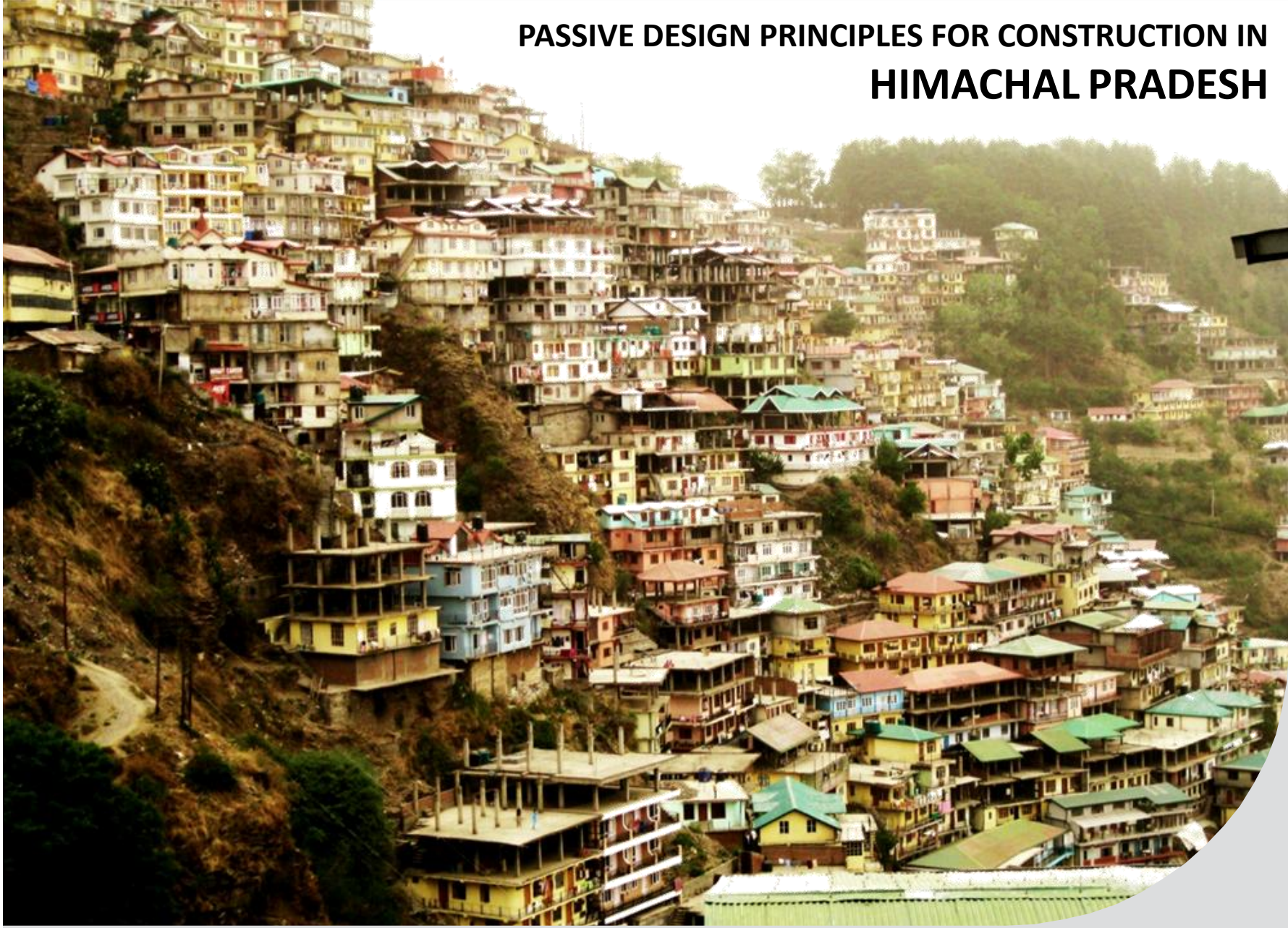
DESIGN FOR LCCR CONSTRUCTION

PASSIVE DESIGN PRINCIPLES FOR CONSTRUCTION IN HIMACHAL PRADESH



Development Alternatives

Low Carbon Climate Resilient Strategies

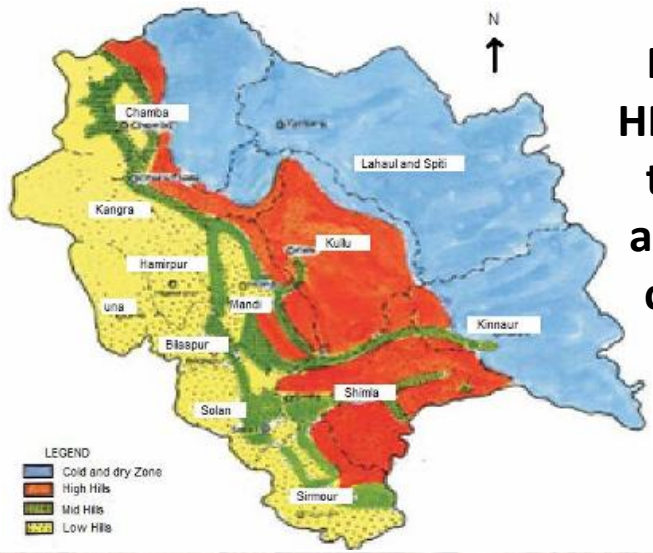
DESIGN FOR LCCR CONSTRUCTION

Low Carbon Climate Resilient Construction

Minimised embodied energy	Minimised operational energy	Disaster Resilience
Rationalizing the use of high energy materials like cement, steel, brick, aluminium.	Maintaining comfortable indoor environmental conditions by adopting passive design strategies	Providing adequate protection from extremities of local climate and calamities

Climate Responsive Design

Each climate has specific seasonal characteristics that need corresponding passive design strategies to create a comfortable indoor environment without over-dependence on mechanical heating, cooling and ventilation and by using freely available renewable sources of energy such as sun, wind and natural vegetation.



