BACKGROUND READING MATERIAL FOR BUILDING PROFESSIONALS

WET & HILLY SPACES

DESIGN

FOR LCCR CONSTRUCTION

ABOUT THE MANUAL

This manual specifically looks at LC-CR construction for wet and hilly climate for artisans. The state of Himachal Pradesh acts as a model for similar wet hilly regions across the Indian subcontinent as well as South Asia. The target group includes architects, civil engineers, project managers of sustainable/ low carbon habitat projects. The objective of the manual is to impart knowledge on design and planning of resource and energy efficient buildings.

This manual aims to elucidate the:

- Relationship between climate change and construction practices
- Relevance of Energy Intensity and Carbon Footprint of construction activity
- Climate design principles, applicable to Himachal Pradesh
- Alternate building technologies for low energy disaster resistant construction

This manual is intended to serve as reading materials for the capacity building of building professionals in LC-CR construction.

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ABOUT THE PROJECT

The Government of India has recognised the need for action in the Low Carbon, Climate Resilient (LCCR) sector. However, there is a lack of attention towards the 70 million strong rural spaces and small towns which are emerging as areas of high growth. "Knowledge Development and Dissemination for Promoting Low Carbon Construction in Rural Areas and Small Towns of India and South Asia" is an initiative undertaken by the Development Alternatives (DA) Group, supported by the Climate, Development and Knowledge Network (CDKN) that aims to bridge this gap.

The initiative has a two-fold focus:

- Mitigation measures against climate change, and
- Adaptive measure to deal with the impacts of this change.

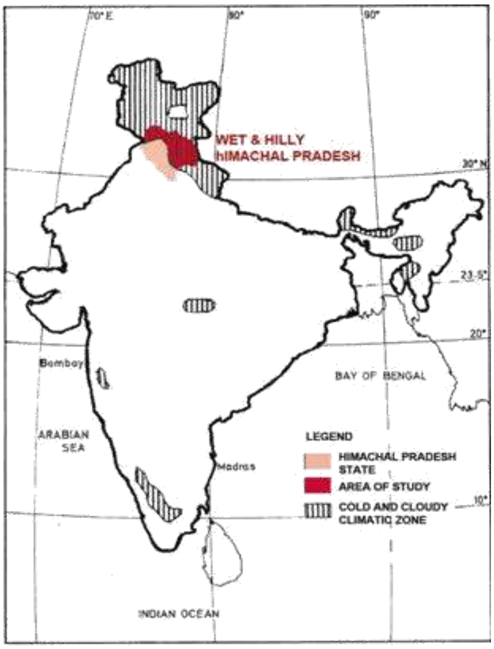
It aims to create an enabling environment focusing on three key factors:

- Knowledge (building a technology base),
- Policy (strengthening the institutional framework), and
- Finance (devising innovative mechanisms).

The initiative seeks to generate knowledge support for LCCR solutions for small towns and rural spaces by building capacity at three levels, viz. Policy Makers, Building Professionals and Artisans. It also attempts to influence policies and building practices in response to imminent climate change trends and need for low carbon construction.

The initiative zones in on three different geo-climatic regions of the Indian subcontinent – coastal, semi-arid and wet & hilly - with the representative study regions located in Orissa, Madhya Pradesh and Himachal Pradesh (HP), respectively (Figure 1). The LCCR guidelines outlined for these regions have features applicable across similar geo-climatic zones in South Asia.

Figure 1: Cold and Cloudy Climatic Zone of India (Area of Study)



Source: Adapted from Climatic Zones of India – National Building Code

Session 1: Global Scenario

Objective:

- To orient participants towards the dynamics of climate change and the building sector
- To highlight the current situation of construction in the area

Chapter 1: The Challenge

What Is Climate Change?

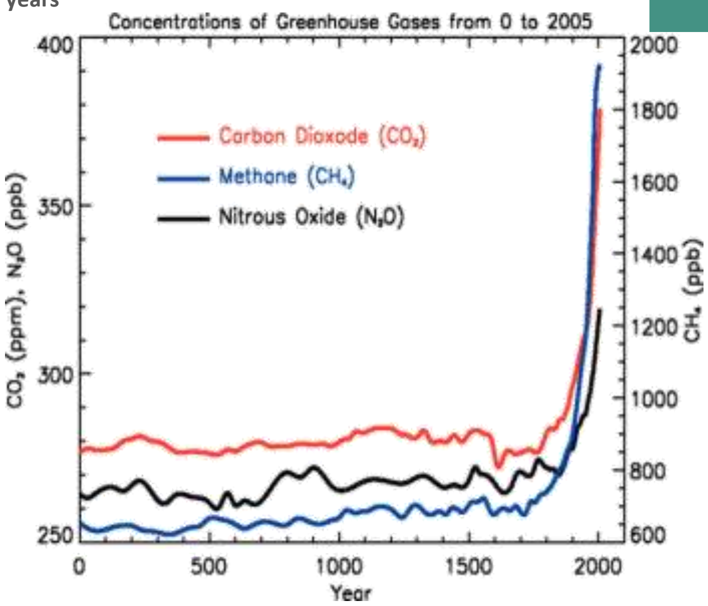
To understand climate change, it is essential to know the definition of "climate" itself. Climate is usually defined as the "average weather". The Inter-Governmental Panel on Climate Change (IPCC) defines it as the mean and variability of relevant parameters like temperature, precipitation, and wind over a period of time. Usually they are averaged over 30 years.[1]

Climate change refers to fluctuations in the "average weather" or variations in patterns of temperature (Figure 2), wind and precipitation over extended periods as well the occurrence of extreme weather events. While climate naturally undergoes some variability over time, it has been confirmed by worldwide studies that human activity and economic growth alter the composition of global atmosphere both directly and indirectly, and is, to a large extent, responsible for climate change.

At A Global Level

The impacts of climate change have been felt in varying degrees in different geo-climatic regions across the globe. These impacts have manifested themselves, both, through temperature and precipitation extremes and erratic natural disasters. They have had far reaching consequences on agriculture, health and shelter. Developing countries of the world (Figure 3), where a large proportion of the population is more strongly connected with natural resources, are more vulnerable to impacts of climate change.

Figure 2: GHG Concentrations during the last 2000 years



Source: IPCC's Fourth Assessment Report Impacts of Climate Change

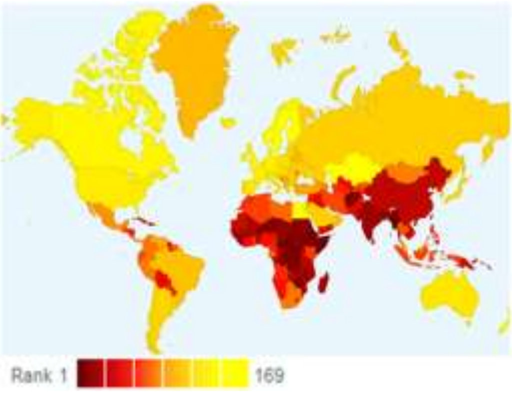
In South Asia

As is evident in Figure 3 above, South Asia, with most of its economies relying on agriculture and natural resources, is expected to be seriously affected by the adverse impacts of climate change.[2] South Asia is annually affected by climate extremes, particularly floods (Figure 4), droughts and tropical cyclones, while large areas are highly prone to flooding and influenced by monsoons.

1 Glossary of Terms used in the IPCC's Third Assessment Report", 2001, IPCC

2 The IPCC's 4th Assessment Report, 2007

Figure 3: Global Climate Change Vulnerability Map



Source: Centre of Global Development

Figure 4: Flooded Sri Lankan Village during 2011 floods that left 1 million people homeless

The projected impacts of climate change on main sectors that specifically apply to South Asia are:

Livelihoods: Low-income rural populations, dependant on traditional agricultural systems, will be affected as changes in rainfall and run-off impact irrigation systems. The expected 2-4°C temperature fluctuation could result in significant change in crop yields, affecting production, storage and distribution acutely.

Habitat: Large tidal variations and tropical cyclones coupled with potential increase in regional rainfall are major potential threats to habitat capable of causing serious physical damage to houses.

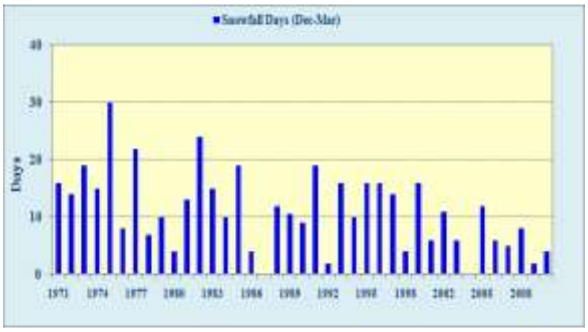
Ecosystems: Sea-level rise and increase in sea-surface temperature could result in coastal erosion and land loss, inundation and sea water intrusion into freshwater bodies. Coral reefs, mangrove wetlands, tropical and temperate forests would be particularly affected. Rise in sea surface temperature by 2-4°C can increase cyclone intensity by 10-20 per cent.

Water: Droughts will aggravate existing water shortages, undermining food security. In parallel, extreme rainfall could increase the risk of flooding. Also changing patterns of run-off and river flows may have serious impacts on hydropower generation and urban water supply.

CLIMATE CHANGE IN HP

The State of Himachal Pradesh (HP) situated in the western Himalayas, which is one of the most vulnerable ecosystems in the world, is seriously affected by the impacts of climate change. Also, as the lives of people in this region are closely intertwined with the natural resource base, HP faces an urgent need to adapt to these impacts, most prominently, extreme weather events such as cloudbursts and flash floods which also trigger landslides. The region also falls under the seismic zones IV and V with very high risk earthquakes of magnitude 8 and greater. According to the International Centre for Integrated Mountain Development (ICIMOD), global warming in the Himalayan region has been much greater than the global average. The average temperature of Shimla has increased by about 10°C during the last 100 years. Figure 5 shows the variation in the average snowfall days in Shimla over a period of 30 years from 1970 to 2010.

Figure 5: Snowfall Days in Shimla during the Winter Season (Dec-Mar)



Source: Indian Meteorological Department: Climate of Shimla (Ajit Tyagi, OP Singh, Manmohan Singh, SC Bhan)

The major projected impacts of climate change in HP are increase in mean monthly air temperature, more intense precipitation resulting in flash floods and landslides, soil erosion and a threat to the natural resources like forests. All these impacts have direct or indirect implications on the construction industry in terms of availability of building resources, building damages due to extreme weather events, reconstruction, etc.

Calamities and Extreme Weather Events

Earthquakes: Huge amount of building damages (Figure 6) have also been observed due to earthquakes in the region. Large earthquakes have occurred in all parts of HP, the biggest being the Kangra earthquake of 1905 killing at least 28,000 people. Earthquakes of lesser magnitudes have continued to strike many areas of HP like Kullu (1906), Sultanpur (1930), Lahaul-Spiti (1955), Chamba-Udhampur (1962), Dutung (1975) and Kangra (2004).[3]

Figure 6: The Effects of Landslides and Floods in HP

Source: http://www.thewanderers.in (top – Spiti 2010), SoER, 2007 (bottom – Mandi 2005)

Floods: Of all the natural disasters that hit the State and cause damage to, both, life and property, floods are most widespread in the state.[4] As per an assessment made by the Central Water Commission (CWC) in 2000, about 70 per cent of the total geographical area of HP can be affected by floods. During landslides and floods, roads are repeatedly damaged, blocked or washed away.

