TECHNICAL ENVIRONMENTAL SYSTEMS (Week 1)

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Summary - Conductive Heat Transfer:

Conduction can be modelled as a mono-dimensional transfer of heat through a material. In the case of buildings, the walls transfer heat from the outside to the inside, or vice versa depending upon the temperature difference. This heat transfer though the wall of the building is called as Conductive Heat Transfer, which can also be considered steady as well.

$\mathbf{Q_{in}}$ (Rate of Transfer into the wall) - $\mathbf{Q_{out}}$ (Rate of heat transfer out of the wall) = $\frac{\mathbf{dE}}{\mathbf{dT}}$ (Rate of change of energy of the wall)

Since, the heat transfer through the wall is modelled to be steady, $\frac{\mathbf{dE}}{\mathbf{dT}} = 0$

Fourier's Law of Heat Conduction:

Rate of Heat Transfer, Q = -kA $\frac{\mathbf{dT}}{\mathbf{dx}}$, where

k- Thermal Conductivity of the material,
A – Area of the wall surface which transfers heat
dT – Temperature Difference
dx – Thickness of the wall

Under steady conditions, dT/dx is Constant

For wall thickness L, $\dot{Q} = kA \times \frac{\Delta T}{L}$ (W)

Thus, rate of heat conduction through a plane wall is directly proportional to the thermal conductivity , area of the wall surface and the temperature difference, while inversely proportional to the wall thickness.

Comparing the situation to the flow of the electric current,
Thermal resistance of the wall can be considered as analogous to electric resistance.

$\dot{Q} = kA\ \frac{\mathrm{T1-T2}}{\mathrm{L}} \longrightarrow \dot{Q} = kA\ \frac{\mathrm{T1-T2}}{\mathrm{R}} \quad \mathrm{I} = kA\ \frac{\mathrm{V1-V2}}{\mathrm{R}}$

Thus, R = $\frac{\mathrm{L}}{kA}$ $°C/W$

Exercise:

L= 0.4 m, A= 20 m2, ΔT= 25, and k=0.78 W/m K

a) Simple Method

$$\dot{Q} = kA\frac{\Delta T}{L} = 0.78 * 20 * \frac{25}{0.4} = \mathbf{975\ W}$$

b) Resistance Concept Method

$$R_{wall} = \frac{L}{kA} = \frac{0.4}{0.78 * 20} = 0.02564\ °C/W$$

$$\dot{Q} = \frac{\Delta T}{R_{Wall}} = \frac{25}{0.02564} = \mathbf{975.04\ W}$$