Parts of HP lies in the wet and hilly climatic zone.

MICROCLIMATIC FACTORS IN HIMACHAL PRADESH:

Wind - Velocity and direction of the wind

Solar exposure - Direction of available solar radiation

Snow and rain – Intensity of precipitation

Relief - Altitude that determines temperature changes

Seasonal Passive Strategies for Wet and Hilly Climate

DESIGN FOR LOCAL CONSTRUCTION

SEASONS:

Summer:

- Temperature peaks ≈ 35°C.
- Diurnal range of temperature> 10°C.

Monsoon:

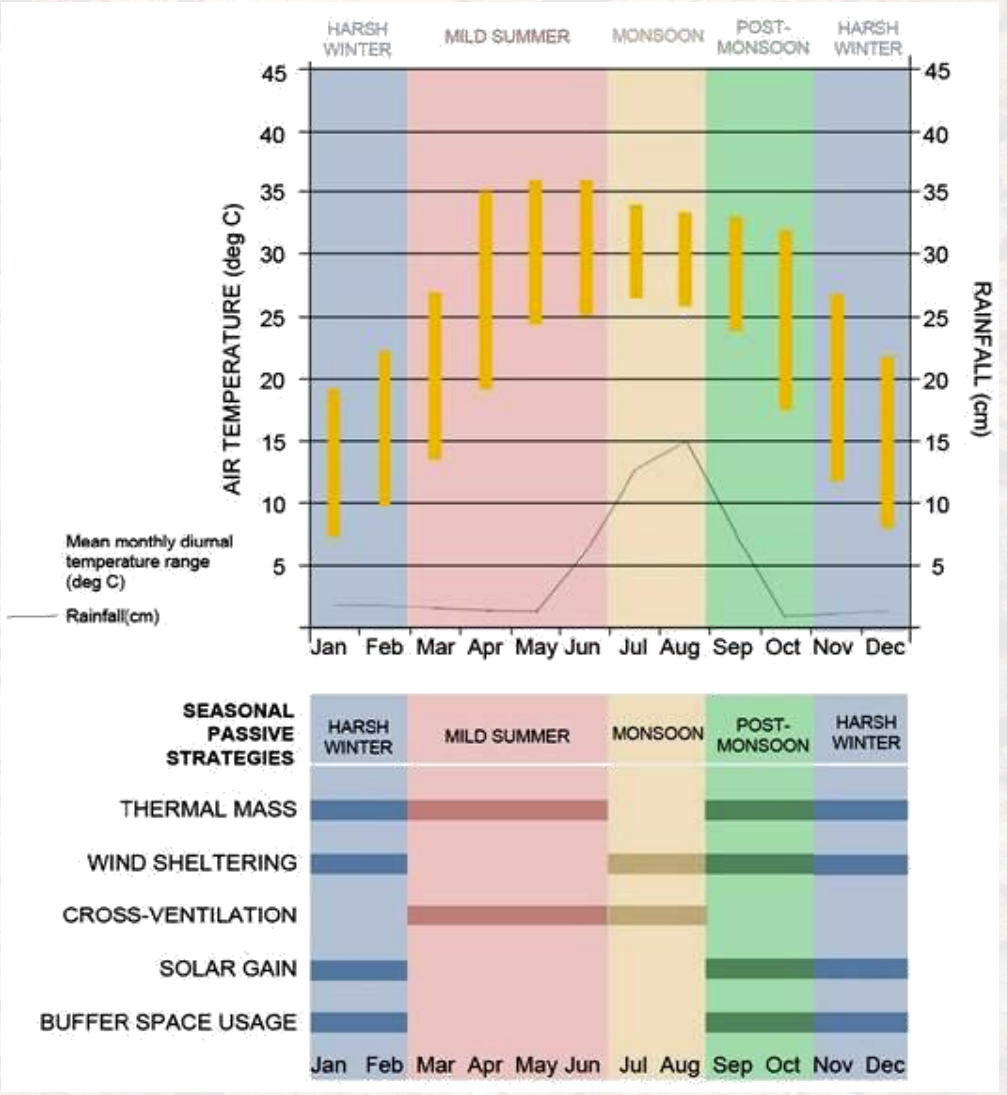
- Heavy rains resulting in floods and landslides.
- RH is high (varying between 76%-95%.)
- The diurnal range of temperature < 10°C.

Post-monsoon:

- Pleasant weather with diurnal range of temperature < 10°C.

Winter:

- Temperatures extremely low even going down to freezing point.
- Heavy to medium snowfall of varying durations occurs, depending on the altitude. There is an average 3 m of snow from altitudes > 1800 metres.
- The intensity of solar radiation is low in winter with a high percentage of diffused radiation and prevalence of cold winds.