Another form of flooding in this hilly state is flash flooding which is of short duration but can cause extensive damage. Often, flash floods are caused due to cloudbursts in the catchment regions, intense and prolonged rainfall as well as downstream blocking of river channels by landslides. In HP, riverine flooding is mostly associated with the snow-fed rivers Satluj and Beas coupled with heavy rains. Since 2000, there have been 3 major flash floods in river Satluj in 2000, 2001 and 2005 which have affected regions in Kinnaur, Kullu, Mandi, Shimla, Solan, Hamirpur and caused damage to crops, houses and public utilities worth more than Rs. 15000 crores[5].

Factors Contributing to Climate Change in HP

- Extensive deforestation, often carried out for mining raw materials for the building sector, removes natural carbon sinks and has been known to alter natural geographical buffers to climatic extremes – these have mostly been to mine natural resources such as limestone for cement, slate, etc.
- Altering the land profile with road cutting to meet demands of increasing urbanization, inevitably affects an area's ecological balance in a negative way.

3 http://asc-india.org/seismi/seis-himachal-pradesh.htm
4 Floods and Flash Floods in HP: A Geographical Analysis, Dr. DD Sharma, HP University, 2006
5 Dr. DD Sharma, Floods and Flash Floods in HP: A Geographical Analysis

Chapter Summary

- Human activity alters the composition of the global atmosphere, both, directly and indirectly, and is, to a large extent, responsible for climate change.
- South Asia ranks among the high vulnerability regions in the world for impacts of Climate Change - projected impacts are on Livelihood, Habitat, Ecosystem and Water.
- Global warming in the Himalayan region has been much greater than the global average. The total number of snowfall days in Shimla has decreased since 1971.
- The state is prone to natural disasters especially earthquakes and cloudbursts resulting in floods.

Points to Ponder

- Are there any impacts of climate change in the region which have been felt by you over the last decade?
- How is the construction sector responding to these changes?

Notes

CHAPTER 2: CONSTRUCTION AND CLIMATE CHANGE

The construction sector accounts for 40 per cent of the total flow of raw materials into the global economy every year[6]. It also accounts for approximately 9 per cent of global Gross Domestic Product (GDP), which is an indicator of economic development.

In India, the construction sector is among the fastest growing sectors today, recording a growth of 156 per cent from 2000 to 2007 while providing employment to 18 million people directly. In 2008-09, the Indian economy reached the trillion dollar mark of which the construction industry was estimated at 70.8 billion dollars[7]. It has been steadily contributing about 8 per cent to the national GDP[8] over the last 5 years. The cyclic link between construction and climate change can be understood in terms of adaptation and mitigation action.

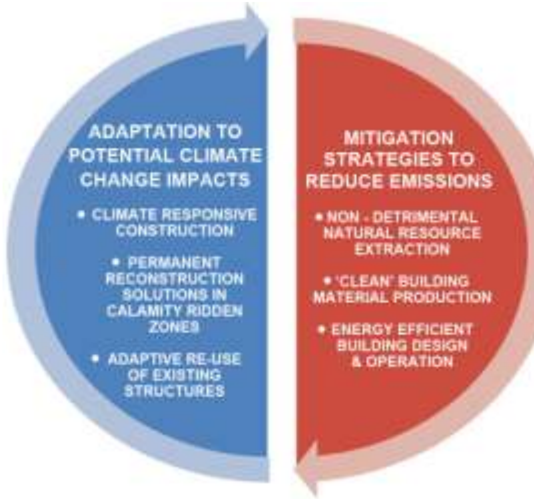
HOW DOES CLIMATE CHANGE AFFECT CONSTRUCTION?

The construction sector meets one of our basic needs of habitat. Design and construction of buildings need to ensure climate resilience to resist climatic extremes of uncomfortably hot or cold temperatures, high velocity winds and intense precipitation. An increased tendency of extreme climatic events places additional demands of durability and performance on buildings.

In flood and earthquake prone HP, the construction sector faces the additional challenge of housing shortage caused by natural disasters. Extreme climatic events like floods and landslides also generate huge amounts of debris from damaged buildings. The disposal or utilization of this debris is an important factor to be addressed by the construction sector.

6 http://www.businessandbiodiversity.org
7 Economic Times Data, November, 2008
8 At constant 2004-05 prices

Figure 7 : Construction and Climate Change: a cyclic link



HOW DOES CONSTRUCTION AFFECT CLIMATE CHANGE?

Building construction and operation activities have extensive direct and indirect impacts on the environment.

- At the national level, the construction sector emits about 22 per cent of the total annual national CO2 emissions out of which 80 per cent result mainly from production of four energy intensive building materials - steel, cement, bricks and lime.
- The massive demands placed by the construction sector on naturally occurring materials such as building stone, wood, limestone (for cement) and soil for making bricks disturbs the natural carbon balance and drastically alters natural geographies in the long-term.
- The operation of buildings contributes to peak in electricity consumption which is directly linked to green house gas (GHG) emissions. In rural areas, biomass is still the dominant energy source which contributes greatly to indoor air pollution.

During the 12th Five-Year Period, there is a national housing shortage of about 40 million houses in rural spaces alone. Without proper policy interventions and technological improvements, the environmental impacts of construction are set to increase manifold.

Chapter Summary

- Construction sector has a significant impact on climate change through its massive demand for material resources and through emissions from electricity used for operation of buildings.
- Construction in HP needs to respond to the increased hazard of extreme climate related events, particularly landslides and floods.

Points to Ponder

- Identify any changes regarding availability of building materials that have taken place in your profession over the last few decades. What are the reasons for these changes?
- Identify cases related to the construction sector in your region which you think have caused environmental degradation.

Notes

Chapter 3: Building Resources in HP

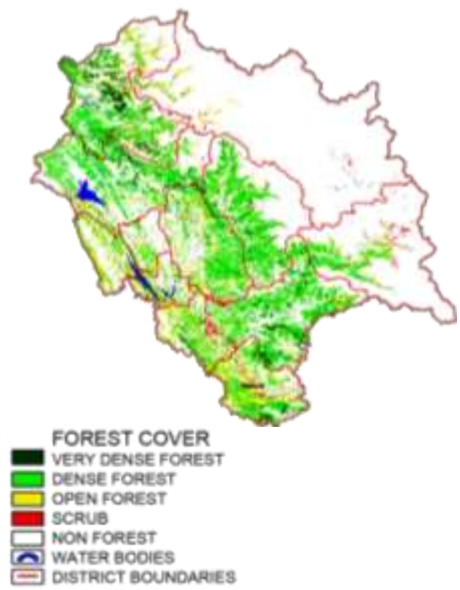
The practices in the construction sector of HP that aggravate climate change need to curb their impact on the local environment by:

- Reducing ecologically detrimental methods of sourcing building materials
- Using more energy efficient construction technologies
- Ensuring minimum amounts of energy used in the operation of buildings constructed

Water Resources

The wet & hilly region in HP has a rich natural resource base of water including glaciers, perennial streams draining into rivers, water bodies like natural lakes and man-made reservoirs, innumerable water springs and large stocks of sub soil water. HP is drained by nine major river systems with a total catchment area of 55,673 sq. km (Figure 8).

Figure 8: Forest Cover in HP



Sources: SoER HP, Dept. of Environment Science & Technology, Govt. of HP

Forests

Forests are a very important natural resource in HP with forest products accounting for 8 per cent of the State GDP. The most valued forest product is timber, followed by medicinal plants, herbs, resin, bamboo, charcoal, fuel-wood, *bhabhar* grass and *khair*. Timber was extensively used in the vernacular architecture in the region, as the forests of deodar wood and other mixed forests were easily available. Now, as a counter measure to deforestation, the use of timber has largely gone out of practice. According to the National Forest Policy, 1988, at least two-thirds of the geographical area should be under forests in mountainous states like HP but only 26.66 per cent of the area is under forest and tree cover (Figure 8). The large scale destruction of the State's forest wealth by mining has resulted in severe flash floods.[9] Loss of the existing forest cover leads to irregular water flow (drying up of natural springs and increases vulnerability to flash floods during rains) as well as increase in levels of atmospheric carbon. Hence, adequate regeneration of the forest cover is of prime importance in the State.

Minerals

Limestone is the most heavily quarried mineral of the State and provides raw material for the three major cement plants. Cement is one of the biggest industries in the State and has caused large scale destruction of natural resources with open cast mining causing substantial degradation of land and turning green hills barren.

As per the land capability map of HP, only 21.4 per cent of land is suitable for agriculture, 37.9 per cent of land is suitable for grazing and forestry and the remaining land is permanently snow covered as protection of water supplies[10]. Hence, soil is a very critical resource in HP and therefore, it is not feasible to use clay bricks as a mainstream material without a large transportation component. Approximately 35 lakh tonnes of sand, gravel and boulders are extracted annually from river/streams to meet the demand of road construction, bridges, building material, etc. Based on these, 260

9 Ravinder Sood, "Global Warming, Himachal could Spell Disaster for India", 2007. http://www.hillpost.in
10 National Bureau of Soil Survey and Landuse Planning, Nagpur

stone crusher units have been set up. The Government of HP recognizes that uncontrolled and illegal mining of sand, concrete and stones is beginning to cause environmental damage by altering the riverbank ecosystems. This also increases the risk of avalanches and flash floods.

Studies indicate that reckless and unscientific mining and quarrying combined with construction of big power projects, cement plants, roads and buildings have contributed to sudden change in the rain pattern in HP. The dust, smoke and silt coming out of these plants have also become heavy sources of pollution. Studies also reveal that over 50,000 hectares of land have seriously been affected by environmental imbalances due to mining and other construction activities. [11]

BUILDING CONSTRUCTION PRACTICES

The region has a rich tradition of climate responsive vernacular architecture based on timber, soil and stone. However, the increasing rate of urbanization has resulted in conventional construction in urban areas that uses burnt brick masonry or stone masonry in RCC framed buildings and flat RCC roofs (Figure 9) or CGI sheet sloping roofs, thereby displacing traditional practices.

Figure 9: Excessive RCC construction in Shimla

Source: http://www.indiamike.com

The use of timber as framing material or under-structure for roofs has been severely restricted due to environmental concerns of forest management. In rural areas, locally sourced material like thatch, earth, stone slates and timber are still commonly used as roofing material. ACGI roofs have replaced stone slates to a large extent; their only advantage is that they are a good barrier for rain.

Studies indicate that contemporary construction in the hilly areas of Kashmir, Kullu and Ladakh needs more heating energy for thermal comfort than traditional designs using local materials[12]. The seismic risks in the region have also created some vernacular structural forms which have withstood earthquakes for many years such as, the use of Dhajji wall construction where the walls are made of timber frames with in-fills of light thin panels made by close packaging of mud mortar, stone and ballast (Figure 10).

