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2021 Building Science Theory Exam Learning Objectives

Indoor and Outdoor Environment:

1. Describe the impact of the characteristics of the Canadian climate (temperature, relative humidity, solar radiation, wind, precipitation) on building design.
2. Explain what is meant by urban heat island effect and how this might affect temperatures in urban areas.
3. Define degree-days and explain the impact of degree-days on heating and cooling loads.
4. Calculate total degree-days given average monthly temperatures.
5. Describe the underlying mechanisms of the various thermal comfort factors (temperature, RH, air movement, radiation, activity level, clothing) and how they impact human's perception of their environment.
6. Predict how changes in thermal comfort factors (temperature, RH, air movement, radiation, activity level, clothing) affect the zone of comfort as defined by ASHRAE Standard 55.
7. Describe the origin, use and limitations of the Predicted Mean Vote (PMV) model and how PMV relates to Predicted Percent Dissatisfied (PPD).
8. Describe how and when the adaptive thermal comfort is used.

9 Explain what heat transfer mechanisms are impacted by Humidex and the Wind Chill Factor and under what conditions these typically occur.

Moisture and Moisture Movement:

Fundamentals

10. Compute, from first principles, the various properties of moist air including density, humidity ratio, partial pressures, relative humidity, specific volume and enthalpy under different conditions.
11. Use the psychrometric chart to determine different properties of moist air (RH, moisture content, enthalpy, sensible and latent heat, dry bulb temperature, wet bulb temperature, specific volume and density).
12. Show the various conditioning processes on a psychrometric chart including heating, cooling, (de)humidification and evaporative cooling.
13. Explain the three main water transport mechanisms in buildings (vapour diffusion, surface diffusion, capillary flow).
14. Explain the difference between permeance and permeability.
15. Explain why material permeance varies depending on dry, wet and inverted cup tests.
16. Describe the difference between adsorbed and free water.
17. Explain how capillary heat transfer occurs.
18. Explain how heat flows through the soil and varies seasonally with annual air temperature.
19. Explain the three conditions required for frost heave to occur.
20. Explain the difference between basal heave and frost heave by the mechanism of adfreezing.

Applications

21. Explain the difference between air barriers and vapour retarders.
22. Calculate moisture diffusion, composite permeances, and vapour pressure drops across materials to determine interstitial relative humidit.
23. Describe how efflorescence and subflorescence occur (including how environmental conditions and material characteristics contribute to these).
24. Describe dimensional changes in materials due to changes in moisture content.
25. Illustrate different strategies for managing moisture in buildings including deflection, drainage, drying and durability.
26. Describe the functions of rainscreen walls and how they are different from face-sealed walls.
27. Describe the conditions required for a leak to occur through a building component (leakage opening, water, force to drive the water).

Heat Transfer:

Fundamental

28. Explain the difference between energy and power.
29. Explain what drives the three main heat transfer mechanisms: conduction, convection and radiation.
30. Explain why different materials exhibit different conductances and conductivities based on their properties.
31. Determine the fractions of absorption, reflection and transmission of radiation from different materials.
32. Calculate emissivity across air spaces.
33. Describe the difference between long and short wave radiation.
34. Calculate the absorption and emission of radiation and why Kirchoff's identity is important.
35. Determine equilibrium temperature of an object given incident radiation and material properties.
36. Calculate transfer of radiation between two parallel surfaces.
37. Identify areas of convective heat loss in buildings and how to prevent them.
38. Use the tables to estimate heat transfer coefficients due to radiation and convection.
39. Determine surface conductance factors for various surface orientations and emissivities.
40. Use Fourier's Law to calculate one-dimensional heat flow rate and total heat flow.

Applications

41. Describe why the thermal resistance properties of insulation materials differ.
42. Describe when 1D, 2D and 3D heat flow analysis are appropriate.
43. Calculate composite thermal resistance.
44. Determine steady state temperature profiles for various envelope sections including walls and roofs.
45. Using temperature and vapour pressure profiles, determine condensation risks for various envelope sections.
46. Using various building materials, show how interstitial condensation can be controlled.
47. Estimate below grade heat losses.
48. Estimate the heating and cooling loads due to transmission heat losses and gains through the envelope.
49. Using climate normals and costs of energy and system efficiencies, estimate the cost of providing heating and cooling given various building envelope options.

Air Movement and Air Leakage in Buildings:

Fundamental

50. Using Bernoulli's fundamental flow equation, calculate the flow through openings in response to pressure differences.
51. Describe how flow differs between sharp-edged and smooth-edge orifices.
52. List the three basic ways in which pressure differences are created in and around buildings.
53. Describe how wind varies with terrain and elevation.
54. Using airport observations, estimate average and peak wind speeds at various elevations and location using terrain exponents.
55. Describe how wind pressure coefficients around buildings vary in time and space and with wind direction.

Applications

56. Describe the importance of air leakage and the potential effects on durability and energy use.
57. Describe how wind pressures influence rain penetration and how pressure-driven water films enter the wall.
58. Identify how wind driven rain can best be controlled and how effective air barriers can be constructed and verified.
59. Calculate pressure differences due to stack action for both low and high rise buildings.
60. Describe how the neutral pressure plane varies depending upon the location of leakage openings.
61. Describe how stack action affects the flow of air in buildings when the building is being heated and when the building is being cooled.
62. Describe how mechanical systems affect air pressure differences within buildings.
63. Calculate the combined effects of wind, stack, and mechanical ventilation on air leakage.
64. Describe the importance of building tight and ventilating right.
65. Estimate the fresh air requirements for various occupancies.
66. Describe how uncontrolled air leakage can lead to energy losses, interstitial condensation, and rain penetration.
67. Describe how a blower door test works and why it would be conducted.
68. With the assistance of blower door data, determine the flow coefficient and flow exponent for the generalized flow equation.
69. Describe the difference, including benefits and drawbacks, between a whole building, guarded floor/unit, and compartmentalized blower door test.
70. Describe the various ways in which air barriers may be made continuous.
71. Describe the strength and the weaknesses of interior, exterior and interstitial air barriers and how these various types can be constructed and maintained.
72. Calculate the energy costs of uncontrolled air leakage and how these costs can be reduced through air-tightness measures and the provision of controlled ventilation.

Solar Radiation and Buildings:

Fundamentals

73. Describe why sun angles and intensity vary with latitude, orientation, time of year and time of day.
74. Identify the major components comprising the solar spectrum (i.e. UV, visible light, infrared) and how they affect/interact with buildings.
75. Use a Sun Path Diagram to determine solar azimuth and altitude at various times of the day and season, for different geographical locations.

Applications

76. Calculate window solar heat gains on a daily and monthly basis using solar heat gain coefficients.
77. Describe how window coatings can be used to control solar heat gain.
78. Describe how multiple glazings, frame types, glass coatings and inert gas fill can be used to reduce transmission heat losses.
79. Calculate daily and monthly net heat gains or losses for various windows and orientations.
80. Define the sol-air temperature for various building surfaces and how this can affect enclosure performance (e.g. sun-driven moisture, moisture cycling in roofing, etc.).
81. Discuss solar design principles, including shading devices, and how they impact building energy use, thermal comfort and visual comfort.