

## **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:

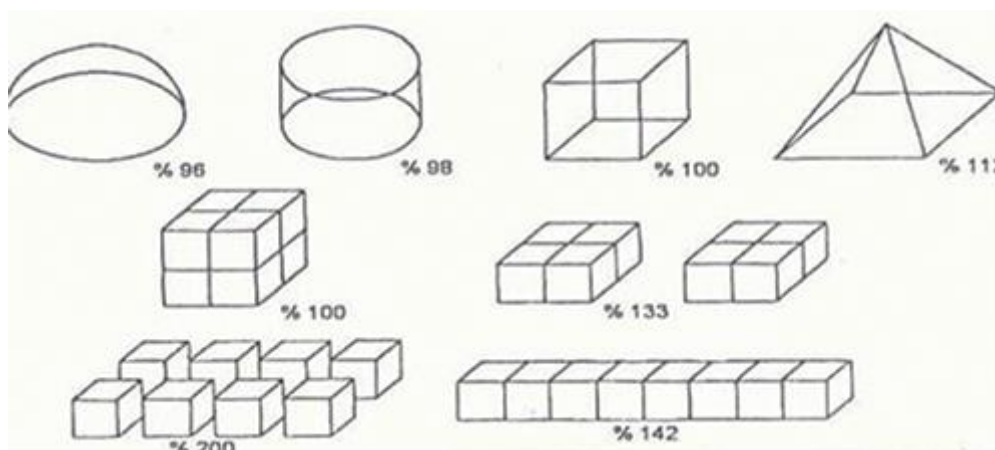
- 1) ***Orientation and Layout:*** The orientation of the building plays a crucial role in maximizing natural light and minimizing heat gain. Design the building's layout to take advantage of prevailing winds, sun angles, and shading to reduce the need for artificial lighting and cooling.
- 2) ***Shape 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:

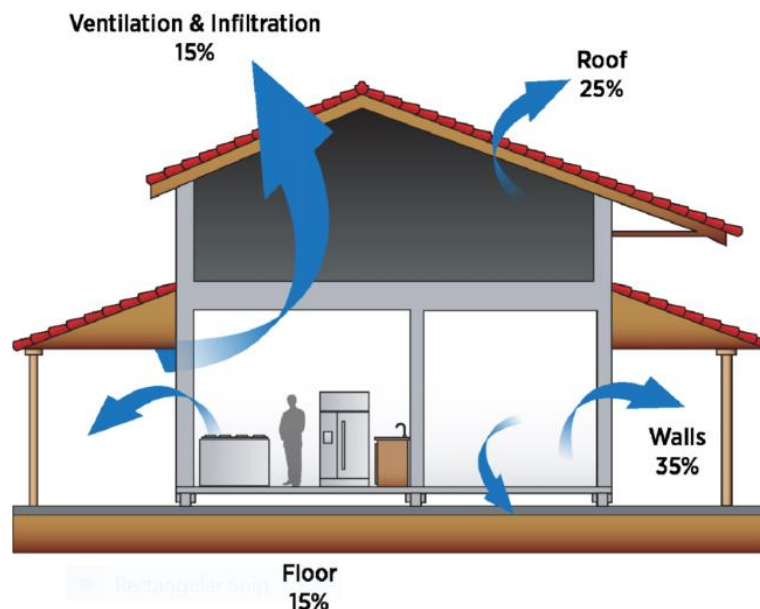
- » **Cold Climate Regions:** Compact building forms are preferred.
- » **Hot-Dry Climate Regions:** Both compact forms & use of courtyards can be effective.
- » **Hot-Humid Climate Regions:** Elongated building forms with the long side oriented to the prevailing wind direction are advantageous.
- » **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/m<sup>2</sup> K)

A = Surface Area (m<sup>2</sup>)

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.

- Ventilation Towers: Incorporate vertical ventilation towers or chimneys that encourage air movement through convection.