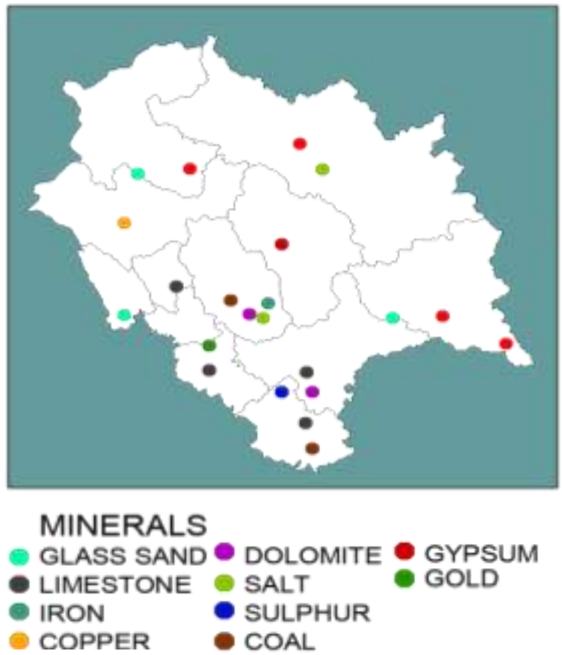
Figure 10: Traditional Dhajji Wall Construction in HP (top) and Stone Slate Roofing in Dharamsala (bottom)

Source: Development Alternatives archive

11 Ravinder Sood, "Global Warming, Himachal could Spell Disaster for India", 2007. http://www.hillpost.in

[12] Vinod Gupta and Ranjit Singh (School of Planning and Architecture, New Delhi) – Energy Conservation in Traditional Buildings in the Mountains

Figure 11: Mineral Resources in HP (left), Deforestation caused by Limestone Quarrying in Kangra (right top) and



Slate Quarrying in Mandi (right bottom)

Sources: Annual Report 2009-10: Ministry of Environment & Forests Govt. of India; http://www.indiamike.com

State level policy in HP has made it mandatory for public buildings to incorporate passive design, waste utilization and rainwater harvesting. Consequently, features like solariums and trombe walls have become more known, although their correct design and implementation remain a major challenge.

The Challenge in HP

Under the increasing pressure of urbanization, the rapidly expanding footprint of built-up area in the State needs to take into account the following factors:

- Water imbalance due to over-exploitation of ground water resources
- Urban heat islands due to excessive heat storage in the mass of buildings in a concrete jungle
- Vehicular pollution due to transportation of cement, steel and bricks over large distances to meet the massive requirement for building materials
- Landslides due to cutting of slopes for construction
- Aggregation and disposal issues of building debris
- Deforestation to clear land for new construction
- High susceptibility to loss of lives and property due to earthquakes, landslides and floods

Chapter Summary

- Forests are the most important natural resources of the State. Use of timber in construction has come under severe stress in the wake of extensive loss of forest cover.
- Traditional methods of construction using local materials and climate responsive strategies have largely been replaced by conventional materials like concrete, steel and bricks.
- Mining of natural resources for building material manufacture or for use in the construction sector has been a major factor in environmental degradation in the State.

Points to Ponder

- Take a look at the photograph which shows contemporary construction in Shimla (Figure 9). Do you think that this pattern of construction is appropriate? If not, then list the future problems it has resulted or can result in.
- What do you think is the main reason for loss of forest cover in the State?
- Do you think the water availability in the State is likely to come under stress? Suggest corrective measures which can be taken in this context.

Notes

CHAPTER 4: ENERGY AND CARBON INTENSITY OF BUILDINGS

One of the main concerns with the 'carbon' impact of building materials is the material resources and energy used in its production and the associated carbon emissions which are released. Cement, steel and bricks, the largest bulk consumption items in the Indian construction industry, account for the largest share of energy consumption and carbon emissions over their lifecycle.

Mining large quantities of materials such as limestone, clay and fuel such as coal often results in extensive deforestation and loss of top soil. Minimising the consumption of these finite materials by using alternative building materials, methods and techniques can result in considerable energy savings as well as reduction in CO_2 emission. Therefore, it is important to understand how buildings can be constructed with a reduced material intensity, while at the same time meeting structural and functional requirements.

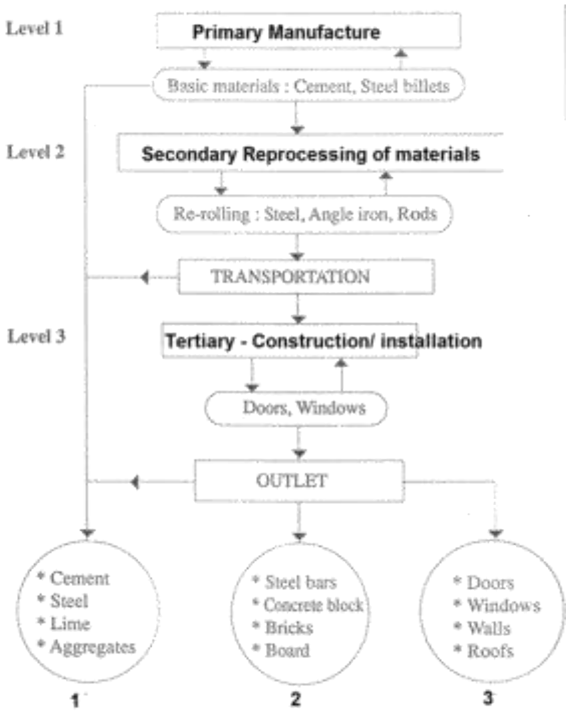
EMBODIED ENERGY

Through the lifecycle, from production of building materials to their use in construction and then finally to their disposal, inputs of energy are needed. In addition to the process-related energy inputs, vast amount of energy is also used in transportation of these materials to their eventual point of use. These energy inputs are summed up as 'Embodied Energy' (Figure 12).

Primary Level: This is the first stage of manufacturing basic raw materials like cement, steel, aggregates, aluminium, PVC, etc. which takes place in large scale centralized plants. Usually, this component of embodied energy is dependent on mainstream industrial practices and level of technology and is therefore outside the control of the building professional.

Secondary Level: At this level, raw materials from the primary level are re-processed into building components like bricks, concrete blocks, plywood, roofing sheets, mangalore tiles, etc. Essentially this involves production energy, either thermal, as in case of bricks or electrical, as in the case of concrete products, and transportation of raw materials to production facilities. Generally, products which require thermal energy, like firing of clay products, have higher embodied energy than products which require electrical energy. Utilization of industrial waste materials has big potential to minimize energy at this level.

Figure 12: Flow of Materials and Embodied Energy

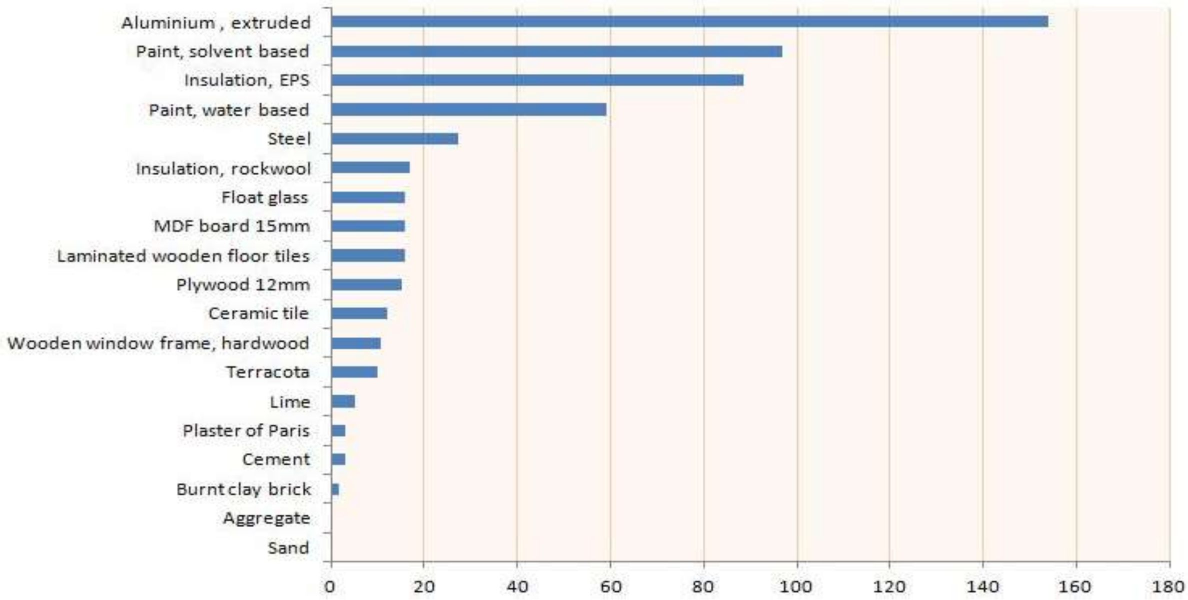


Tertiary level: This level involves the use of building materials in the construction of foundation, walls, roofs, etc.

Embodied energy can be measured in different units – Joule, kWh or calories – depending on convenience, understanding and norm. Universally, and particularly in India, embodied energy computations are mostly expressed in Mega Joules/ kg (MJ/kg) of the material or MJ/m^2 of the building system.

Although the use of high energy materials like cement and steel is indispensible in construction today, building professionals can significantly lower the embodied energy of buildings at the secondary and tertiary levels by carefully selecting the building materials and construction technologies.

Figure 13: Primary Level Embodied Energy for Common Building Materials



Source: Compiled from existing data on Embodied Energy of building materials in India

OPERATIONAL ENERGY

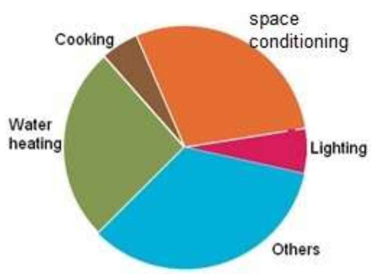
After construction, the building needs energy for its day-to-day operation such as indoor and outdoor lighting, heating, ventilation and air-conditioning (HVAC), use of appliances, water pumping and heating, elevator movement, etc. This set of energy demands is called Operational Energy. While electrical appliances determine the operational energy consumption in urban areas, cooking and lighting are the primary energy consumers in rural areas where biomass such as wood, agricultural residue and dung cakes are predominant sources of operational energy. The use of biomass does not necessarily contribute to climate change because it is renewable, unless harvested in an unsustainable way. However with prevalent technologies, it does cause serious indoor pollution.

With increasing urbanization, electricity consumption is projected to increase in areas where it is currently at a low level – typically rural areas. A study by The Energy Research Institute (TERI) estimates that building energy consumption in India increased from 14 per cent in the 1970s to nearly 33 per cent in 2004-05. The study estimates the national average electricity consumption at around 80 kWh/m2 per annum and 160 kWh/m2 per annum for residential (Figure 14) and commercial buildings, respectively. However, the levels of energy consumption are also dependent on socio-economic factors and lifestyle and will therefore be much lower in HP.

The globally accepted way of evaluating the energy efficiency of a building is the Energy Performance Index (EPI) which is expressed in kWh/m2/annum.

The most effective way to lower operational energy requirements of buildings is by addressing the issue at its basic level, at the architectural design level itself. Passive design of buildings which focuses on natural principles for thermal comfort, ventilation and lighting is the best strategy for energy efficiency.

