Electric Lighting Design Using the Zonal Cavity Method

An office is 30' long by 20' wide and the ceiling is 9' high. The sill height is 3' and above the sill is a 6' tall window that runs along the length of the room. Ceiling reflectance is 80%. Wall reflectance is 50%. The floor reflectance is 20%. Since the primary task is reading, the required illumination level is 50 fc on the work surface 2'-6" above the floor. The fixtures (see fixture #47 from Table 15.1) each provide 2900 lumens/lamp in a radial batwing distribution from four T8 fluorescent lamps with a flat prismatic lens. These direct lighting fixtures are recessed in the ceiling, are replaced on burnout, and are in a "very clean" environment and are cleaned on a 12 month cycle. The proposed lighting control (a light switch) does not include any daylight sensor features.

I. Based on the above information, determine the number of fixtures needed to provide the required illumination. Ignore the potential effects of daylighting for this step. Design a layout for each potential number of lighting fixtures that meets the lighting level requirements. When possible, use standard geometric layouts (e.g., if your calculations show 12 fixtures are needed then lay out 4 rows of 3 fixtures, 3 rows of 4 fixtures, or 2 rows of 6 fixtures) and confirm that the layout satisfies S/MH requirements.

II. The fixtures each consume 128 watts of power. What is the power required for lighting this space (expressed as watts and watt/sf)? If the energy code allows a maximum of 2.0 watts/sf usage for lighting, which of the proposed schemes meet the energy code if no allowance for daylighting controls are included in the calculation?

III. Consider using a daylighting sensor that includes a 3-step controller (PAF=0.20). What impact will using this control have on the energy consumption? Which of the proposed layouts, if any, now meet the energy code?

IV. If the space is used 8:00AM-5:00PM weekdays throughout the year and electricity costs $0.081/kwh, what does it cost annually to operate these lights without the daylight controls? With the daylight controls?

V. Your client will accept energy conservation upgrades with simple paybacks of less than three years. If the daylighting control costs an additional $100 beyond what the simple light switch control would have cost, should you recommend the inclusion of the daylighting control?
Part 1: Heat Loss/Gain

1. Determine the U-value for a wall assembly consisting of:

   Wood Bevel Exterior Lapped Sheathing (0.75” x 10”)
   ½” Plywood (Douglas Fir)
   2”x4” Douglas Fir framing with 3-1/2” Fiberglass Batt Insulation
   ½” Sound Deadening Board
   ½” Gypsum Board

2. Determine the average weight of one square foot of this wall.
ARCH-4372/6372
Heat Loss/Gain

Part 2: Heating and Cooling Loads

Complete the heating and cooling load calculations for the following conditions:

Building Name: Miller Office Building, 375 South 1530 East, Salt Lake City, UT
Winter Design Conditions (97.5%): 8°F ODBT; w=0.0006# H2O/# of dry air
Summer Design Conditions (2.5%): 95°F ODBT; MDR: 32°F

Building Plan Dimensions: 90' x 150' (4 stories tall)
Gross Wall Area (SF): N=4100 E=7200 S=4300 W=7100
Glazing Area (SF): N=1000 E=1980 S=1208 W=1860
Projection Factors: N=0.20 E=0.20 S=0.50 W=0.20

Wall Description:
- 4" Brick
- 2" Rigid Insulation
- 8" Concrete Block
- 0.75" Airspace
- 0.5" Gypsum Board

U_{wall} = 0.054 \text{ Btuh/sf-}^\circ\text{F} \quad \text{Heat content} = 27.33 \text{ Btu/sf-}^\circ\text{F}

Roof Description:
- Built Up Roof
- 0.625" Plywood Deck
- 1.25" Air Space
- R-19 Insulation
- 0.5" Gypsum Board
- 0.5" Acoustic Tile

U_{roof} = 0.042 \text{ Btuh/sf-}^\circ\text{F}
Color: dark
Vented: yes

Slab Description:
- Unheated slab on grade; \( U_{slab} = 0.16 \text{ Btuh/sf-}^\circ\text{F} \)
- 48" deep vertically oriented rigid insulation, R=5.4;
Groundwater temperature: 53°F

Window Description:
- Glazing: Insulating Double Paned with 0.5" airspace, Clear inside/Heat Absorbing Outside. E=0.15 on surface 2.

Frames: Commercial aluminum with thermal breaks.
Interior Shading: Low transmittance high reflectance
Drapes: \( U_{oi} = 0.46; \ VT = 0.37; \ SC = 0.32 \)

Skylight Description:
- Glazing: same as windows, no interior shading
Area (sf): 675 sf.
Door Description: 1-3/4" Solid urethane foam core with thermal break.
Area (SF): N=18  E=36  S=18  W=36
U_{door} = 0.19  Btuh/sf-°F

Equipment Description: Power Density: 0.5 watt/sf

Lighting Description: Power Density: 1.5 watt/sf
Daylighting Controls: None
Design Lighting Level: 50 fc
Type: Fluorescent

Occupant Description: Offices: seated, light work, no smoking permitted
Winter Interior Conditions: 68°F/45% RH; w= 0.0066
Summer Interior Conditions: 75°F
Number of Occupants: 378
Ventilation Required (cfm): 7560 (20 cfm/person)

On the attached forms, complete the heating and cooling load calculations for this building. Since the building is positively pressurized, ignore infiltration. For the DETD cooling load calculation, ignore the doors.

1. What is the design heating load?

2. What is the design cooling load?