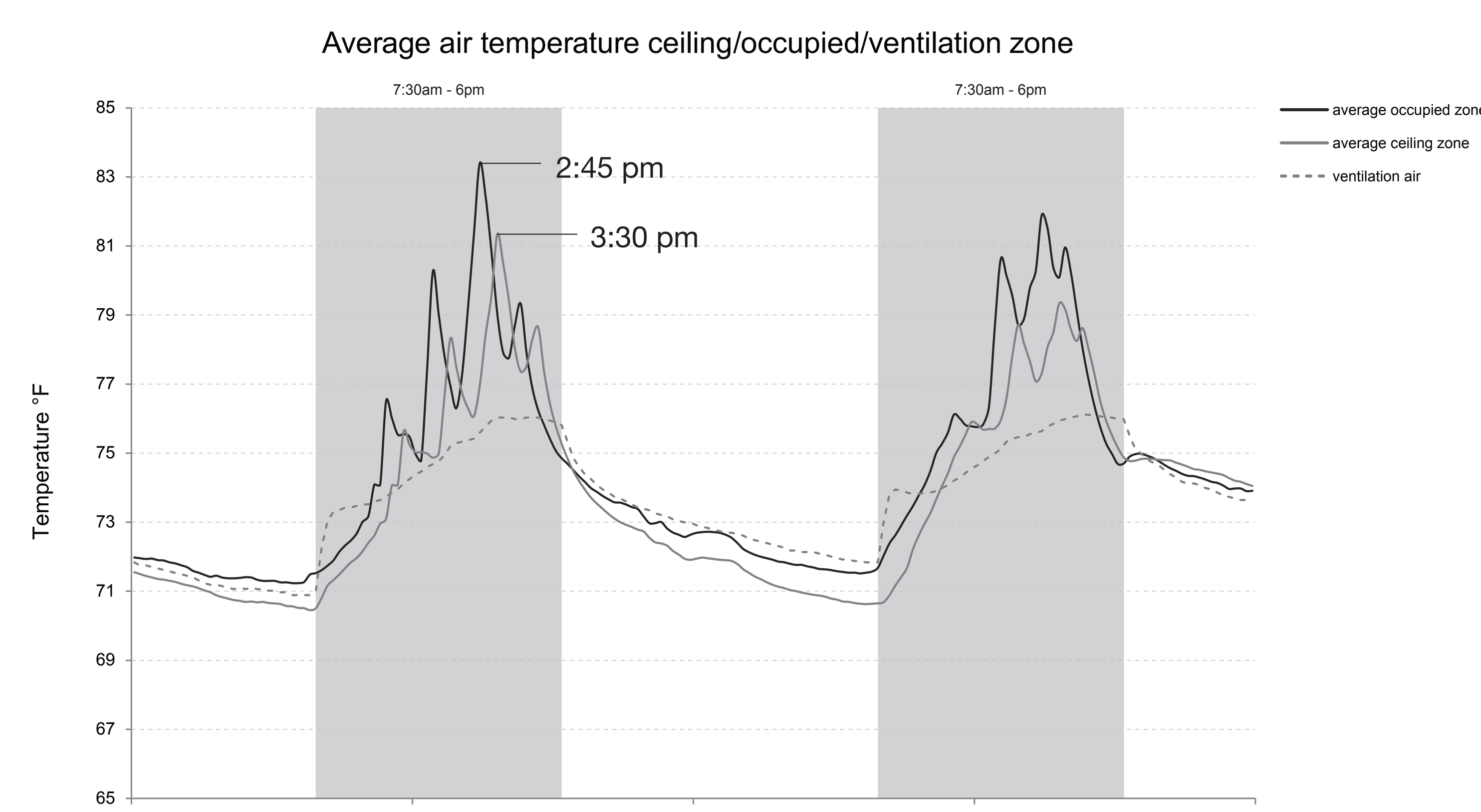


figure 5

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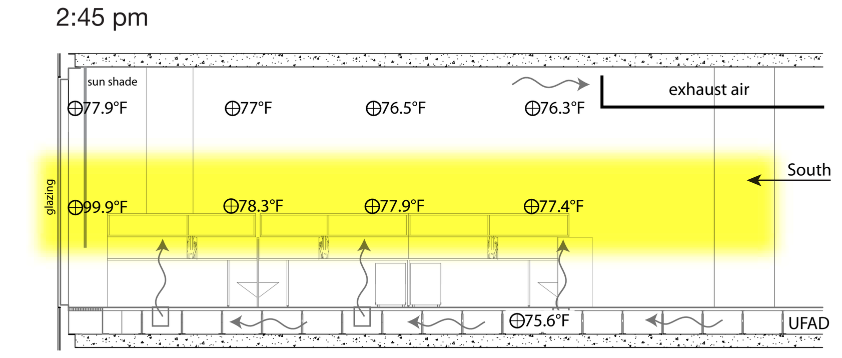

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