Figure 14: Electricity Consumption in Residential Buildings



Source: Energy Fact Sheet TERI 2007, based on survey of households in the National Capital Region of Delhi

Carbon Footprint

Carbon footprint is the total set of GHG emissions emissions caused directly and indirectly by an individual, individual, organization, event or product[13]. It is a is a measure of GHG emissions associated with an an activity or a group of activities or a product. Globally, Globally, awareness about the environmental impact of impact of our activities has increased tremendously. tremendously. Carbon footprints are a tangible parameter to assess this impact in terms of mass of mass of emissions resulting from various sectors (

sectors (

Figure 15) and also as a means of promoting Low-Carbon practices. Definitions of carbon footprint vary in terms of activities and GHGs which should be included within the scope of a carbon footprint assessment. In the context of buildings, it is acceptable to assume CO_2 as the primary emission from two stages:

- Production of materials and their consumption in building construction
- Emissions from energy use to maintain comfortable indoor environments

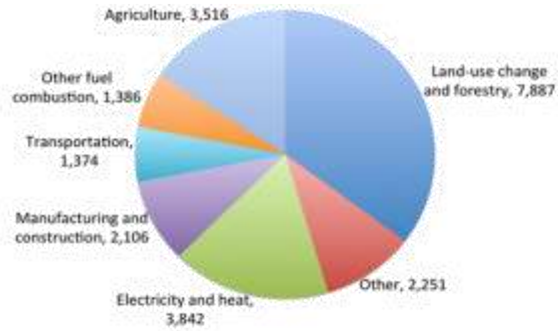
Computing Embodied Energy and CO_2 Emissions

Table 1 outlines the calculation of embodied energy and CO_2 emissions for which data has been collected by the DA Group.

Operational Energy Requirements of Appliances

The carbon footprint of a building, once occupied, is decided by the use of appliances which are used for cooling, heating and lighting. Although the use of appliances is also significantly influenced by economic and lifestyle related parameters, building designs which respond to climatic extremes provide indoor environments in which appliance usage can be reduced. Indicative estimates of emissions resulting from appliance usage are given in Table 2.

Figure 15: CO_2 Emissions (million metric tonnes) by Source for Developing Countries, 2000



Source: Little Green Date Book, 2007

13 "Carbon Footprint Measurement Methodology" , Version 1.1, 2007, Carbon Trust, UK

Table 1: Embodied Energy and CO_2 Emissions for a 230 mm Thick Burnt Clay Brick Wall

Primary level energy: This has been ignored in the calculation because the energy associated with digging, crushing and mixing with soil, water, etc. is predominantly manual energy.	
Secondary level energy: A fixed chimney brick kiln has been considered for brick production – this is the most commonly used technology to produce clay bricks.	
Weight of 1000 bricks @ 2.5 kg per brick	2500 kg
Coal required for 1000 bricks (for conventional bull's trench kiln with fixed masonry)	140 kg
Energy content of coal	27.5 MJ/kg (7.64 kWh/kg)
Embodied energy of 1000 bricks	3850 MJ (1069.44 kWh)
Embodied energy of 1 brick	1.55 MJ/kg (0.43 kWh/kg)
Tertiary level energy	
Number of bricks in 1 m^2 wall	120
Weight of bricks in 1 m^2 wall	300 kg
Embodied energy of bricks in 1 m^2 wall@ 1.55 MJ/kg	465 MJ (129.17 kWh)......(1)
Mortar volume in 1 m^2 wall – ratio 1:6 cement:sand	0.06 m3
Weight of cement in 0.07 m^3 mortar	15.5 kg
Embodied energy of cement in 1 m^2 wall @ 3.2 MJ/kg	49.6 MJ (13.78 kWh).......(2)
Weight of sand in 0.07 m^3 mortar	102 kg
Embodied energy of sand in 1 m^2 wall @ 0.15 MJ/kg	15.3 MJ (4.25 kWh).........(3)
Embodied energy of burnt clay brick masonry (1+2+3)	530 MJ/m2 (147.22 fMkWh/m2)
CO_2 emissions have been considered for emissions arising out of burning of coal in firing bricks and in production of cement used in mortar. Although, emissions are also associated with diesel consumed in transportation, they have not been included because they are negligible. Similarly, it is assumed that negligible emissions are associated with quarrying and transportation of sand.	
CO_2 emissions per kg coal	2.42 kg
CO_2 emissions due to bricks (= 140/1000 x 120) x 2.42	40.65 kg.........(4)
CO_2 emissions per tonne of cement produced	1830 kg
CO_2 emissions due to cement used in mortar (=1.83 x 15.5)	28.4 kg..........(5)
Total CO_2 emissions of burnt clay brick masonry (4+5)	69 kg CO_2/ m^2

Table 2: CO_2 Emissions from Usage of Domestic Appliances in HP

Appliance	CO_2 emissions (in kg) from 1 hour of appliance usage
Fluorescent Tubelight 40W with non-electronic choke	0.05
Incandescent Lamp 60W	0.042
CFL 14 W	0.012
Desert Cooler 100 W	0.071
Air Conditioner 1 TR	0.994
Heat Convector 1500 W	1.065
Radiator	1.065
Geyser 6 litres storage type 3000W	2.13
Microwave 1500W	1.065
Refrigerator 200 Litres	0.284

Source: Based on power rating of common appliances

Chapter Summary

- The construction sector accounts for a large share of energy consumption and carbon emissions at the national level and has huge potential to lower its carbon footprint.
- Buildings can significantly lower their embodied energy by careful selection of building materials and construction technologies.
- Passive design which focuses on thermal comfort, ventilation and lighting through natural means can significantly lower the operational energy requirements of buildings.

Points to Ponder

- Identify the top 5 most commonly used building materials in Bhopal today. From how far away are these materials sourced?
- What according to you are the 3 most effective ways to reduce the carbon footprint of buildings in MP?
- Identify the largest consumer of electricity in your office. Make an assessment of the average number of units it consumes every day.

Notes

SESSION 2: STRATEGY FOR CHANGE

Objective:

- To orient the participants towards LCCR strategies for the construction sector

CHAPTER 5: LCCR STRATEGIES

LCCR construction means that buildings, through their entire lifecycle, from sourcing of building materials till the operation of the building through its serviceable life, should satisfy the following criteria:

- Minimize the embodied energy of buildings by rationalizing the use of high energy materials like cement, steel, brick, aluminium, etc. This will minimize dependence of the buildings on non-renewable natural resources for manufacture of building materials.
- Minimize carbon emissions during operation- minimising electrical energy to maintain comfortable indoor environmental conditions by adopting passive design strategies.
- Provide adequate protection from extremities of local climate and natural disasters.

CLIMATE RESPONSIVE DESIGN

Responding to the climate is a critical requirement for LCCR buildings. 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. The pattern of energy use in buildings is strongly related to the building type and the climate zone where it is located.

HP is characterised by cold and cloudy climate. Most cold and cloudy regions are situated at high altitudes and these highland regions have abundant vegetation in summer. Relief plays a decisive part in determining temperature with a fall of 6°C for every 1000 m of altitude[14]. Keeping this in mind, the main seasons in HP are:

Summer: In March-June the temperature peaks around 35°C. There is a diurnal range of temperature of over 10ºC.

Monsoon: The heavy rains in July and August cause a lot of damage resulting in floods and landslides. The relative humidity is usually high varying between 76 to 95 per cent. The diurnal range of temperature is low.

Post-monsoon: September-October have pleasant weather with not much diurnal range of temperature.

Winter: November-February is extremely cold with the temperature 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 December to March at altitudes above 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

In the plains, climate is determined by temperatures, wind, relative humidity, solar radiation and precipitation. In the mountains, building design is more site specific because climate can vary considerably within a few kilometres. Following are some important micro-climate factors which need to be considered while designing buildings in the mountains:

- Wind - Velocity and direction of the wind varies considerably with time of day and seasons.
- Solar exposure - Direction of available solar radiation unlike the plains, where the winter sun is always from the south (in

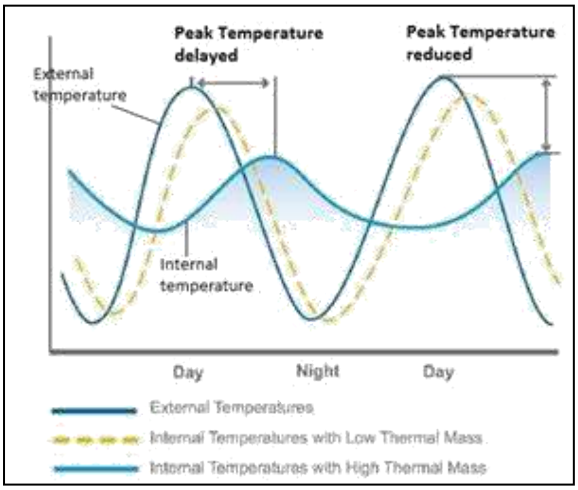
14 Solar Heating in Cold Regions- A Technical Guide to Developing Country Applications, 1996

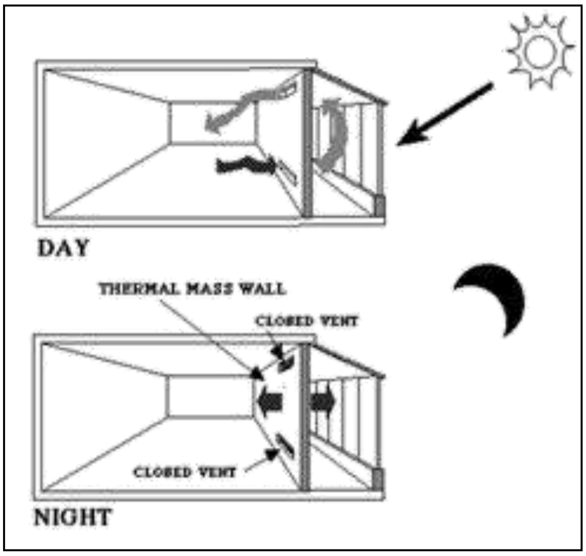
the northern hemisphere), on mountain slopes, solar radiation can get obscured by other mountains and, therefore, the direction of available sunlight may be east or west rather than south. Steep north slopes get no sunlight at all, while south slopes are ideal for solar radiation.

- Snow and rain are also important climatic parameters.

The strategy for passive solar design must be selected depending on the type of usage of the building. Day time use buildings like offices should focus on capturing solar heat and preventing its loss during the day. 24 hour use buildings like houses should consider a high thermal mass of the walls which can store heat during the day and release it into the interior during night time. The following strategies for passive design can be adopted for making buildings in HP more energy efficient and comfortable:

Figure 16: Maximising Heat Gain (top) and Buffer Space Utilization (bottom)

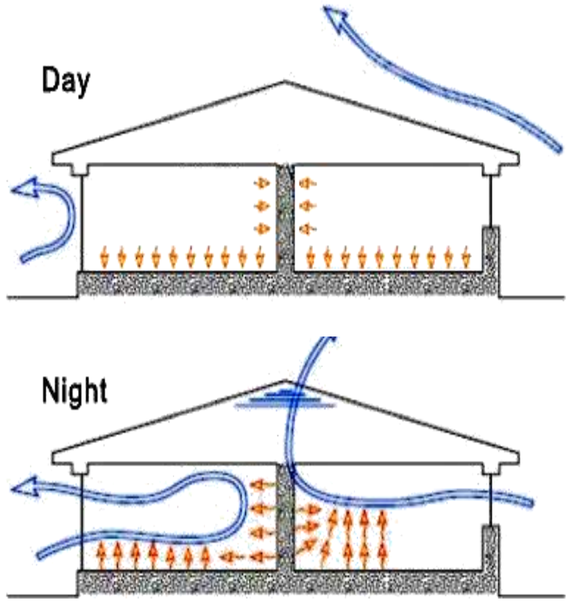




Winter

- Orienting the building for maximum solar exposure and promoting heat gain by directly admitting and trapping solar radiation within living spaces (
- Figure 16) – this can be direct gain through sun spaces/ skylight windows or indirectly through thermal mass of buildings or techniques such as trombe walls. Buffer spaces such as double facades and sunspaces can be along the sunny side of the building perimeter to increase heat gain and reduce heat loss.
- Preventing heat loss through the building – the size, location and insulating value of the glazed areas are the most important factors for preventing heat loss.

