

UNIT-III

UNIT-III: Building Form – Surface area and Fabric Heat Loss, utilizing natural energy, Internal Planning, Grouping of buildings. Building Fabrics- Windows and doors, Floors, Walls, Masonry, Ecological walling systems, Thermal Properties of construction material.

BUILDING FORMS:

Building forms in the context of green buildings refers to the design and layout of a structure, taking into consideration energy efficiency, sustainability, and environmental impact. Here are the key points to consider when building forms for green buildings:

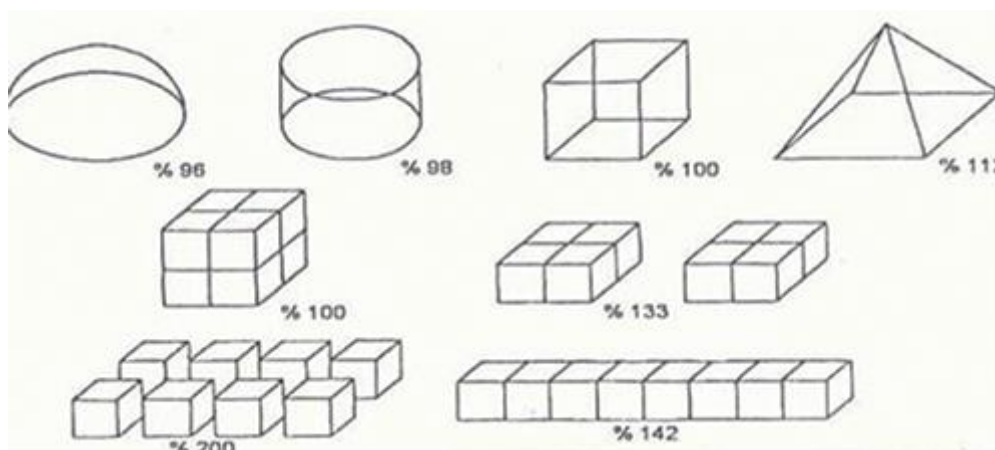
- 1) ***Orientation and Layout:*** The orientation of the building plays a crucial role in maximizing natural light and minimizing heat gain. Design the building's layout to take advantage of prevailing winds, sun angles, and shading to reduce the need for artificial lighting and cooling.
- 2) ***Shape and Massing:*** The shape and massing of the building can impact its energy consumption. Compact forms with minimal surface area exposed to the outside reduce heat loss in winter and heat gain in summer.
- 3) ***Envelope Design:*** Building envelope (walls, roofs, windows) should be well-insulated & have high thermal resistance to prevent heat transfer. Energy-efficient windows and consider incorporating shading devices to control solar heat gain.
- 4) ***Materials Selection:*** Opt for sustainable and locally sourced materials with low embodied energy. Choose materials that have a lower environmental impact, are recyclable, and have a longer lifespan.
- 5) ***Day lighting:*** Design the building with ample windows and skylights to maximize natural daylight. This reduces the need for artificial lighting during the day, which saves energy and enhances occupants' well-being.
- 6) ***Passive Solar Design:*** Incorporate passive solar design principles, such as using thermal mass (materials that absorb and release heat) to regulate indoor temperatures and harnessing solar energy for heating.
- 7) ***Ventilation and Airflow:*** Plan for natural ventilation by positioning windows to facilitate cross-ventilation. This reduces the reliance on mechanical ventilation systems, leading to energy savings.
- 8) ***Renewable Energy Integration:*** Integrating renewable energy sources like solar panels, wind turbines & geothermal systems to power the building.
- 9) ***Life Cycle Assessment:*** Consider the life cycle impact of materials and design decisions, including construction, operation, and end-of-life considerations.

- 10) **Certification Standards:** Adhere to recognized green building certification standards like LEED (Leadership in Energy and Environmental Design) or BREEAM (Building Research Establishment Environmental Assessment Method) to ensure your building meets rigorous sustainability criteria.

SURFACE AREA & FABRIC HEAT LOSS:

Surface area is the total measurement of all the exterior surfaces of a building, including walls, windows, doors, and roof. Larger the surface area, the more potential for heat exchange between the inside and outside of the building.

A more compact shape with fewer exposed surfaces generally results in lower heat loss. This is because a compact building has less surface area relative to its volume, which reduces the amount of heat that can escape through the walls, roof, and windows. **For example:** Consider a cube versus a long, narrow rectangle. The cube has less surface area relative to its volume compared to the rectangle, resulting in less heat loss.



The surface of the cube that was taken as 100 was accepted as a reference.

Building shape in different climate regions:

- » **Cold Climate Regions:** Compact building forms are preferred.
- » **Hot-Dry Climate Regions:** Both compact forms & use of courtyards can be effective.
- » **Hot-Humid Climate Regions:** Elongated building forms with the long side oriented to the prevailing wind direction are advantageous.
- » **Mild Climate Regions:** Mild climates offer more flexibility in building forms. Compact designs are still valuable for energy efficiency, but there's room for more architectural creativity.

Fabric heat loss, also known as thermal or envelope heat loss refers to the heat that escapes from a building through its walls, roof, windows, and other

surfaces. It occurs due to the temperature difference between the inside and outside of the building.

There are three primary modes of heat transfer:

1. **Conduction:** This is the direct transfer of heat through a solid material, such as when heat flows through a wall. Materials with higher thermal conductivity (like metals) allow heat to pass more easily than materials with lower thermal conductivity (like insulation materials).
2. **Convection:** This involves the transfer of heat through a fluid (liquid or gas) moving across a surface. For example, warm air near a window can cool and create a convection current, leading to heat loss.
3. **Radiation:** This is the transfer of heat through electromagnetic waves. All objects emit and absorb thermal radiation. Windows, walls, and roofs can both emit and receive radiation, contributing to heat exchange.