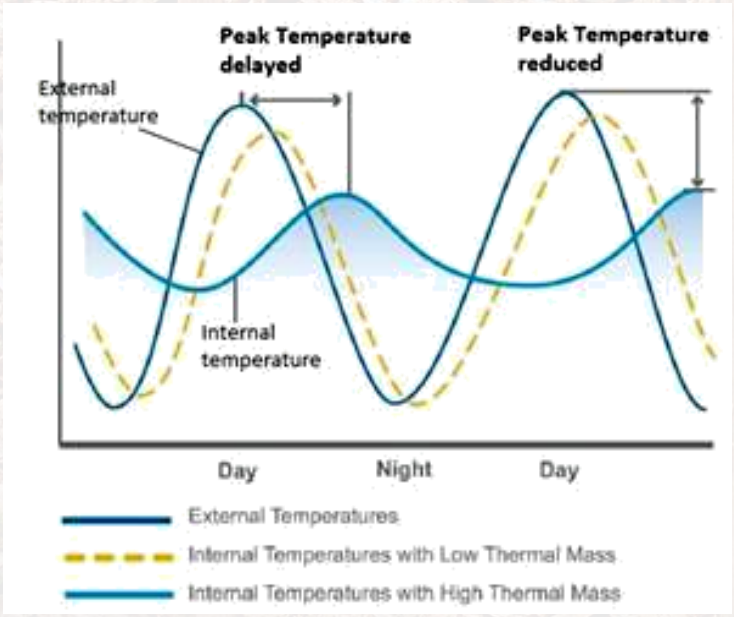


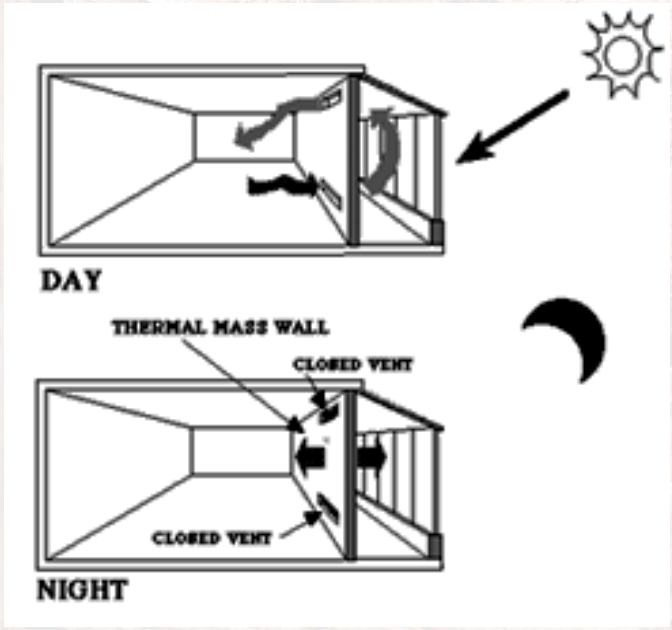
Seasonal Passive Strategies for Kullu, HP

Winter Strategies

MAXIMISING HEAT GAIN

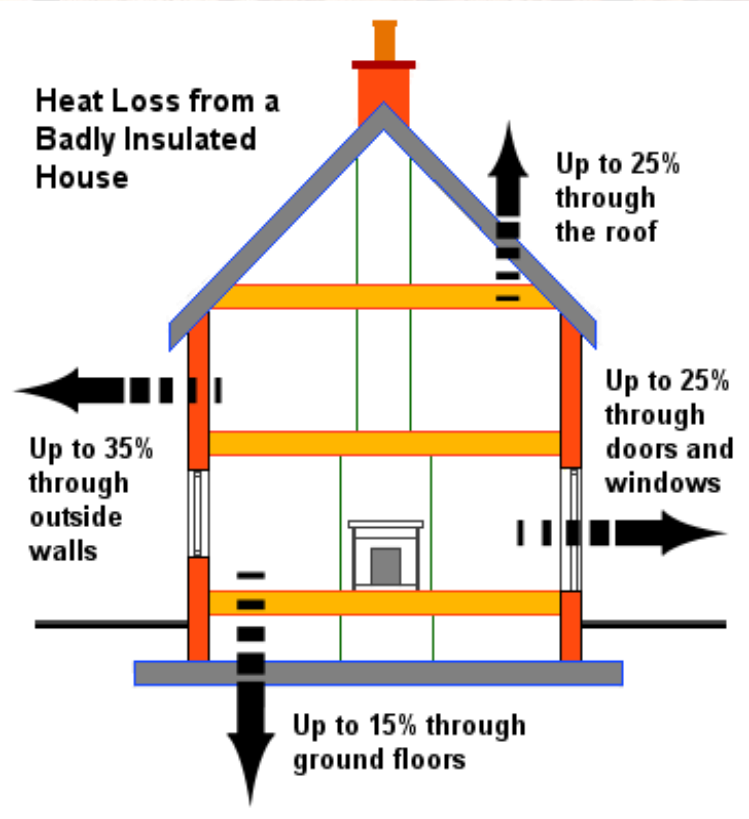
- Orientation of building for maximum solar exposure
- Trapping direct solar radiation through sunspaces or skylight windows.
- Trapping heat indirectly through increased thermal mass of buildings or buffer spaces.





