BACKGROUND READING MATERIAL FOR BUILDING PROFESSIONALS

SEMI-ARID SPACES

DESIGN FOR LCCR CONSTRUCTION

ABOUT THE MANUAL

This manual specifically looks at LCCR construction for semi arid climate for building professionals. The state of Madhya Pradesh acts as a model for similar semi arid 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.

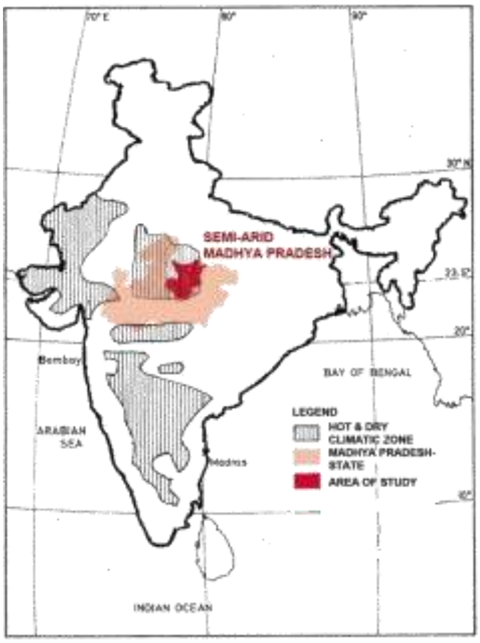
It aims to create an enabling environment focusing on three key factors:

- 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: Hot and Dry 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 (refer 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.

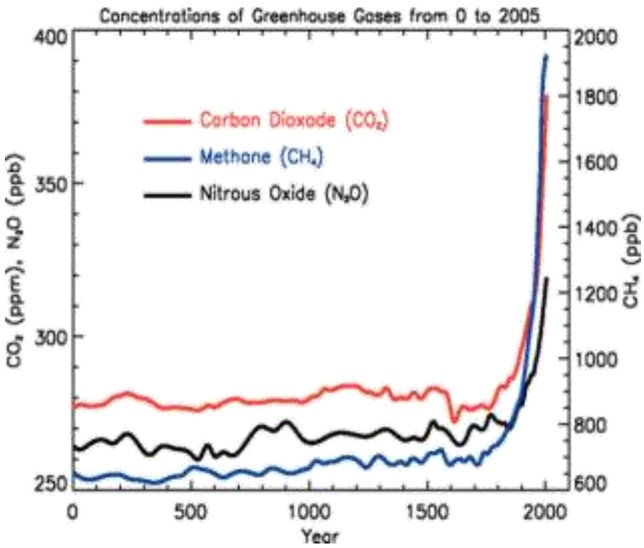
At a Global Level

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, where a large proportion of the population is more strongly connected with natural resources, are more vulnerable to impacts of climate change.

In South Asia

As is evident in Figure 3, 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.

Figure 2: GHG Concentrations during the last 2000 years

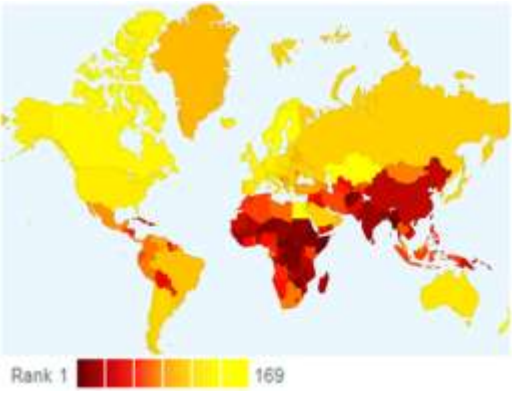


Source: IPCC's Fourth Assessment Report Impacts of Climate Change

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 MP

- In 2007, Madhya Pradesh recorded 15, 33,665 ha of degraded land.[3]
- Record water fluctuation from decadal average – May 1999-2005 to 2006 - with a 2m fall in water levels observed in entire regional area of the State.[4]
- July rainfall is found to be significantly decreasing in last 100 years in eastern Madhya Pradesh.[5]
- In 2009, Madhya Pradesh Government declared 37 out of total 50 districts as drought-hit in what was said to be the "worst drought of the century". [6]