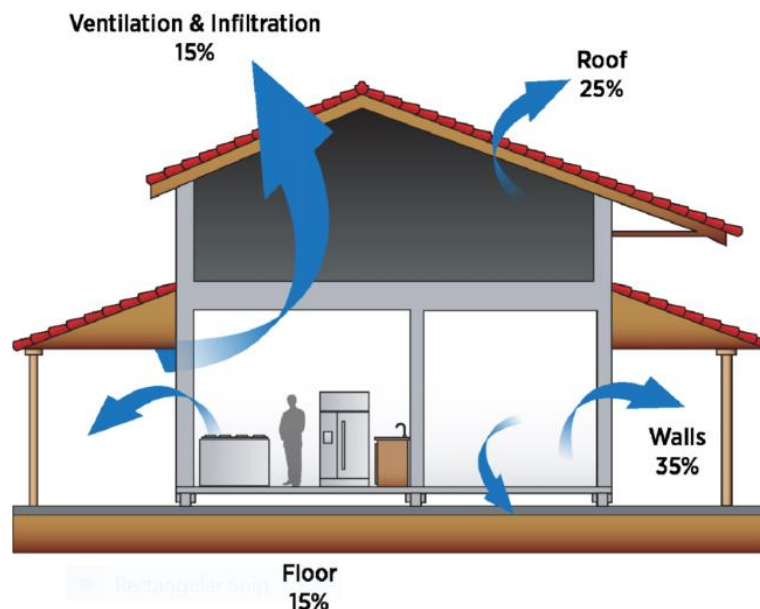


Fig:- Heat loss through residential building envelope

To understand fabric heat loss and calculate it using surface area, you have to consider a building's envelope, including walls, roof, floor, windows, and doors. Here, "fabric" refers to the building's structure and not to cloth or textile.

1. Heat Loss Through Building Fabric

Heat loss through the building fabric is generally due to conduction. The formula for calculating heat loss through conduction is given by:

$$Q = U \times A \times \Delta T$$

Where; Q = Heat loss (Watt or W)

U = Coefficient of Heat transmission (W/m² K)

A = Surface Area (m²)

ΔT = Temperature difference between outside and inside of a building (K or °C)

Factors affecting fabric heat loss:

1. **U-Value:** This measures how effective a building material is as an insulator. Lower U-values indicate better insulation.

Different materials have varying levels of thermal conductivity. Materials with higher thermal conductivity allow heat to pass through more easily, leading to increased heat loss.

2. **Surface Area:** As mentioned earlier, a larger surface area results in more heat loss, as there is more space for heat to escape.
3. **Temperature Difference:** The greater the temperature difference between the inside and outside of a structure, the higher the heat loss through the fabric.
4. **Thickness of the Fabric:** Thicker fabrics generally provide more insulation and resist heat loss better than thinner ones.
5. **Thermal Bridging:** It occurs when there's a break in insulation, like through studs in walls or metal connections, allowing heat to flow more easily.
6. **Air Leakage:** Gaps and cracks in the building envelope can lead to air leakage, which carries heat away.
7. **Orientation:** The direction a building faces can impact how much sunlight it receives and how much heat is lost through its surfaces.
8. **Climatic Conditions:** Wind increases the rate of heat loss by carrying away the heat that accumulates near the fabric's surface.

High humidity levels can affect heat loss by affecting the fabric's thermal properties and promoting heat transfer through moisture.

UTILIZING NATURAL ENERGY:

Utilizing natural energy, also known as passive design or passive solar design, involves harnessing the energy provided by the sun, wind, and other natural elements to enhance the energy efficiency and comfort of buildings. This approach minimizes the reliance on mechanical systems and maximizes the benefits of local climate conditions.

1. ***Solar Energy:***

Passive solar design takes advantage of the sun's energy for heating and lighting. Key principles include:

- Orientation: Position the building to maximize south-facing exposure in the Northern Hemisphere (or north-facing in the Southern Hemisphere) to capture the most sunlight during the colder months.
- Solar Heat Gain: Incorporate well-insulated windows on the sun-facing side to allow sunlight to penetrate and warm the interior spaces.
- Thermal Mass: Use materials with high thermal mass, like concrete or stone, to absorb and store heat from sunlight, releasing it slowly to maintain a comfortable temperature.

2. ***Daylighting:***

Design for natural daylighting to reduce the need for artificial lighting:

- Window Placement: Place windows strategically to allow for even distribution of natural light throughout the building.
- Light Shelves and Reflectors: Use architectural features like light shelves and reflectors to bounce and redirect sunlight deeper into the building.

3. ***Natural Ventilation:***

Passive cooling through natural ventilation reduces the need for mechanical cooling systems:

- Cross-Ventilation: Design openings on opposite sides of the building to facilitate the movement of fresh air through spaces, promoting cooling.
- Stack Effect: Utilize the difference in air density to create a natural upward flow of warm air, drawing cooler air from lower openings.

4. ***Shading and Overhangs:***

Proper shading helps prevent overheating and excessive solar gain:

- Eaves and Awnings: Design extended eaves or awnings that provide shade to windows during the hottest parts of the day.
- Louvers and Sunscreens: Incorporate adjustable shading devices that can be adapted to changing solar angles.

5. ***Wind Energy:***

In areas with consistent wind patterns, natural ventilation and wind-driven ventilation strategies can reduce cooling demands:

- Ventilation Openings: Design openings to allow prevailing winds to pass through and promote passive cooling.