MINIMISING HEAT LOSS

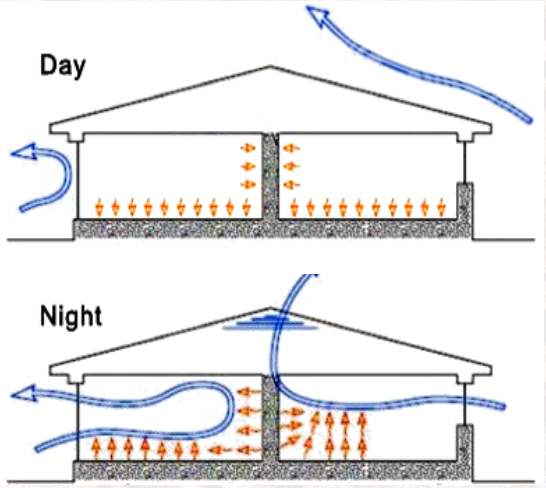
- Appropriate size, location and insulating value of the glazed areas to prevent heat loss.
- Insulating building envelope.
- Reducing infiltration of cold by ensuring air tightness in construction details.
- Additional insulation with buffer spaces such as double facades and sunspaces can be located along the building perimeter, facing the sunny side of the building and can be occupied or unoccupied.



Summer and Monsoon Strategies

PREVENTING OVERHEATING

- The fenestration should be partly operable to flush out heat, whenever needed.
- Night time ventilation can be used for removal of accumulated heat loads of the day using night time winds and can be very effective for keeping interiors cool during warm summers. It is usually coupled with thermal mass use during the warmer seasons in places of high diurnal range of temperature and good prevailing winds.
- Operable shading features to cut down the solar gain.
- Deciduous trees to provide seasonal shading

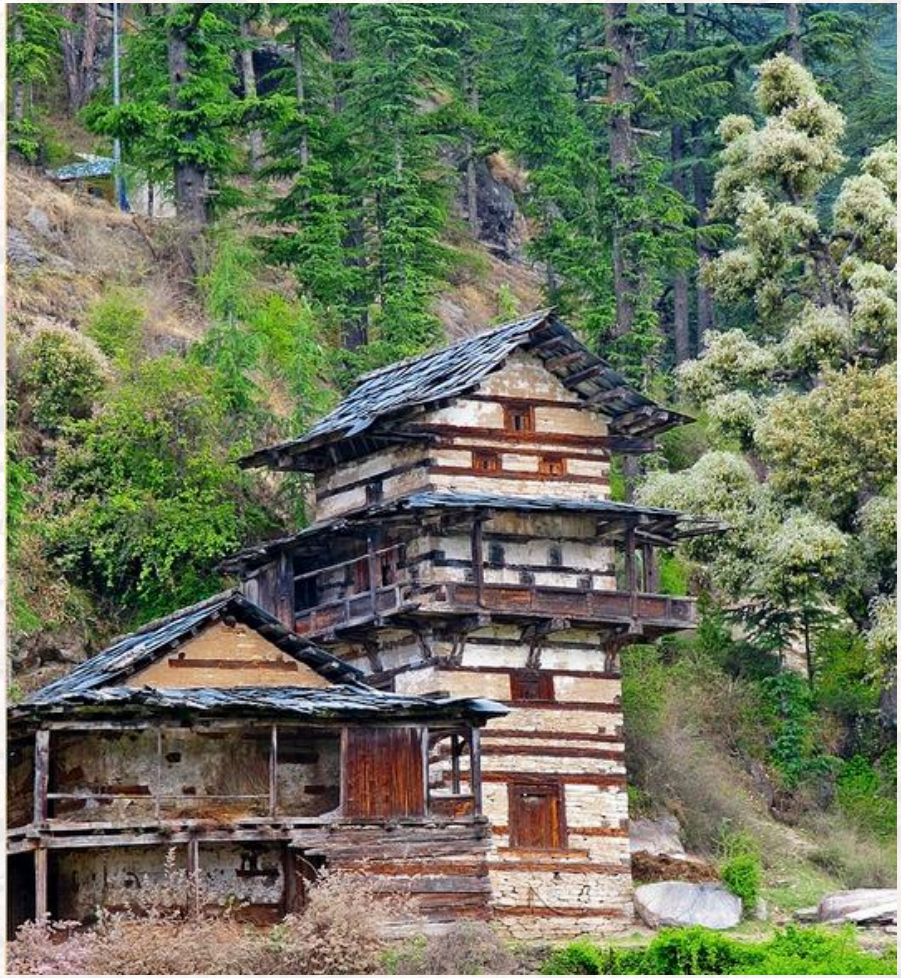


Summer and Monsoon Strategies

DESIGN FOR LCCR CONSTRUCTION

RAIN SHELTERING

- Optimum rainwater run-off and drainage provisions using natural contours .
- Optimum roof and fenestration design.
- Optimum water proof material and construction system selection.



Building Envelope Properties

U-VALUE

U-Value is…

a measure of the rate of heat loss or gain through a material and is an important parameter for passive design. It is measured in W/m^2K.

A value of 1 W/m^2K means that the material will lose or gain 1 W heat through every $1m^2$ of its surface for each degree of temperature difference between the building interior and exterior.