#### 6. *Cooling Courtyards and Water Features:*

Courtyards with vegetation and water elements can provide cooling through evapotranspiration and creating a microclimate of comfort.

#### 7. *Green Roofs and Walls:*

Vegetated roofs and walls contribute to thermal insulation, absorb rainwater, and provide cooling effects.

#### 8. *Site-Specific Design:*

Tailor passive design strategies to the local climate, topography, and vegetation, ensuring that the building responds effectively to its surroundings.

### INTERNAL PLANNING:

Internal planning in building design refers to the strategic layout and organization of spaces within a building to optimize functionality, comfort, and efficiency for its occupants. Some key aspects of internal planning are:

#### 1. *Space Zoning and Function Allocation:*

Internal planning involves dividing the building into distinct zones or areas based on their functions. For instance, residential buildings may have zones for living, sleeping, dining, and cooking. Commercial buildings might have zones for offices, meeting rooms, and public spaces. Proper zoning enhances the flow of activities and minimizes conflicts between different functions.



#### 2. *Space Layout and Efficiency:*

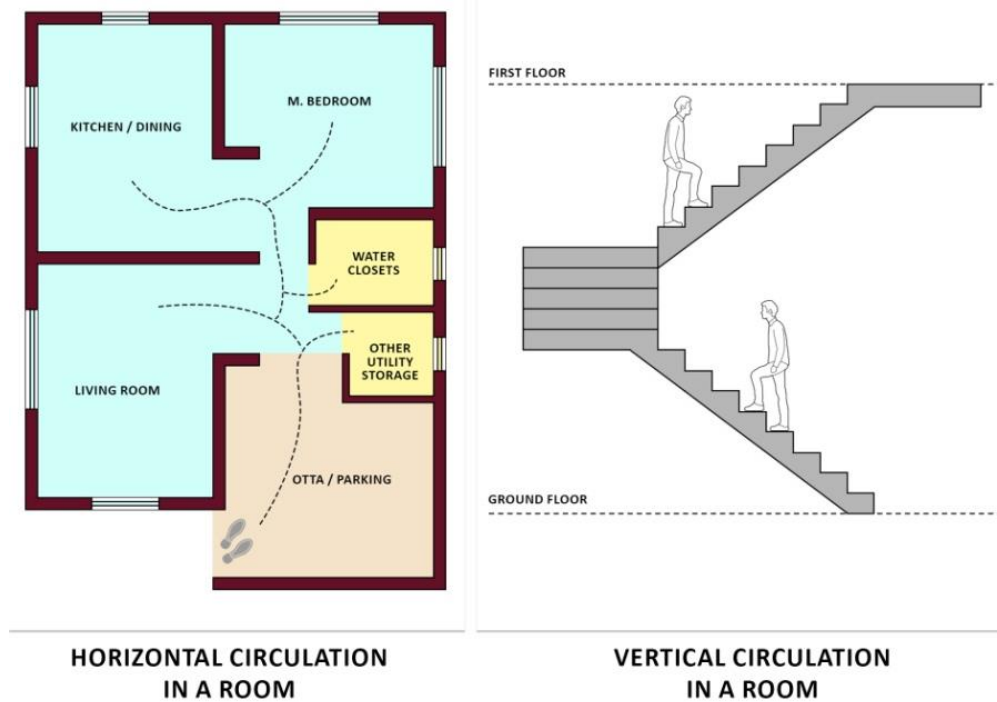
The arrangement of spaces within a building affects its efficiency and usability. Efficient layouts reduce wasted space, promote easy navigation, and



ensure that every area serves a purpose. Open floor plans, modular designs, and flexible spaces are examples of layout strategies that adapt to changing needs.