PREDICTED IMPACTS

The major impacts of climate change in Madhya Pradesh are higher maximum temperature, shifts in rainfall pattern, leading to acute shortage of water resources, drought, increased risk of forest fire, degraded soil cover, increased runoff in some river basins and water logging. These may have direct or indirect implications on building industry in terms of availability of water, increased damage to building foundation due to ground shrinkage, scarceness and steep cost rise of building materials and construction etc.[7]

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3 Land Degradation Mapping, Soil and Land use survey of India,2007, Dept of Agriculture and Co-operation, Ministry of Agriculture, Govt. of India
4 http://cgwb.gov.in/ncr/GWmonitoring.htm, Central Ground Water Board, Ministry of Water Resources, Govt of India.
5 2005, P. Guha Thakurta and M. Rajeevan, Trends in rainfall pattern over India, National Climate Center, India Meteorological Department, Pune
6 www.zeenews.com, August 2009.
7 Madhya Pradesh State Action Plan on Climate Change, 2011.

Factors Contributing to Climate Change

Extensive exploitation of natural resources, such as destroying forest cover, top soil erosion and disturbing the groundwater hydrology, inevitably affects an area's ecological balance. While factors such as deforestation remove natural carbon sinks, extensive quarrying has been known to alter natural geographical buffers to climatic extremes – all these in turn aggravate climate change. This is true also of semi-arid Madhya Pradesh where extensive deforestation (refer Figure 5), depletion of water resources and uncontrolled mining and industrial activities has been carrying on unrestricted for years. Many of these activities are carried out to support the needs of the construction activities within the state.

Figure 5 : MP has a large proportion of wastelands because of extensive deforestation over the last 50 years

Chapter Summary

- Human activity alters the composition of 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.
- Semi-arid regions like Madhya Pradesh are experiencing extensive deforestation, depletion of water resources and uncontrolled mining and industrial activities unrestricted for years.

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[8]. 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[9]. It has been steadily contributing about 8 per cent to the national GDP[10] over the last 5 years. The cyclic link (Figure 6) between construction and climate change can be understood in terms of adaptation and mitigation action.

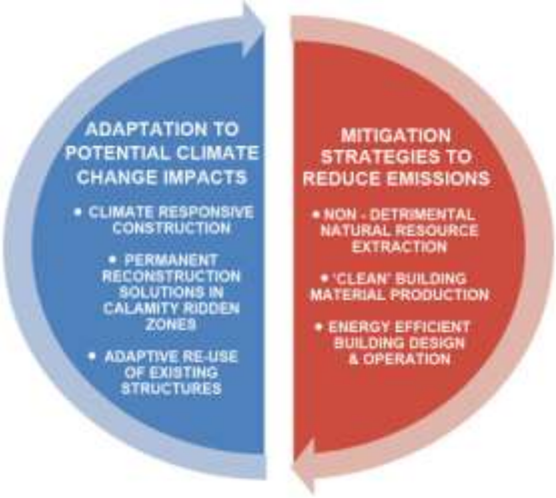
How Does Climate Change Affect Construction?

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.

The practices in the construction sector of Madhya Pradesh that aggravate climate change need to curb their impact on the local environment by, A) Reducing ecologically detrimental methods of sourcing building materials. B) Using more energy efficient construction technologies. C) Ensuring minimum amounts of energy used in the operation of buildings constructed.

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

Figure 6 : 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 CO_2 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 the state needs to respond to the increased hazard of extreme climate change due to deforestation, mining and stone crushing.

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 MP

The practices in the construction sector of MP 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 state has 5 major river systems but unfortunately, faces tremendous ecological stress primarily because they are visualized only as a source of water, leading to their depletion.

The region also has a geological disadvantage - its underlying granite layer does not allow enough groundwater recharge, which is the reason why the region is dense with surface water harvesting structures or shallow dug wells.