A building envelope of low U-Value is a must to reduce space conditioning loads in cold climates where mechanical heating is needed.

For a 24 hour use building in cold climates the ideal maximum U-Values of different elements of the building envelope must not exceed the following:

Roof- 0.261 W/m^2K

Walls- 0.369 W/m^2K

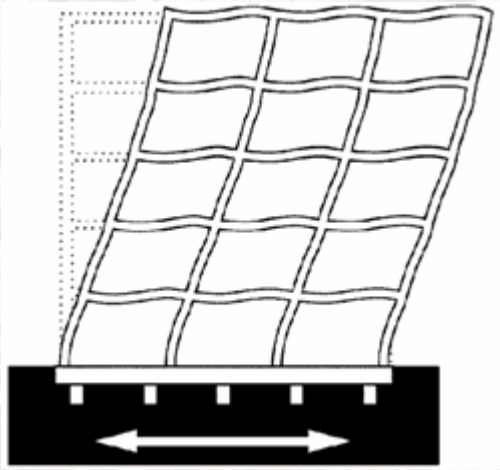
Glazing- 3.3 W/m^2K.

-The Energy Conservation Building Code of India

Earthquake Resistance

Most of Himachal Pradesh falls in Zones IV and V of the seismic map of India.

Buildings damaged due to horizontal forces are exerted on a structure that is often meant to contend only with vertical stresses.



The seismic design measures depend on

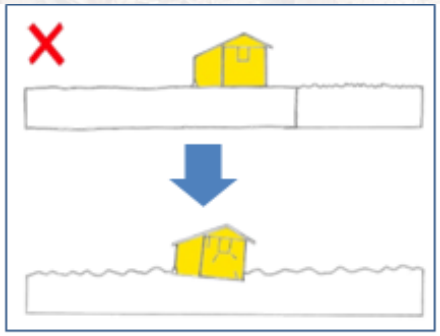
- Severity of risk
- Soil type
- Number of storeys
- Storey height
- Importance of the building

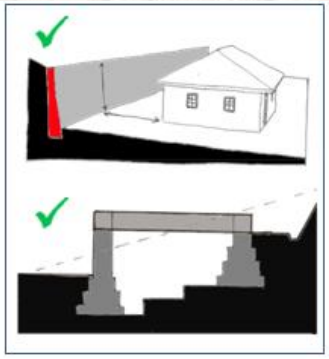
LCCR Design Guidelines

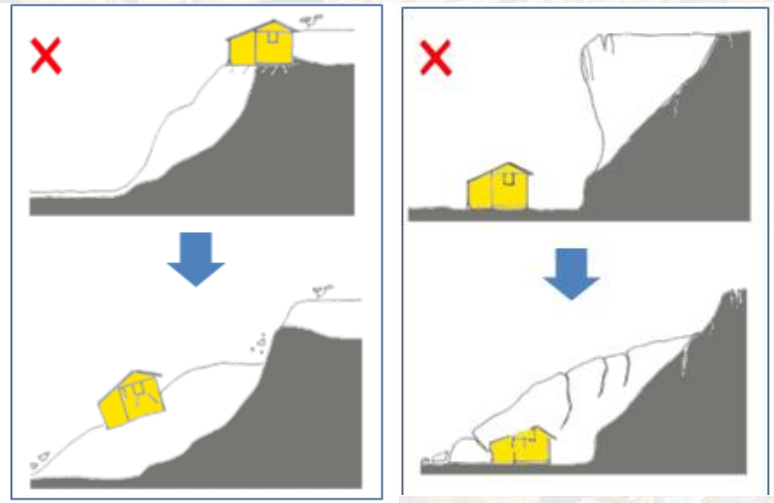
DESIGN FOR LCCR CONSTRUCTION

Location:

- Using natural topography and vegetation of the land for wind protection.
- Locating building above storm water surge level.
- Avoiding building on steep/ unstable slopes, lose ground, areas susceptible to landslides and rock fall or near rivers.
- Maintaining a minimum distance of 4 feet from slopes and provide a retaining wall if necessary.
- Terracing and levelling sloped land prior to construction.







LCCR Design Guidelines

Adaptive Reuse:

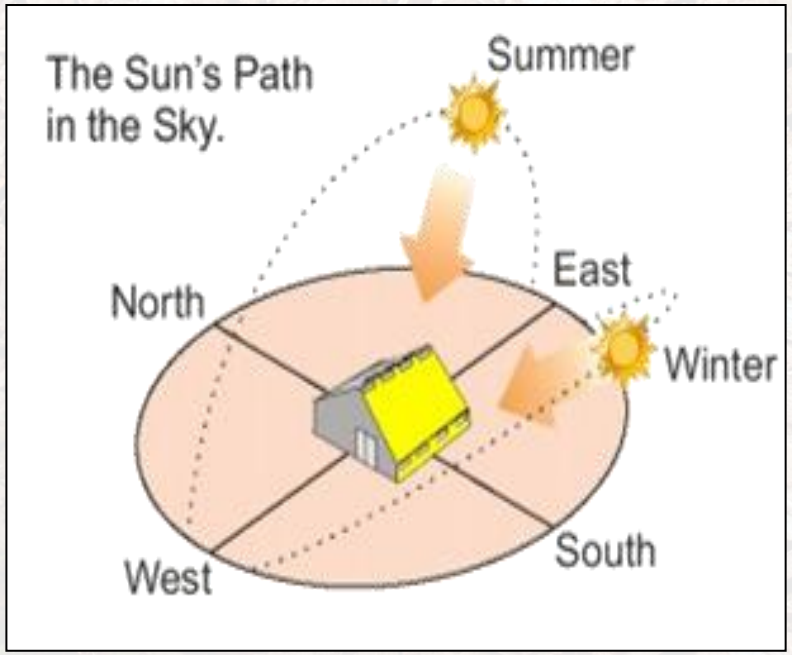
• Many old and deserted buildings can be restored and underused infrastructure can be put to proper use.