Figure 17: Night Ventilation



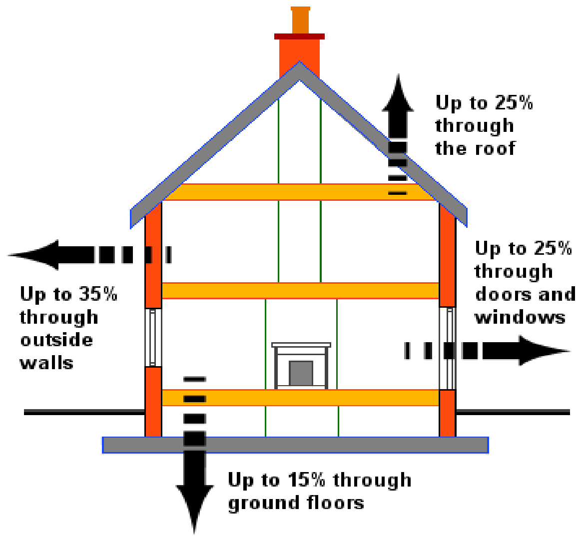
Source: http://sustainabilityworkshop.autodesk.com

Summer

- Overheating of the building interior is an important concern during the warm summers.
- The fenestration should be partly operable to flush out heat, whenever needed.
- The building must have shading features to cut down the solar gain.
- Night time ventilation (Figure 17) can be used for removal of accumulated heat loads of the day using night time winds; effective for keeping interiors cool during warm summers.

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 sq. m of its surface for each degree of temperature difference between the building interior and exterior.

Figure 18: Heat Loss from a Badly Constructed Building Envelope



Source: www.sipcrete.com

A building envelope of low U-Value is a must to reduce space conditioning loads in cold climates where mechanical heating is needed. The Energy Conservation Building Code of India specifies that 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.[15] These U-Values can be achieved through various combinations of materials for wall/ roof and insulation (Figure 18). Insulating the building envelope helps in ensuring low U-Values. Location of the insulation and optimum thickness are also important.

Rain sheltering: The building envelope, if made with water proof materials with optimum rainwater run-off provisions, can withstand heavy spells of rain. Optimum roof and fenestration design, material selection and proper drainage are crucial for good rain-sheltering. In HP, natural contours of hilly sites can also be used for drainage of rainwater.

Figure 18 demonstrates recommended passive strategies for Kullu district in HP.

15 Energy Conservation Building Code- User Guide, 2009, Bureau of Energy Efficiency.

Earthquake Resistance

Most of HP falls in Zones IV and V of the seismic map of India. Therefore, design for earthquake safety in this region becomes an integral part of any construction activity. Buildings suffer damage during an earthquake primarily because horizontal forces are exerted on a structure that is often meant to contend only with vertical stresses. The seismic design measures depend on the severity of risk, the soil type, number of storeys and storey height and also the importance of the building. Based on extensive study of earthquakes, there are clearly defined design guidelines for earthquake resistance for various types of buildings - masonry, timber, earthen - which are available for reference to building professionals.

The principal factors that influence damage to buildings and other built structures are listed below.

- **Building Configuration:** An important feature is regularity and symmetry in the overall shape of a building.
- **Opening Size:** In general, openings in walls of a building tend to weaken the walls and the fewer the openings lesser the damage suffered during an earthquake. In the mountains, where openings are critical for solar access, they should be sufficiently strengthened and well-tied with the building structure (Figure 20).
- **Ductility:** 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 (Figure 21). The addition of steel reinforcement adds ductility to brittle materials.

Figure 19: Seasonal Passive Strategies for Kullu, HP

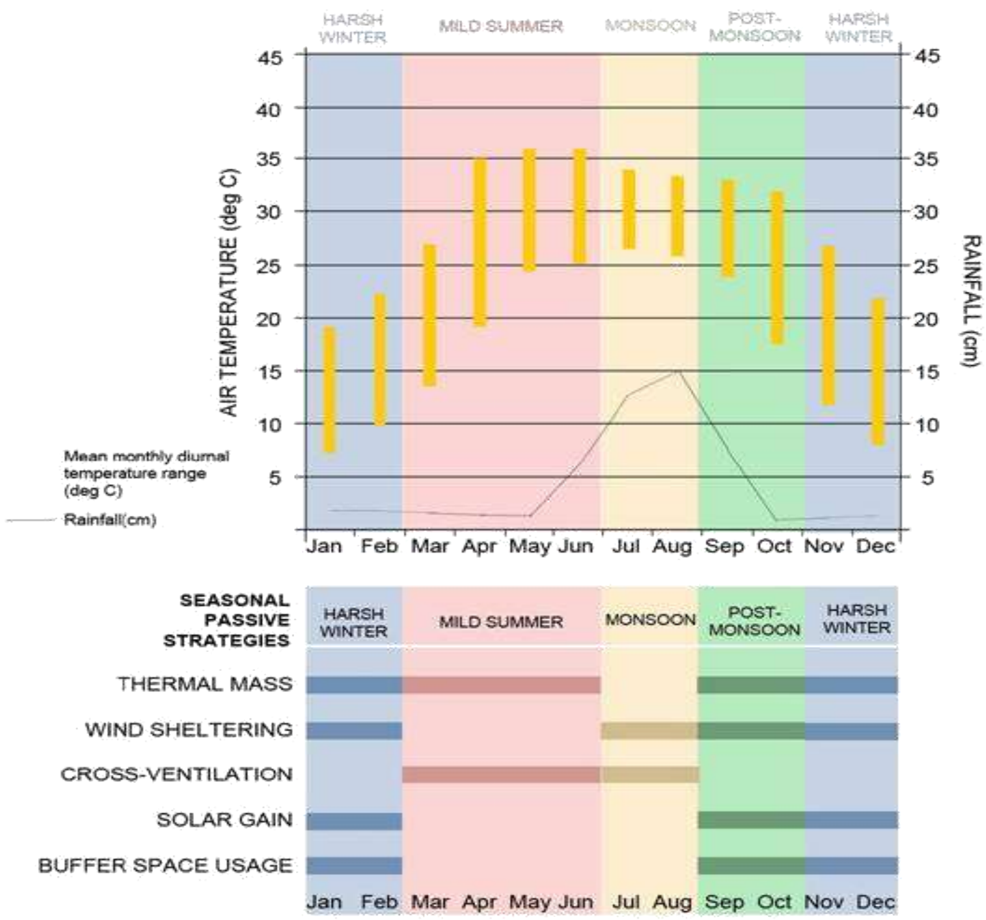
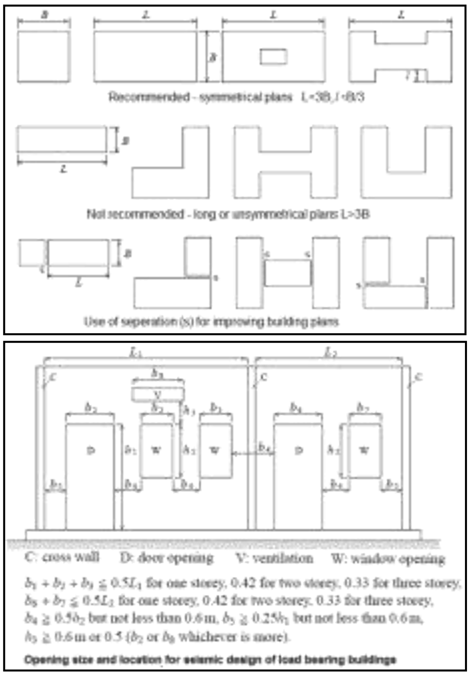


Figure 20: Guidelines for Plan Forms (top) and Openings (bottom)

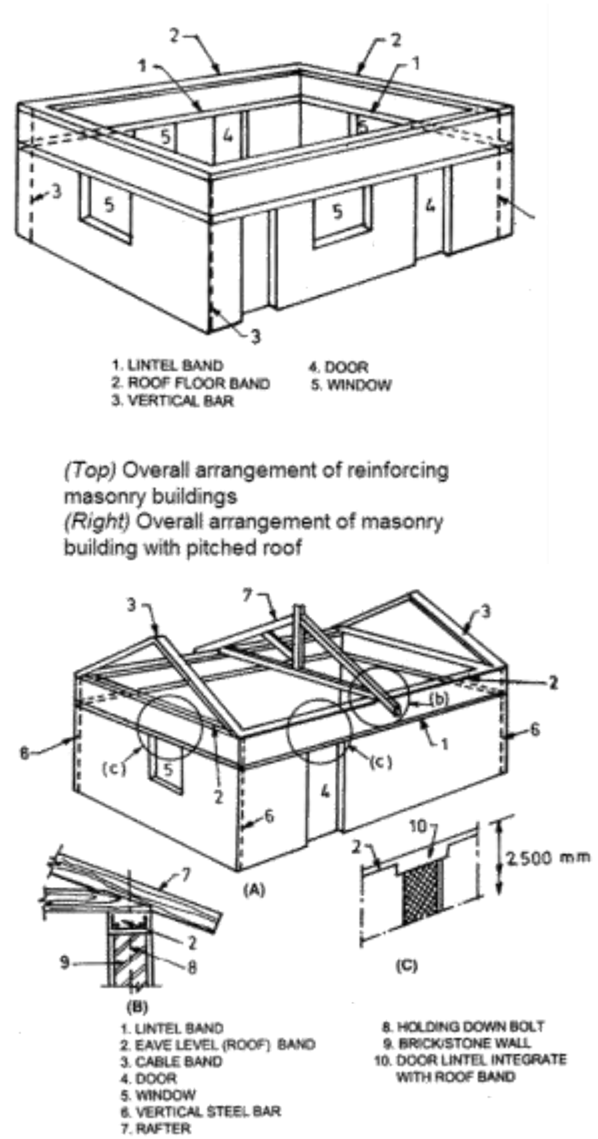


Source: National Building Code of India

The most important horizontal reinforcing is through bands provided continuously through all load bearing longitudinal and transverse walls at plinth, lintel, and roof eave levels, as well as at top of gables by providing horizontal bands. The bands can also be provided in both, reinforced cement concrete and timber (including bamboo splits). Vertical reinforcement must be provided in jambs, corners of walls and at all shear wall junctions.

Particularly, in case of rural non-engineered buildings built with local materials and in load bearing masonry, it is critical to ensure that commonly used materials like stone and bricks are suitably reinforced to increase their resistance to earthquakes. In load bearing wall construction, the wall thickness should not be less than 190 mm, wall height not more than 20 times the wall thickness and wall length between cross-walls not more than 40 times the wall thickness. Unreinforced earth and masonry have no reliable strength in tension, and are brittle in compression. Generally, they must be suitably reinforced by steel or wood. Mortar mix “cement: sand” equal to “1 : 6” by volume or equivalent in strength should be minimum.