Deforestation, combined with neglect of traditional water harvesting systems of tanks and ponds, has distorted the water scenario. The region reeled under a severe drought from 2003 to 2008 , brought on by a serious deficit in rainfall. Most of the drinking water sources- traditional and masonry wells and hand-pumps dried up between 2003-08.

According to an inter-ministerial report, only about 7 per cent villages in Bundelkhand region have year round water availability[11]. This is in sharp contrast to the fact that till the 1980s, the traditional wells in villages ensured enough drinking water for both humans and animals even during years with light monsoons.

11 Report On Drought mitigation strategy for Bundelkhand region of Uttar Pradesh and Madhya Pradesh, Inter-Ministerial Central Team(IMCT), 2008

Forests

The natural resources in Madhya Pradesh have been severely impacted by extensive deforestation, over the last 50 years and the Forest survey of India suggests significant increase in deforestation in the last decade. There was a recorded loss of forest cover of about 12 per cent (over 3500 sq. Km of forest area) in between 2001 to 2011[12].

Minerals

Madhya Pradesh is the second richest state in mineral resources. Multi-coloured granite, flagstone and limestone are quarried and there are 35 cutting and polishing industries working in the State. The major consumer of limestone is the cement industry. Flagstone is one of the major building stones present in the state.

The extraction and processing of mineral resources is critical for the economy of the State (Figure 7) as well as a major cause of environmental degradation in the form of loss of forest cover, accelerated erosion, silting of water bodies, air and water pollution.

Figure 7: MP map showing key mineral deposits (left) and a Stone crushing unit (right)

Huge amount of work is done with a help of stone crushers in Madhya Pradesh, which not only indiscriminately quarry and destroy the resource base, but also dump the stone dust on agricultural land, thereby converting it rapidly into a wasteland. The high suspended particulate matter (SPM) around these units is also a cause of concern for health and human well-being.

12 State of Forest Report, Forest Survey of India, 2001-2011

Industrial Waste

Madhya Pradesh is the leading producer-of cement in the country. There are 7 major Cement plants in the State and the total cement production in the state amounted to 38 million tonnes during 2000-2001[13]. The setting up of 21 new cement plants is being planned[14].

There are 5 major power plants with installed capacity of around 8,000 MW and many more projects are coming up due to state government initiative in Madhya Pradesh. These plants produce tonnes of fly-ash per year as a waste material resulting in huge potential for its utilization in building materials.

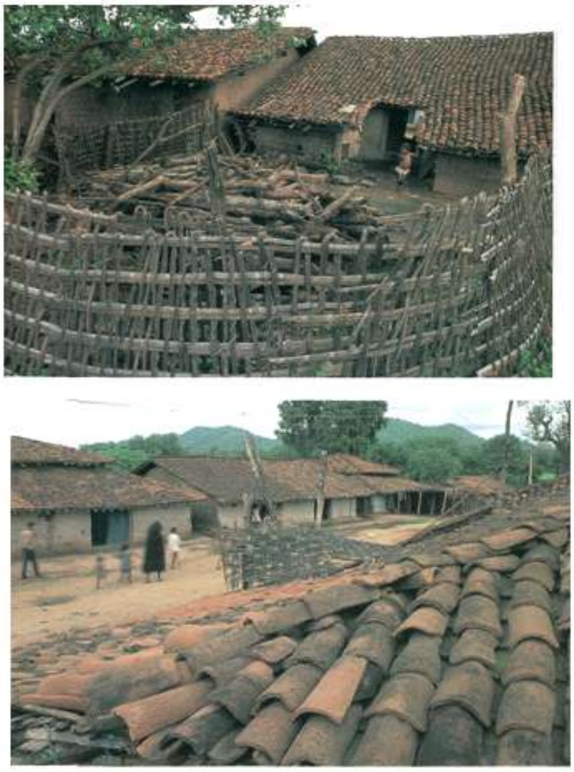
Stone crushers are a good source of stone dust which is commonly used as an alternative to coarse sand in construction activity.

