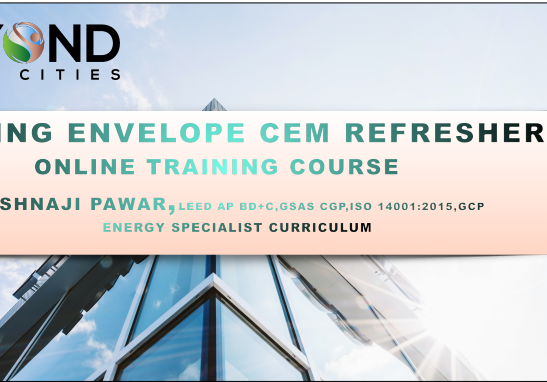


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BUILDING ENVELOPE CEM REFRESHER
ONLINE TRAINING COURSE

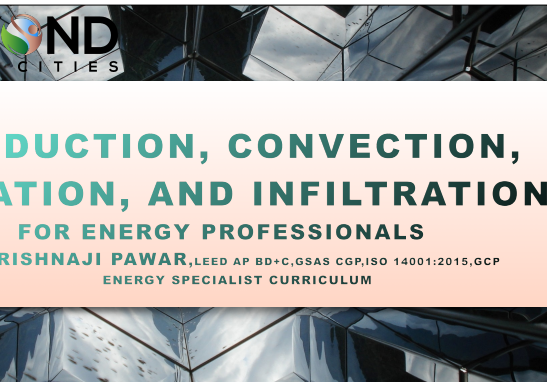
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**CONDUCTION, CONVECTION,
RADIATION, AND INFILTRATION**
FOR ENERGY PROFESSIONALS

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WHAT SHOULD YOU LEARN



**Learn Conduction, Convection,
Radiation, and Infiltration**

**Understand Conductivity,
Conductance, and R Values**

**Sources of Building Heat Gain/
Loss (Solar Heat Gain
Coefficient)**

INTRODUCTION

✓ Any matter which is made up of atoms and molecules has the ability to transfer heat. The atoms are in different types of motion at any time. The motion of molecules and atoms is responsible for heat or thermal energy and every matter has this thermal energy. The more the motion of molecules, more will be the heat energy. However, talking about heat transfer, it is nothing but the process of transfer of heat from a high-temperature body to a low temperature one.

✓ What is Heat Transfer?

According to thermodynamic systems, heat transfer is defined as

"The movement of heat across the border of the system due to a difference in temperature between the system and its surroundings."

Interestingly, the difference in temperature is said to be a 'potential' that causes the transfer of heat from one point to another.

HOW IS HEAT TRANSFERRED?

✓ Heat can travel from one place to another in several ways. The different modes of heat transfer include:

⇒ Conduction

⇒ Convection

⇒ Radiation

Meanwhile, if the temperature difference exists between the two systems, heat will find a way to transfer from the higher to the lower system.

✓ Conduction is defined as "The process of transmission of energy from one particle of the medium to another with the particles being in direct contact with each other"

✓ Convection is defined as "The movement of fluid molecules from higher temperature regions to lower temperature regions"

✓ Radiant heat is present in some or other form in our daily lives. Thermal radiations are referred to as radiant heat. Thermal radiation is generated by the emission of electromagnetic waves.

RADIATION

✓ These waves carry away the energy from the emitting body. Radiation takes place through a vacuum or transparent medium which can be either solid or liquid. Thermal radiation is the result of the random motion of molecules in matter. The movement of charged electrons and protons is responsible for the emission of electromagnetic radiation. Let us know more about radiation heat transfer.

✓ Radiation heat transfer is measured by a device known as thermocouple. A thermocouple is used for measuring the temperature. In this device sometimes, error takes place while measuring the temperature through radiation heat transfer.

✓ Following are the examples of radiation:

⇒ Microwave radiation emitted in the oven is an example of radiation.

⇒ UV rays coming from the sun is an example of radiation.

⇒ The release of alpha particles during the decaying of Uranium-238 into Thorium-234 is an example of radiation.

HEAT LOSS AND GAIN

- ☑ Heat is lost and gained through walls and ceilings.
- ☑ Consider a two cm (20 mm) plywood wall.
- ☑ Conduction heat losses through walls and ceilings

$$q = \frac{A \times \Delta T}{\Sigma R} \quad [W]$$

- ☑ Heat loss is proportional to the area A and the temperature difference ΔT between inside and outside.
- ☑ ΣR is the sum of the resistances of everything that resists heat flow.

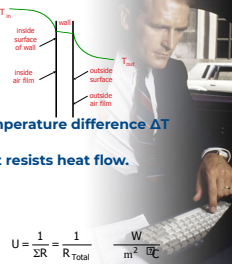
$$\Sigma R = R_{\text{inside air film}} + R_{\text{plywood}} + R_{\text{outside air film}} \quad \frac{m^2 \cdot ^\circ C}{W}$$

- ☑ The equation often is written

$$q = U \times A \times \Delta T \quad [W]$$

- ☑ where U is the overall thermal conductance.

$$U = \frac{1}{\Sigma R} = \frac{1}{R_{\text{Total}}} \quad \frac{W}{m^2 \cdot ^\circ C}$$



SURFACE AIR FILM RESISTANCE (BUILDINGS)*

Wall or roof position	Direction of heat flow	R_s ($m^2 \cdot ^\circ C/W$)
<u>Still air</u>		
Horizontal	up	0.11
Horizontal	down	0.16
Vertical	horizontal	0.12
<u>Moving air</u>		
24 km/h (winter)	All	0.030
12 km/h (summer)	All	0.044

*Data from 2001 ASHRAE Fundamentals Handbook, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, Georgia. p. 25.2.

WALL AND INSULATION RESISTANCES

- ☑ R can be obtained from the conductance C, given for a specified thickness of material,

$$R = \frac{1}{C}$$

- ☑ If the conductivity k is given, R can be calculated knowing k and the material thickness t in metres.

$$R = \frac{t}{k}$$

CONDUCTANCES AND CONDUCTIVITIES

Material	Description	Conductivity k	Conductance C or U
Building boards	Gypsum 12.7 mm	(0.16)	12.6
	Plywood	0.11	
	Plywood 19 mm	(0.116)	6.1
Insulating materials	Fibreglass, batt, blanket, board	0.036	
	Mineral wool, batt, blanket, loose	0.039	
	Vermiculite (expanded)	0.066	

BASIC HEAT FLOW PROBLEM

- ✓ What is the rate of heat loss through a two centimetre plywood wall if the inside temperature is 16°C and the outside temperature is 0°C and windy? The area of the wall is 100 square metres. Include surface films.

Solution start – $R_{pw} = t/K = 0.02/0.11 = 0.182$

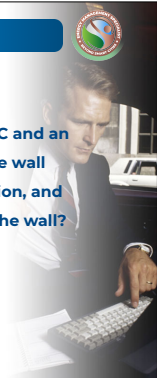
BASIC HEAT FLOW EQUATIONS

- ✓ How could we reduce the heat flow?
- ✓ Often the answer is insulation—a simple and inexpensive way of adding more resistance to the denominator of the equation

$$q = \frac{A \times \Delta T}{\Sigma R} \quad [W]$$

COMPOSITE WALL EXAMPLE

A 160 m² wall is exposed to an inside temperature of 24 °C and an outside winter temperature of 4 °C in windy weather. The wall consists of 12.7 mm plywood, 90 mm of fiberglass insulation, and 12.7 mm gypsum board. How much heat is lost through the wall? Include surface films.





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