• One of the main environmental benefits of reusing buildings is the retention of the original building's "embodied energy".

LCCR Design Guidelines

Orientation:

• Maximize south, east and west façade exposure for daylight and solar heat gain. Internally, the spaces that need direct solar gain during the winter are oriented towards the south.

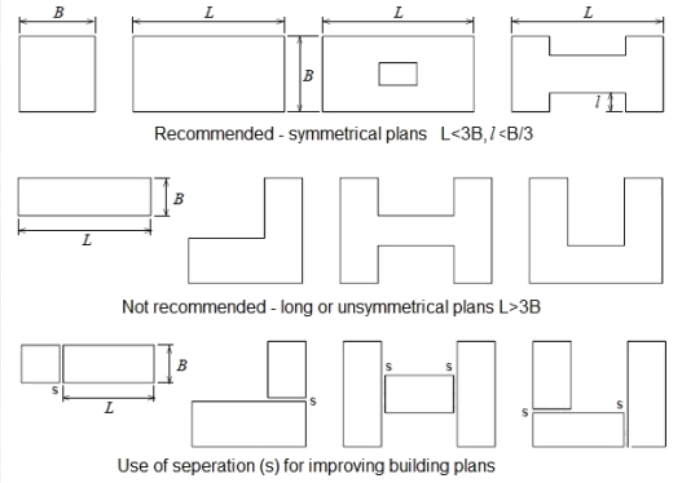


LCCR Design Guidelines

DESIGN FOR LCCR CONSTRUCTION

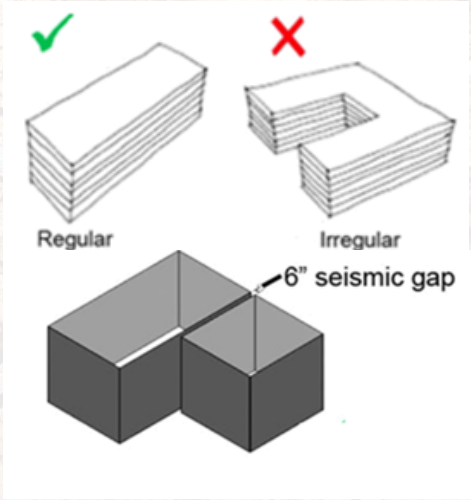
Building Shape:

• Regular shapes like square, rectangular and circular resist an earthquake more effectively as compared to irregular shapes.



•All components, such as wall, roof and floor should be well tied together.

• Closer and compact built form:
- Reduced exposed surface area & volume therefore
- Reduced amount of building materials needed.

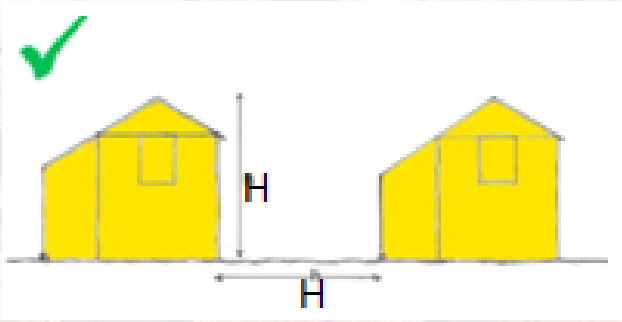


• If irregular shapes are required then a seismic separation gap should be made at points to create structurally isolated boxes.

LCCR Design Guidelines

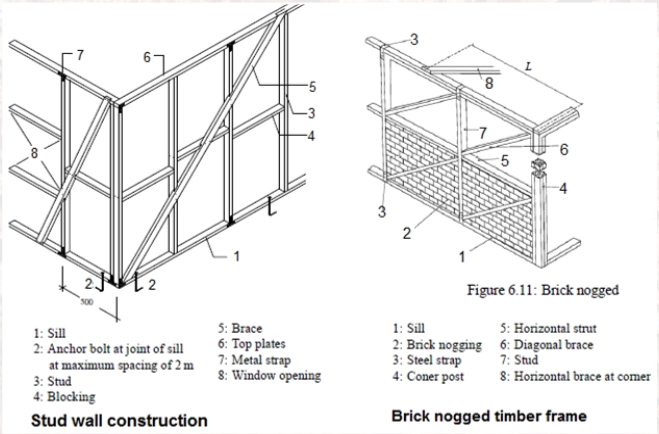
Cluster Design:

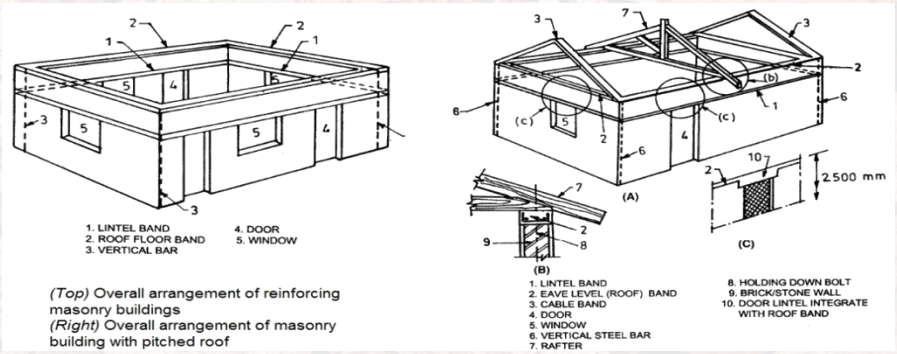
•Buildings must be located a good distance between each other (at least equal to height of adjacent trees or a house) in case of the collapse of one during an earthquake.



Structural Design:

• Ductility is the ability of the building to bend, sway, and deform by large amounts without collapse. Most damage during past earthquakes was to unreinforced masonry structures constructed of brittle materials, poorly tied together. The addition of steel reinforcement adds ductility to brittle materials.





Tying Together the Structure to Resist Lateral Loads

Source: National Building Code of India

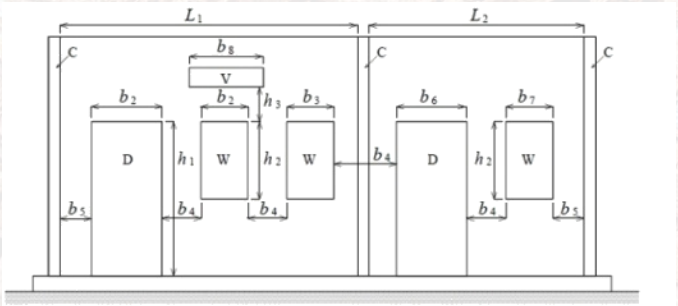
Cross Bracing of Infill Walls in Timber

LCCR Design Guidelines

DESIGN FOR LCCR CONSTRUCTION

Wall Design:

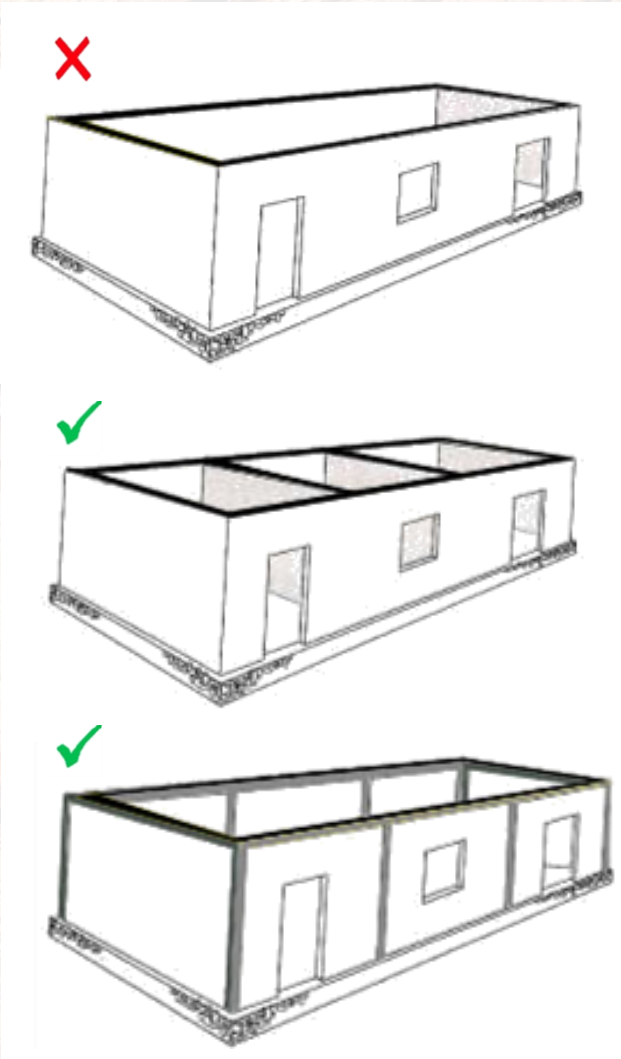
- High thermal mass to: moderate temperature fluctuations effectively when the diurnal range of temperature is over 10°C. For this, use of thicker and heavy construction materials is recommended.
- Water proofing
- Earthquake resistance: long and narrow buildings divided into separate rooms rather than one long room. If this is not possible framing elements should be introduced.



C: cross wall D: door opening V: ventilation W: window opening

$b_1 + b_2 + b_3 \leqq 0.5L_1$ for one storey, 0.42 for two storey, 0.33 for three storey,
$b_6 + b_7 \leqq 0.5L_2$ for one storey, 0.42 for two storey, 0.33 for three storey,
$b_4 \geqq 0.5h_2$ but not less than 0.6 m, $b_5 \geqq 0.25h_1$ but not less than 0.6 m,
$h_3 \geqq 0.6$ m or 0.5 (b_2 or b_8 whichever is more).