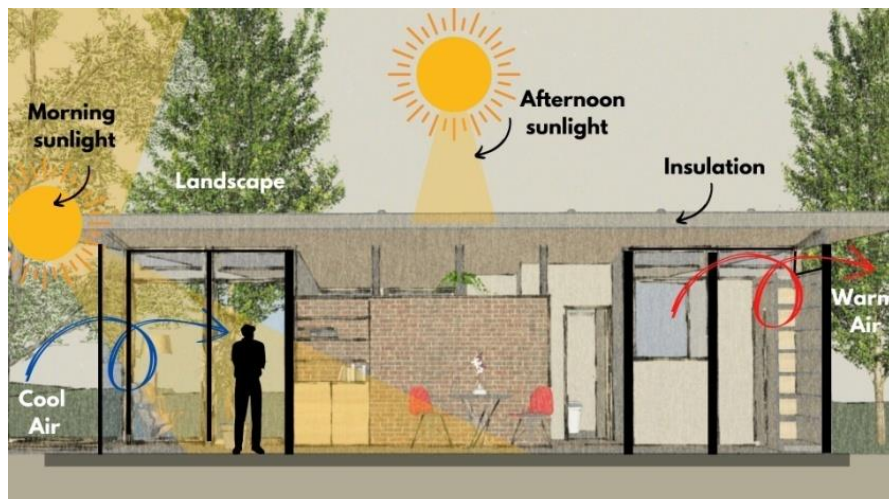
### ***3. Circulation and Accessibility:***

Designing efficient circulation paths is crucial to ensure easy movement throughout the building. Consideration of entrances, corridors, staircases, and elevators is essential to provide accessible and safe routes for occupants. Circulation paths should be intuitive and minimize dead-end spaces.



### ***4. Natural Lighting and Views:***

Maximizing natural light and providing views to the outside are important for occupant well-being and energy efficiency. The internal plan should prioritize placing frequently used spaces near windows and avoiding obstructions that could block light penetration.

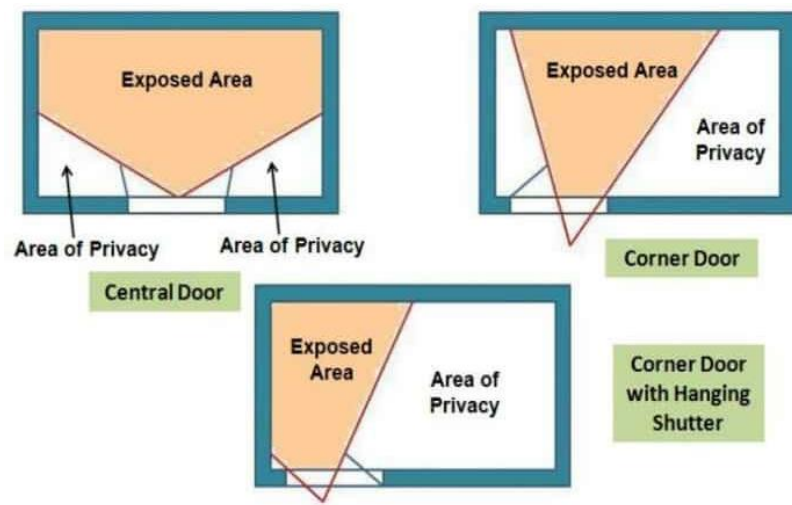


### ***5. Ventilation and Indoor Air Quality:***

Proper ventilation is necessary to maintain good indoor air quality. The internal plan should facilitate cross-ventilation by positioning windows and openings to allow for the flow of fresh air. Design strategies that promote natural airflow reduce the reliance on mechanical ventilation systems.

### ***6. Privacy and Noise Control:***

The internal plan must balance the need for private spaces with communal areas. Bedrooms, bathrooms, and workspaces require a higher degree of privacy, while shared spaces like living rooms and kitchens can be more open. Adequate sound insulation between spaces also contributes to a comfortable environment.