Building Construction Practices

The semi-arid region of Madhya Pradesh has a rich tradition of building with stone and brick (see Figure 8). Burnt clay brick masonry and sandstone slabs are common building systems in rural areas, where locally produced clamp bricks are used which are generally of a sub-standard quality. Clamp burnt bricks and tiles placed overlapping on wooden under-structure is typically used to construct houses in least cost.

Locally fired clay tiles, of low strength and durability, known as ‘khaprail’ are used for sloping roofs. However, wherever financial resources permit, there is an increased preference for Reinforcwd Cement Concrete (RCC) roofs in rural areas, even if these roofs are less thermally comfortable and frequently suffer from poor quality control. Sandstone slabs on steel girders are another common trend for flat roofs. Random rubble masonry is the most common option for foundations because of stone being available in abundance. Water harvesting from roof-tops and surface run-off rain has largely not been adopted. Institutional buildings such as school buildings, government offices, mostly use RCC or sandstone slab roofs.

Figure 8 : Village dwellings in Palaspani, MP



Source: Traditional Buildings in India

13 Mining data, Cosmos Mining Consultancy
14 http://www.aggregateresearch.com

Chapter Summary

- The region reeled under a severe drought from 2003 to 2008 , brought on by a serious deficit in rainfall. Most of the drinking water sources-traditional and masonry wells and hand-pumps dried up and only about 7 per cent villages in Bundelkhand region have year round water availability.
- There was a recorded loss of forest cover of about 12 per cent (over 3500 sq. Km of forest area) in between 2001 to 2011 and the extraction and processing of mineral resources is a major cause of environmental degradation in the form of loss of forest cover, accelerated erosion, silting of water bodies, air and water pollution.
- The semi-arid region of Madhya Pradesh has a rich tradition of building with stone and brick.

Points to Ponder

- 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.

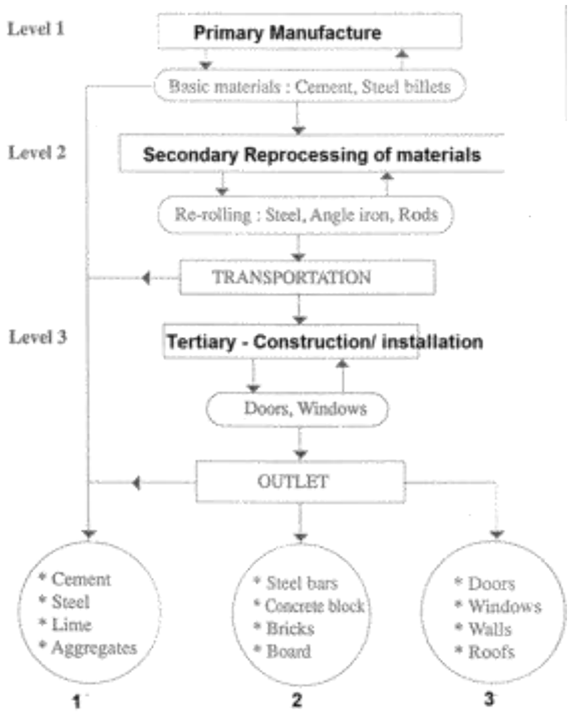
Embodied Energy

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 9).

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 9: 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 (Figure 10) 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 indispensable 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.