Figure 21: Tying Together the Structure to Resist Lateral Loads



Source: National Building Code of India

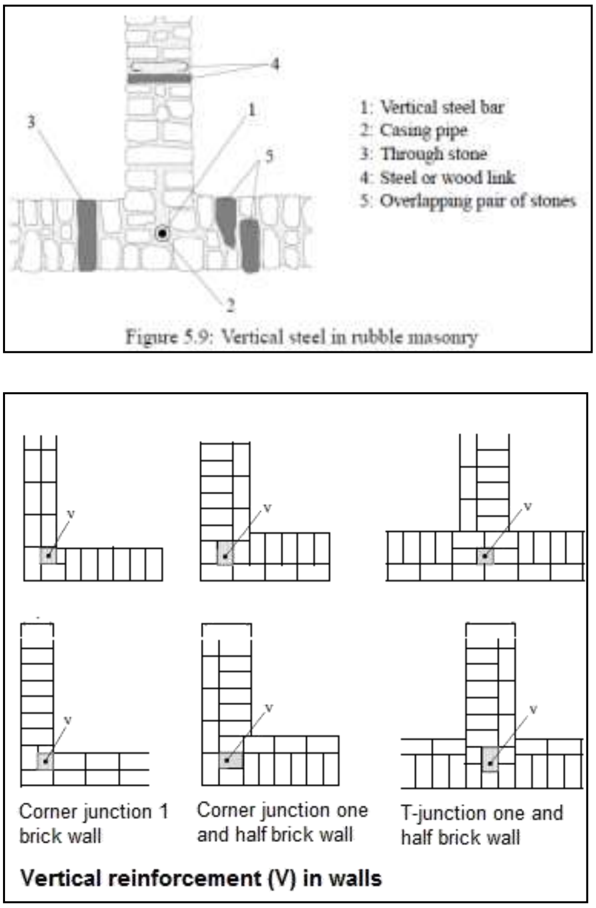
Wood has a high strength per unit weight and is extremely suitable for earthquake resistant construction. The wood used should be seasoned and dry, with its moisture content less than 20 per cent. Stud wall construction and brick-nogged timber frame can be adequately strengthened for seismic safety (Figure 23). Dressed stone masonry in stretcher bond can also be used.

Roof tiles frequently slide off during earthquakes if they are not adequately fastened to the roof under-structure. Failure of the connection between columns and beams and the bottom chords of roof trusses are common occurrences due to earthquakes.

Design Guidelines for LCCR Construction

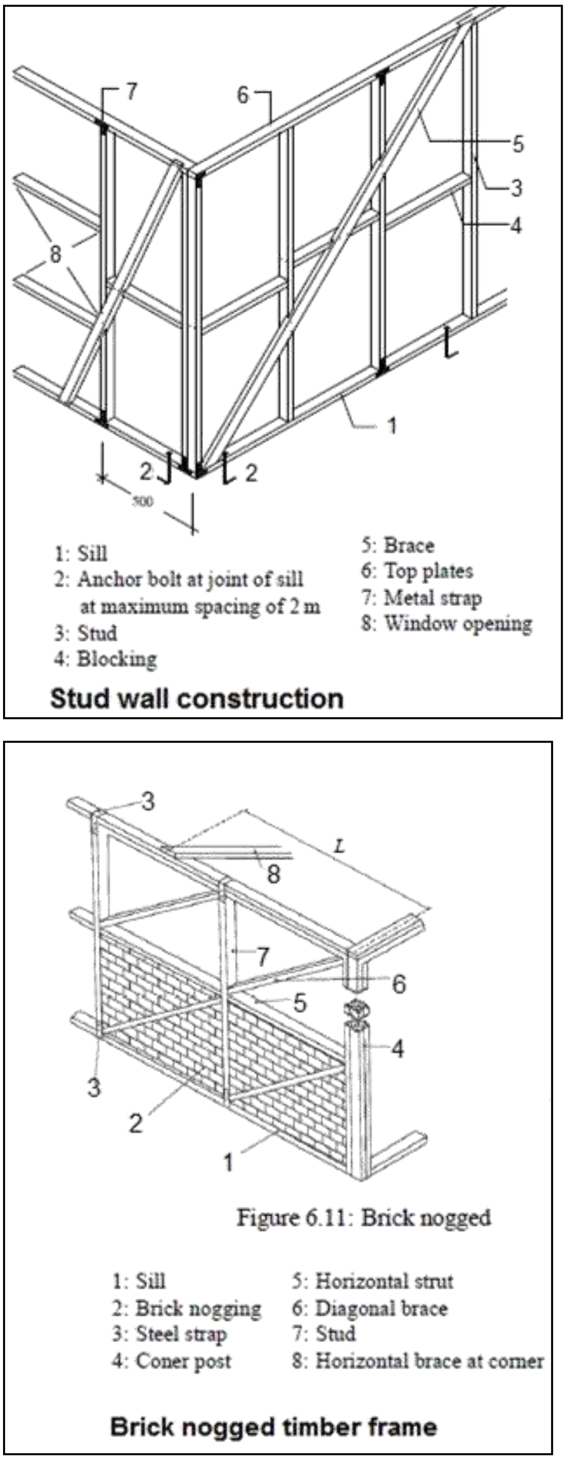
Location: The natural topography and vegetation of the land should be used as protection from cold winds. Location of the building should take into account the slopes and their stability, susceptibility to landslides and the stability of foundations in water saturated soils near rivers. The building should maintain a minimum distance of 4 feet from the slope and provide a retaining wall if necessary. Terracing and levelling the land is important in these situations.

Figure 22: Bracing of Rubble (top) and Brick (bottom) Masonry



Source: National Building Code of India

Figure 23: Cross Bracing of Infill Walls in Timber



Source: National Building Code of India

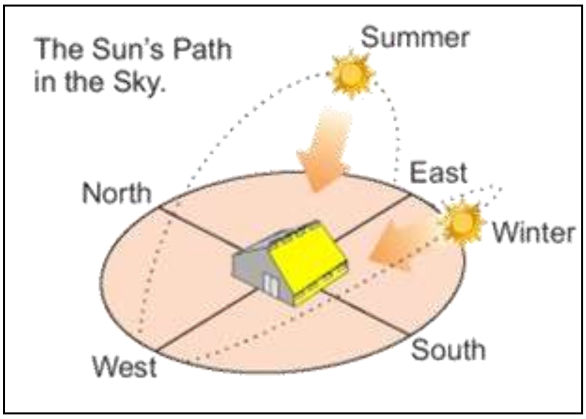
Adaptive Reuse: Along with brownfield reclamation, adaptive reuse is a key factor in reduction of urban sprawl and indirectly helps to reduce the CO_2 emission. Many old and deserted buildings can be restored and underused infrastructure can be put to proper use. One of the main benefits of reusing buildings is the significant lowering of embodied energy and environmental impact of the building.

Size of Spaces: Particularly in public office buildings, there is a great potential to rationalize the size of working areas which directly controls the amount of heating energy needed and also impacts the effectiveness of passive design measures.

Building Shape: Closer and compact built form is more optimum because it reduces exposed surface area and volume therefore minimizing heating/cooling needs and reduces amount of building materials needed. Regular shapes like square, rectangular and circular resist an earthquake more effectively as compared to irregular shapes.

Orientation: Solar access should be considered to decide orientation. Predominant wind direction is also an important factor (Figure 24). The response to these two factors is usually very site specific in buildings in hilly regions.

Figure 24: Sun Path for Southern Hemisphere (top)



Wall Design: The main design criteria are the thermal mass of walls and their insulating value. For earthquake resistance, the walls should be adequately strengthened and joined with other parts of the structure.

Fenestration Design: Maximum operable window openings must be provided on the south facades, some on the west and minimal openings to the north. Opening size is based on daylight and ventilation requirements of specific spaces inside. Adjustable shading devices like horizontal overhangs (sunshades), vertical fins, louvers, operable blinds, and screens should be used to prevent overheating during summer months. These need to be combined with night shutter systems to prevent heat loss at night during winter. The framing of openings has a big influence on infiltration through the openings, resulting in heat loss from inside the building in cold winter months.

External Finishes: Dark coloured and absorptive materials are recommended as they absorb surface radiation and therefore increase heat collection and transfer (Figure 25). Natural Bark Singles (NBS) have been used on a large scale in other mountainous regions and are a good alternative for a weather resistant external finish with no environmental impact of chemicals/ preservatives in the product.

Semi-outdoor Spaces: Sunspaces, solariums or greenhouses should be used as heat trapping buffer spaces oriented towards the south. Stored heat can either reach the building passively through the walls between the sunspace and the interior or be distributed by an active mechanical system.

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

Figure 25: Dark Coloured External Finishes

Chapter Summary

- The space design and the selection of materials for the envelope of the building should be according to the climatic features of the region.
- Access to solar radiation and its utilization for space heating is a basic requirement for passive design of buildings in hilly regions.
- Hilly regions, typically being seismically active, the structural design should tie the building together and ensure appropriate connections between foundations, walls and the roof for resistance to earthquakes.

Points to Ponder

- Are the walls and windows of your house appropriate for the local climate? Why or why not?
- Identify 3 ways in which the energy consumption of your house can be reduced.
- Does your house capture enough solar heat to keep the interiors comfortable during the winter? How?
- Do you think your office building and your house will be able to resist large scale damage during an earthquake in your region? Why or why not?
- Corrugated Iron Sheet is one of the most common roofing materials seen today in hilly areas. Do you think there is a better alternative to this material? If yes, what is it and why?

Notes

Chapter 6: Alternate Building Technologies for Wet & Hilly Areas

Alternate materials and technologies offer benefits in terms of the environment and economics, while maintaining efficiency and quality parameters. The technologies listed here have been chosen based on the following key parameters:

- Reduced embodied energy and fuel consumption hence reduced carbon emissions
- Reduced environmental damage through optimal resource use and waste utilization
- Better thermal efficiency and comfort
- Resistant to natural disasters
- Aligned to local production in terms of material and skill availability
- Cost efficiency

Walling Technologies

Cavity Wall Construction

Principle: A cavity wall consists of two layers of masonry, separated by a cavity of varying dimensions ranging from 50-100 mm that has better insulation properties than a regular masonry wall (Figure 26). The masonry layers may consist of solid brick, structural clay tile or concrete masonry units. They are bonded together with stainless steel or PVC masonry ties, normally positioned at 900 mm x 450 mm in a staggered fashion (2.5 ties per m^2) The isolation of the exterior and interior layers by the air space allows heat to be significantly absorbed and dissipated in the outer layer and cavity before reaching the inner layer and building interior. The cavity, ranging from 50-75 mm in width, may or may not contain insulation. It requires larger floor space – a 260 mm cavity wall which replaces a 230 mm thick wall reduces the carpet area of a typical bedroom (3.5 x 4.5 m) by 2 per cent, considering only the 2 outer walls are replaced. However, this quantum of reduction can result in significant improvement in the building envelope, particularly, if applied on the unfavourable west orientation, which will cut into the major part of radiation that falls on the building.

Figure 26: Cavity Wall with Waste Thermocol Infill

Source: Cavity wall construction in DA World headquarters in Delhi

Design: The technique is well suited for both wet and hilly and semi-arid regions where extreme heat or cold are common. Although, it may not be feasible for rural houses, it has good potential for use in public buildings, where significant savings in operational energy can be realized.