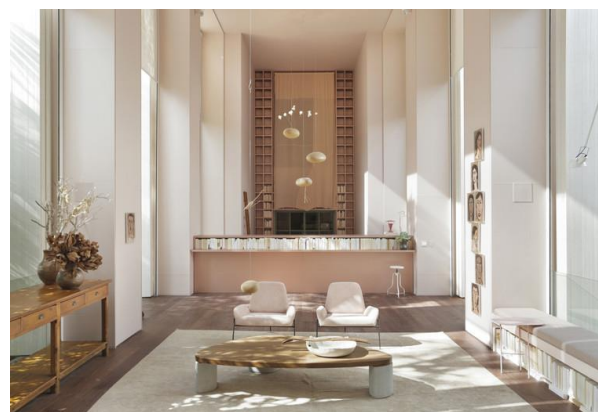


### ***7. Flexibility and Future Adaptability:***

An effective internal plan should anticipate future changes and adaptability. Designs that allow for reconfiguration or expansion help accommodate evolving needs without extensive renovations.

### ***8. Aesthetics and User Experience:***

The internal plan contributes to the overall aesthetics and ambiance of the building. Thoughtful design can create pleasant and inviting spaces that enhance the occupants' experience.





## ***9. Cultural and Social Considerations:***

Internal planning can also reflect cultural preferences and social norms. Different cultures have varying expectations regarding the arrangement of spaces and social interactions within buildings.

## **GROUPING OF BUILDINGS:**

Grouping of buildings refers to the intentional arrangement and organization of multiple buildings within a site or complex. This approach takes into consideration various factors such as function, aesthetics, energy efficiency, circulation, and communal spaces. Grouping buildings thoughtfully can lead to improved urban design, better space utilization, enhanced energy efficiency, and a more cohesive overall environment. Here are some key aspects to consider when it comes to grouping buildings:

### ***1. Site Planning:***

Grouping of buildings involves careful consideration of the site's layout, topography, orientation, and surrounding context. The arrangement of buildings should respect the natural features of the site while maximizing its potential for energy efficiency, aesthetics, and functionality.

### ***2. Functional Relationships:***

Buildings within a complex are often designed to serve different functions. The way buildings are grouped can facilitate functional relationships, such as locating related spaces close to each other for convenience and efficiency. For instance, residential buildings might be grouped around shared amenities like courtyards or communal gardens.

### ***3. Microclimates and Sunlight Exposure:***

The arrangement of buildings can create microclimates within the complex. Proper orientation can optimize sunlight exposure and shading, making use of natural light and passive solar heating. Strategic placement of buildings can also mitigate wind effects, creating more comfortable outdoor spaces.

### ***4. Energy Efficiency and Sustainability:***

Grouping of buildings can have significant implications for energy efficiency. By clustering buildings closely together, wind exposure can be reduced & shared walls can provide thermal insulation. This can lower energy consumption for heating and cooling, as well as reduce the overall environmental footprint of the complex.

### ***5. Open Spaces and Landscaping:***

Grouping buildings can create opportunities for designing open spaces, courtyards, plazas, and green areas. These communal spaces can serve as gathering points, enhance the overall environment, and provide a sense of community for the residents or occupants.

### ***6. Pedestrian Circulation:***

The layout of buildings can influence pedestrian circulation patterns. Well-designed groupings ensure easy and efficient pedestrian movement while creating interesting pathways and visual connections.

### ***7. Visual Harmony and Aesthetics:***

Grouping buildings harmoniously can enhance the visual appeal of the complex. Consideration of architectural style, proportion, and scale can create a unified and aesthetically pleasing environment.

### ***8. Privacy and Views:***

Building grouping should also take into account privacy considerations. Proper spacing between buildings can maintain privacy for occupants while providing desirable views and exposure to the surroundings.

### ***9. Mixed-Use Developments:***

In mixed-use developments, grouping buildings with different functions (residential, commercial, recreational) can create vibrant and convenient environments where people can live, work, and play in close proximity.

### ***10. Cultural and Social Context:***

The grouping of buildings can reflect cultural and social norms, integrating local architectural traditions and fostering a sense of place.