Opening size and location for seismic design of load bearing buildings



LCCR Design Guidelines

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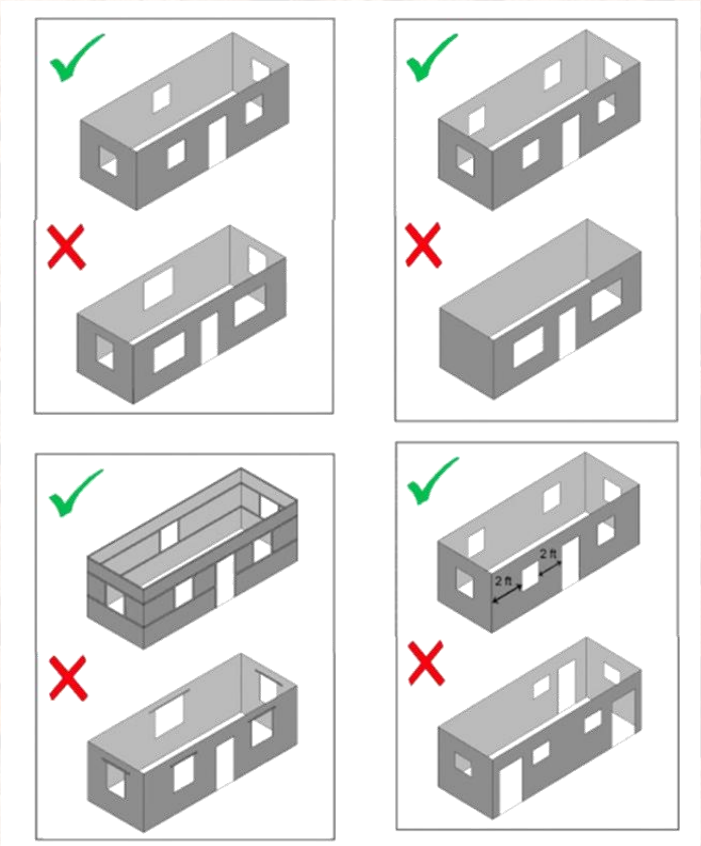
Fenestration Design:

- South façade: Maximum operable openings
- West façade: some openings.
- North façade: minimal openings.
- Opening size based on daylight and ventilation requirements of specific spaces inside.
- Kitchens and living rooms need maximum daylight.
- Kitchens and bathrooms need maximum ventilation.
- Adjustable shading devices: horizontal overhangs (sunshades), vertical fins, louvers, operable blinds, and screens
- Night shutter systems



- **Prevent overheating during summer**
- **Control and filter daylight**
- **Reduce indoor glare.**
- **Prevent heat loss at night in winter.**
- **Must not compromise earthquake resistance.**

LCCR Design Guidelines

External Finishes:

• Dark coloured and absorptive materials are recommended as they absorb surface radiation and therefore increase heat collection and transfer.

• Natural Bark Singles (NBS) can be used in place of Synthetic Siding. NBS has no chemicals, preservatives or borax added to it – so no leaching.

Semi-outdoor Spaces:

• Sunspaces, solariums or greenhouses should be used as heat trapping buffer spaces oriented towards the south

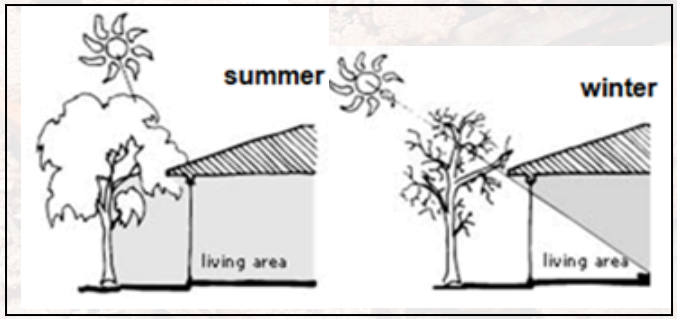
Landscaping:

• The existing vegetation and top soil must be conserved to the maximum extent possible.

• Trees on site must be used for protection from strong winds.

•Deciduous can be planted as they provide shade in summer and allow percolation of sunlight during the winter.

Dark Coloured External Finishes



Seasonal use of deciduous trees

Passive Strategies for Wet and Hilly Regions

DESIGN FOR LCCR CONSTRUCTION

Objective		Physical manifestation
Resist heat loss	Decrease expose surface area	Orientation and shape of the building. Use of trees and vegetation as wind barriers.
	Increase thermal resistance	Optimum roof insulation, wall insulation and double glazing.
	Increase thermal capacity (Time lag)	Thicker walls of materials like stone of high thermal mass.
	Increase buffer spaces	Air locks/ Lobbies.
	Decrease air exchange rate	Increasing air tightness of the building envelope.
Promote heat gain	Increase surface absorptivity	Darker colours of finishes.
	Reduce shading	Rightly sized, oriented and unobstructed sun-facing walls and glass surfaces.
	Trapping heat	Sun spaces/green houses/Trombe walls, etc.
Disaster resistance	Earthquake resistance	Structurally stable building configuration, opening sizes, stiffness distribution and ductility.
	Flood/Landslide resistance	Structural resistance to storm surges. Incorporating rain-sheltering features.
	Siting	Locating building in areas that are not flood or landslide prone.

Thank you

Disclaimer

DESIGN FOR LCCR CONSTRUCTION

Climate & Development Knowledge Network

Development Alternatives