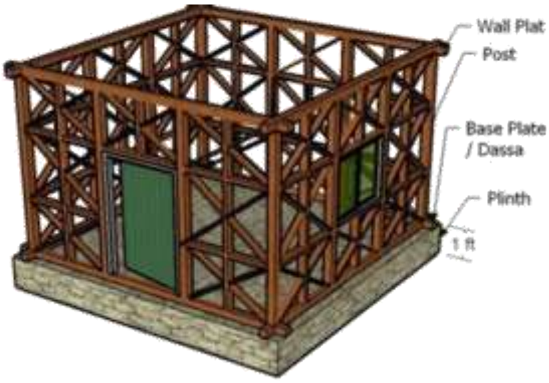
Low Carbon Climate Resilient Features

- Significantly improved thermal performance because of the cavity and hence is effective against the climate extremes. The performance of walls can further be enhanced by adding insulation.

Dhajji Wall Construction

Principle: This walling system comprises timber bracing with an infill of stone masonry that is mud plastered or left exposed (Figure 27). It is highly resistant to earthquakes and uses local materials.

Figure 27: Timber Framing (top) and Dhajji Wall Construction Technique (bottom)



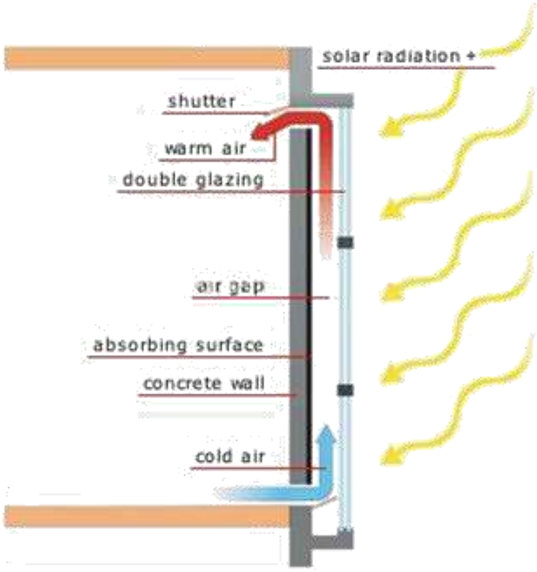
Low Carbon Climate Resilient Features

- A traditional system designed using principles of earthquake resistant design – very good potential for incorporating the design and construction principles into contemporary rural buildings.
- Low embodied energy because, in principle, the system uses only locally available materials.

Trombe Wall Construction

Principle: A Trombe Wall is a sun-facing wall separated from the outdoors by glass and an air space, which absorbs solar energy and releases it selectively towards the interior at night (Figure 28). A solid masonry wall works well – the more massive the better. It also needs to be thermally conductive so that the energy stored in one place moves uniformly across the wall for re-radiation. The exterior surface must be dark coloured whether painted or naturally pigmented.

Figure 28: Working Principle of Trombe Wall



Design: The space between the thermal mass wall and the glass should be a minimum of 4 inches. Vents used in a thermal mass wall must be closed at night. The thermal wall thickness should be about 10-14 inches for brick, 12-18 inches for concrete, 8-12 inches for adobe or other earth material and at least 6 inches for water heating systems.

Low Carbon Climate Resilient Features

- Reduces heating needs in winter, as it radiates heat, which is more penetrating and pleasant than traditional convective forced air.

Timber Reinforced Stone Masonry – Hybrid System

Principle: This construction system, also referred to as Koti Banal Architecture, consists of horizontal pairs of wooden logs connected to each other by wooden shear pins/tenons which act like a wooden frame braced by well-dressed flat stones in between the logs, thus increasing the bearing and lateral capacity of the construction (Figure 29). This hybrid system can be used to construct multi-storied buildings that are earthquake resistant.

Figure 29: Wooden Logs as Ring Beams between Layers of Stone, External Verandas Resting on Massive Columns

Source: Housing Report - Timber-reinforced Stone Masonry (Koti Banal Architecture) of Uttarakhand and HP, Northern India 2008 (Authors - Piyoosh Rautela, Girish Chandra Joshi, Yogendra Singh, Dominik Lang)

Design: Buildings using this system need to have regular plans to be earthquake resistant. Window openings need to be well framed with timber frames.

Low Carbon Climate Resilient Features

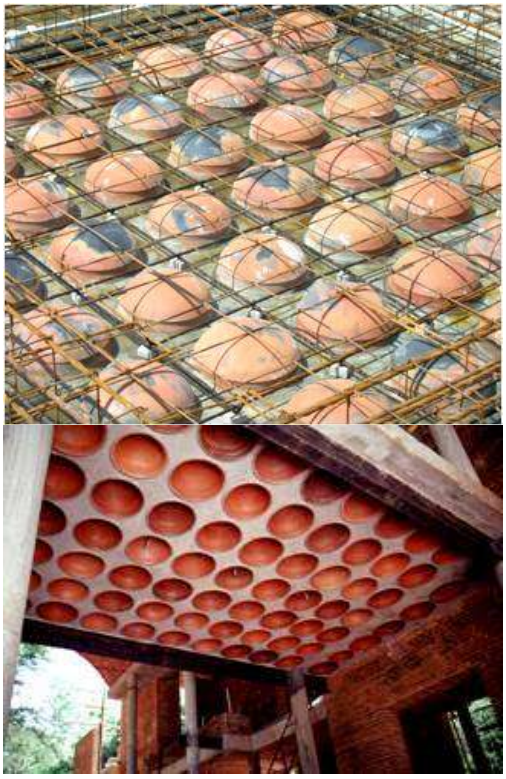
- A traditional system designed using principles of earthquake resistant design – very good potential for incorporating the design and construction principles into contemporary rural buildings and public buildings.
- Low embodied energy because, in principle, the system uses only locally available materials.

ROOF TECHNOLOGIES

Filler Slab

Principle: It is a roofing system which is based on replacing the concrete portions of a roof slab with filler materials. The material used as a replacement includes Resource Efficient Bricks (REBs), tiles, cellular concrete blocks, etc. The filler slab is based on the principle that for roofs which are simply supported, the upper part of the slab is subjected to compressive forces and the lower part of the slab experience tensile forces. Concrete is very good in withstanding compressive forces and steel bears the load due to tensile forces. Thus the lower tensile region of the slab does not need any concrete except for holding the steel reinforcements together and hence can be replaced with other lighter materials. Therefore in a conventional RCC slab lot of concrete is wasted and it needs extra reinforcement due to added load of the concrete which can otherwise be replaced by low-cost and light weight filler materials, which will reduce the dead weight as well as the cost of the slab to 25 per cent (as 40 per cent less steel is used and 30 per cent less concrete). The air gap in between the tiles makes it a good heat insulator and the ceiling looks attractive as well (Figure 30).

Figure 30: Reinforcement Details & Earthen Pot Positions: Ceiling of Earthen Pot Filler Slab (top), Auroville (bottom)



Source: http://wiki.auroville.org.in/

REBs are either perforated or hollow, have better insulation properties, and less energy and resources are consumed in their production. Ecologic Building Systems (P) Ltd. has set up a new unit in Una district of HP last year with an initial investment of Rs 40 crore with state-of-the-art fully automated German technology to manufacture concrete products. They have an installed capacity of 60,000 concrete blocks and up to 600,000 units of bricks/pavers a day.

Figure 31: Ferrocement Channel Roof (clockwise from top left) Office Building in TARA Gram, Orchcha, Manual Production of Ferrocement Channel, Cyclone Resistant Shelter House in Orissa, Office Building in Delhi

Design: This roofing technique can be used for large spans of flat roofs, domes or sloping roofs. The use of filler materials is modular and hence the span of the ceiling is determined by the size of each module. The aesthetic and acoustic properties of using various materials as fillers must be utilized.

Low Carbon Climate Resilient Features

- Consumes less concrete and steel due to reduced weight of slab by the introduction of a less heavy, low cost filler material like two layers of burnt clay tiles (slab thickness minimum 112.5 mm).
- Enhances thermal comfort inside the building due to heat-resistant qualities of filler materials and the gap between two burnt clay tiles.
- Increases saving on cost of this slab compared to the traditional slab by about 23 per cent.

Ferro Cement Channel Roofing

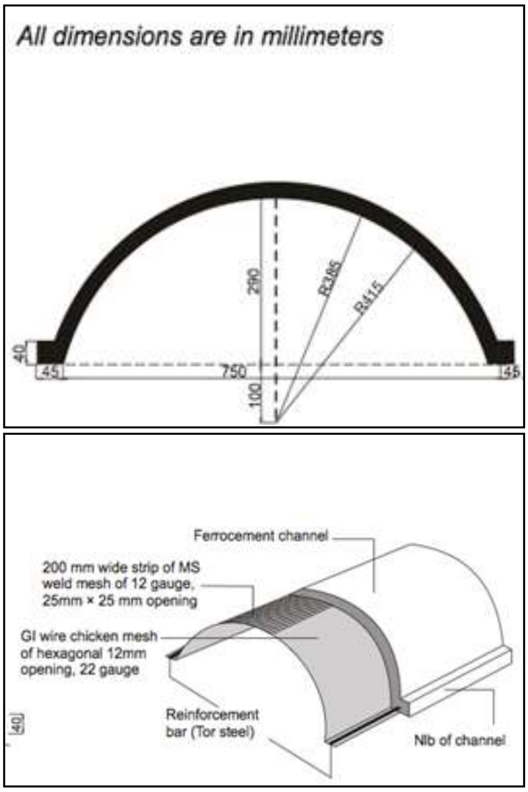
Principle: The building system uses pre-cast ferrocement roofing channels of a segmental arch profile which are placed adjacent to each other and spanning over two supports. After partly filling the valley between channels with concrete, the channels form an idealized T-beam and are able to carry the load of a roof / floor (Figure 30). Ferrocement comprises of a uniform distribution of reinforcement by use of chicken wire mesh and welded mesh encapsulated in rich cement mortar, thereby achieving significant reduction in both steel reinforcement and dead weight of roof. This composition provides a more uniform distribution of strength as compared to RCC. There can be up to 20 per cent saving in cost, because of reduction in steel quantity and elimination of coarse aggregates and shuttering.

Design: These channels can be used to cover almost all spaces. However, the space has to be designed in such a way that it conforms to the module sizes of channels (Figure 32). Also, it can have provisions for false ceiling if required.

Low Carbon Climate Resilient Features

- Low environmental degradation during extraction and production
- Utilises waste (concrete mixes with flyash, etc.)
- Low embodied energy (less use of steel)
- Pre-casting of roof leads to substantial reduction in construction time
- Low scale production

Figure 32: Section and View of the Channel



Bamboo Super Structure

Principle: Bamboo is also a traditional building resource in many parts of India. Due to its renewable property, bamboo and bamboo composites have immense potential to serve as a green building material in housing and construction. Moreover, due to its tensile property, it is also used as a tension member in many roofing systems such as bamboo truss.

Figure 33: A Bamboo Prototype House Developed by Wondergrass

Bamboo based housing technology is suitable for construction of cost effective houses in earthquake prone areas. Sustainably managed plantations and harvesting in bamboo rich regions can ensure the use of bamboo on a large scale.

Figure 34: Bamboo Flooring Tiles (top), Bamboo Truss Roofing (bottom)

Source: http://abari.org

Design: Bamboo composites are a good alternative to conventional housing components in number of areas such as non-load bearing wall fill, roof under structure, rafters and purlins. Roof covering, doors and windows shutter panels, etc. In fact some prototype building systems have been developed which comprise even foundation, columns and floor. The materials include Bamboo Mat Board, Bamboo Mat Corrugated Sheet, Treated Bamboo Post and systems such as roof trusses, wall infill panel, post and beam. Technological support from building professionals and local building artisans is required to give more prominence to bamboo in the construction industry.

Low Carbon Climate Resilient Features

- Low embodied energy because of natural material – the main energy component comes from the bamboo treatment or processing into sheets.
- Lightweight building material capable of resisting seismic forces through appropriate designed structural connections.
- Both, wet & hilly regions as well as coastal regions have good bamboo resource and are appropriate for bamboo based construction techniques.

FLOORING TECHNOLOGIES

Wooden Flooring

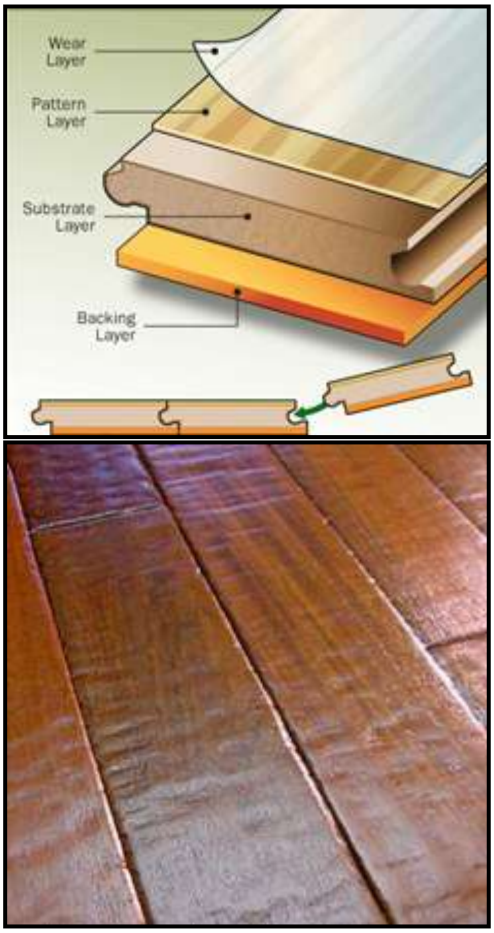
Principle: Wooden flooring is a natural and low carbon option and can be provided in various forms – 100 per cent wood or composite wood floorings which includes various reconstituted wood or other ligno-cellulose material based products, such as MDF (medium density fibre), HDF (high density fibre) with laminate or veneer. They can incorporate a large recycled content from agricultural/industrial wastes. Wood ply construction ("sandwich core") uses multiple thin piles of wood adhered together, wherein stability is attained from using thin layers of wood that have little to no reaction to changes in the immediate environment.

Also, reclaimed (salvaged) wood can be used for flooring which usually provides a more durable floor than using freshly harvested wood. This is one of the best options for low carbon construction, however, procuring of the same from other building sites is not a mainstream activity and needs to be organized such that recycling of used wooden elements can be practiced more commonly.

Low Carbon Climate Resilient Features

- Low embodied energy, especially if reclaimed wood is used.
- Thermal efficiency – wooden floors provide a thermally more comfortable flooring option than most other flooring materials.

Figure 35: Recycled Wooden Flooring (top), Wooden Panel Flooring (bottom)



SANITATION

Ecosan Toilet

Principle: Ecological sanitation, or Ecosan, is a new paradigm in sanitation that recognizes human excreta and water from households not as a waste but as resources that can be recovered, treated where necessary, and safely used again. Tailored to local needs, ecological sanitation systems, ideally, enable a complete recovery of nutrients in household wastewater and their reuse in agriculture. In this way, they help preserve soil fertility and safeguard long-term food security, whilst minimizing the consumption and pollution of water resources.

The basic principle of the Ecosan toilet is separation of faeces and urine and separate storage of the two wastes and then application of the nutrients contained in human waste as manure and fertilizer in agriculture. Typically, the toilet is built on a raised platform, about 1m high, to create storage space at the ground level for the waste. The faeces are stored and decomposed for a period of around 6 months and urine is diluted with water before use. The toilet has a special pan to separate the solid and liquid waste. The major challenge in the success of Ecosan is the social and habitual change which the user should be comfortable with during use of the toilet and later, to recycle the nutrients.

Design: Ecosan toilets need to be integrated into the building's waste and water system, site planning and landscaping.

Low Carbon Climate Resilient Features

- Promotion of recycling by safe, hygienic recovery and use of nutrients, organics, trace elements, water and energy.
- Appropriate sanitation solution for areas of high water table or soil types where leaching of waste is not feasible.

Figure 36: Ecosan Toilet on a Raised Platform with Waste Storage Below (top), Ecosan Pan for Waste Separation (bottom)

Source: Biome Environmental Solutions Pvt. Ltd

Chapter Summary

- There are alternate building technologies for these regions which can be used for different purpose.
- Alternate materials and technologies offer benefits in terms of the environment and economics, while maintaining efficiency and quality parameters.
- Each technology has specific low carbon climate resilient features which are low cost, helps in improving performance, efficiency etc.

Points to Ponder

- Identify options to construct public buildings in HP using building materials which have not been sourced from more than 100 km away – list at least two options for both wall and roof construction.
- Identity at least 2 materials that you think should be used on a bigger scale in the construction sector in HP.

Notes

Chapter 7: Policy Linkages

Policy Context

Recognizing the threat climate change poses, the Indian government announced the National Action plan on Climate Change (NAPCC). The NAPCC charts the development course of the country in an ecologically sustainable manner. The eight missions under the NAPCC outline the strategies for achieving climate change adaptation and mitigation goals for the country. Sustainable Habitats have been identified as key thrust area for these missions. In addition, the 12th Five Year plan promotes inclusive growth, for faster sustainable growth. Thus there is a growing understanding on the importance of adopting LCCR strategies.

Following the lead of the national government, many states have taken proactive steps towards incorporating these LCCR strategies. Himachal Pradesh is one of the most forward thinking states with respect to environmental concerns. The current Chief Minister of HP Prof. PK Dhumal announced that the State would be the first in the country to be carbon-neutral by 2020 by undertaking “Carbon Smart Growth”. The carbon footprint of HP is 1.4 tonnes CO_2 per capita in comparison to the national average of 1.57 tonnes CO_2 per capita. A State Centre on Climate Change was established in 2011 under the aegis of the State Council for Science Technology & Environment (HPSCSTE), Department of Environment, Science & Technology, HP so that the State's initiatives could be dovetailed with the Centre's initiatives.

HP Initiatives

In order to spur on the green growth envisaged by the Chief Minister, the State Government has initiated a community led awareness, assessment, advocacy and action programme (CLAP) in association with the DA Group. CLAP follows a multi-stakeholder participatory approach, with the goal of mobilising community responsibility for environment protection and carbon neutrality in the state through a network of Eco-Clubs, *Mahila Mandals*, Panchayats, Urban Local Bodies (ULBs) and NGOs.

In parallel, the State advocates the market-based instrument "payment for eco-system services". They are working towards obtaining carbon revenues for afforestation that will be shared with the communities conserving and maintaining these lands. The State Government has signed an agreement with The World Bank for harnessing carbon credits to generate revenue amounting to Rs. 20 crores for 20 years under "Bio-Carbon Projects” in 177 Gram Panchayats in 10 districts of the State. The Rs. 365 crore HP Mid-Himalayan Watershed Project, being co-funded by The World Bank, is the first such project in India registered for carbon credits.

In an attempt to conserve the environment and reduce emissions connected with electricity generation, the State Government is actively encouraging renewable energy sources especially solar and hydro. Almost 22 percent of the State’s electricity comes from hydro based power plants. The State Government is planning to bring out a Solar Energy Policy for speedier harnessing of this natural source to meet the ever increasing energy demand. The State Government has launched "*Atal Bijli Bachat Yojna*" to reduce energy consumption and GHG emission by distributing 4 free CFL bulbs to every household in the State.

LCCR Construction

The HPSCSTE has taken proactive steps in promoting Solar Passive design. The State recognizes that the technology has not penetrated in the field in spite of policy initiatives taken by the Government of HP and that there is a need to bridge the gap between policy, design and execution. Workshops on Solar Passive Housing Technology for both practitioners and policy makers were organized by the HPSCSTE in April 2010. As an outcome of these workshops a Green Building code will be prepared for the State.

Another significant move is to devise a Solar Passive Housing action plan as a means to promote passive design to reduce pressure on conventional heating sources like fire wood, coal and electricity. Government buildings are seen as front-runners to incorporate and demonstrate the viability of passive solar features in buildings in the region. The Government of HP and the Solar Energy Research Group of the HPSCSTE formulated a Solar House Action Plan. HP became the first State in the country to take a policy decision in the year 1994 in which all the Government and Semi-Government buildings are to be designed and constructed incorporating passive solar heating and natural day lighting features. More than 200 passive solar buildings including offices, hospitals, schools and houses were constructed under the programme which has resulted in 40-60 per cent of energy saving required for winter heating.

The State Forest Department has also recommended a separate 'Bamboo Policy' for the State, pertaining to the National Bamboo Mission. The forest area under bamboo cultivation is targeted to be densified and bamboo production is to be promoted as a lucrative business for farmers. With the ban on timber, bamboo is a good alternative material for construction.

The State Water Policy for HP[16] lays stress on Rain Water Harvesting. It says that 'All commercial and institutional buildings, tourist and industrial complexes, hotels, etc., existing or coming up and having a plinth area of more than 1000 sq m will have rain water storage facilities commensurate with the size of roof area'[17].

Other initiatives include a ban on plastics, the emphasis on energy efficiency, local technologies for green buildings and the need to look for alternative models for mobility so that cities do not first pollute and get congested before cleaning up.

16 HP Irrigation and Public Health Department

17 No Objection Certificates required under different statutes will not be issued to the owners of the buildings unless they produce satisfactory proof of compliance of the new law. Toilet flush systems will have to be connected with the rainwater storage tank. It has been recommended that the buildings will have rain water storage facility commensurate with the size of roof in the open and set back area of the plot at the rate of 0.24 cft. per sq. m. of the roof area.

Chapter Summary

- There is National Action Plan for Climate Change which was started in India, under which Himachal Pradesh is one of the most forward thinking states with respect to environmental concerns.
- A State Centre on Climate Change was established in 2011 so that the State's initiatives to have Carbon Smart Growth can be achieved.
- Sustainable habitat is given importance and there is a growing understanding on the importance of adopting LCCR strategies.
- In HP, state government is actively encouraging renewable energy sources especially solar and hydro.
- The HPSCSTE has taken proactive steps in promoting Solar Passive design.
- Another significant move is to devise a Solar Passive Housing action plan as a means to promote passive design to reduce pressure on conventional heating sources like fire wood, coal and electricity.
- Other initiatives include a ban on plastics, the emphasis on energy efficiency, local technologies for green buildings and the need to look for alternative models for mobility so that cities do not first pollute and get congested before cleaning up.

Points to Ponder

- Identify the policies and programs that help bring about a change in your practice.
- What support would you require from the Government in order to incorporate LCCR strategies in your design?

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KNOWLEDGE PARTNER:

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