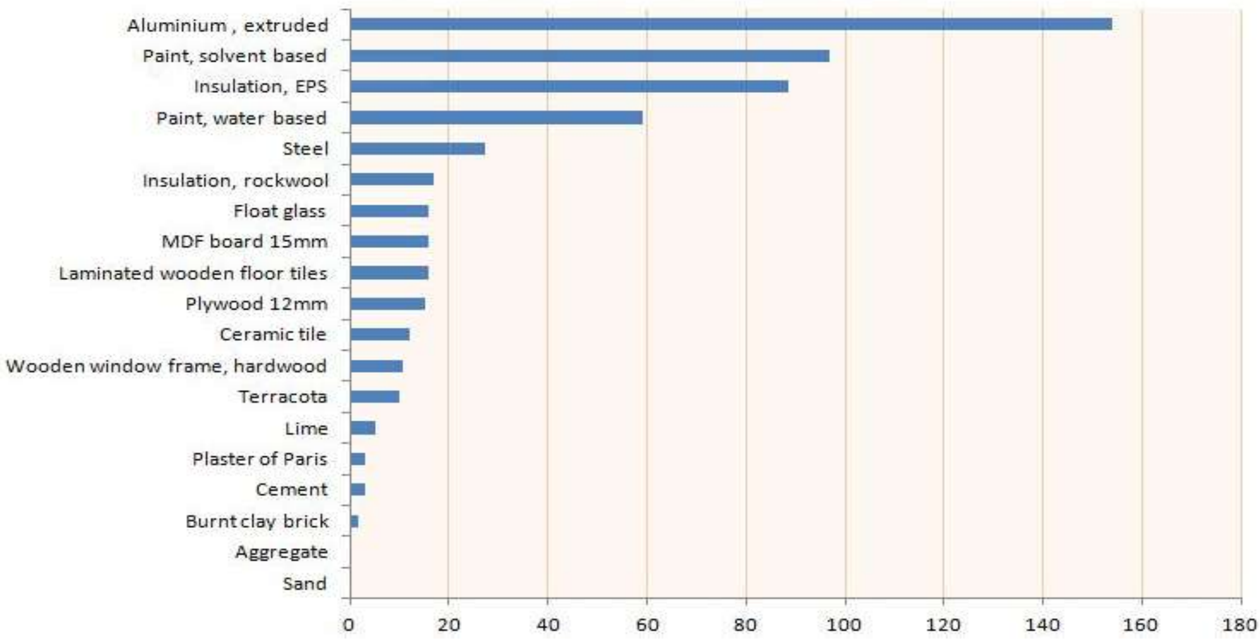


Figure 10: Primary Level Embodied Energy for Common Building Materials

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

OPERATIONAL ENERGY

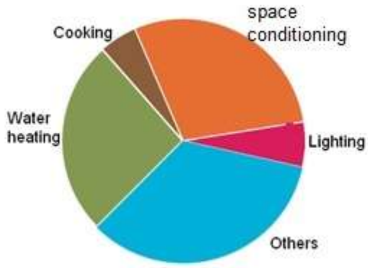
After construction, the building needs energy for its day-to-day operation such as indoor and outdoor lighting, heating, ventilation and air-conditioning (HVAC), use of appliances, water pumping and heating, elevator movement, etc. This set of energy demands is called Operational Energy. While electrical 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/m^2 per annum and 160 kWh/m2 per annum for residential (Figure 11) 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 MP.

The globally accepted way of evaluating the energy efficiency of a building is the Energy Performance Index (EPI) which is expressed in kWh/m^2 /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 11: 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 caused directly and indirectly by an individual, organization, event or product[15]. It is a measure of GHG emissions associated with an activity or a group of activities or a product. Globally, awareness about the environmental impact of our activities has increased tremendously. Carbon footprints are a tangible parameter to assess this impact in terms of mass of emissions resulting from various sectors (Figure 12) 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

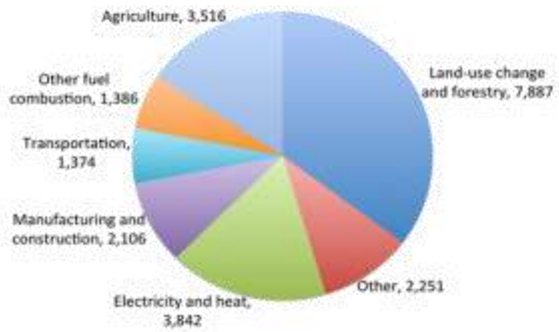
Table 1 outlines the calculation of embodied energy and CO_2 emissions for which data has been collected by the DA Group.

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

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



Source: Little Green Date Book, 2007

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 m^3
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/m^2 (147.22 fMkWh/m^2)
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 MP

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 (Figure 13) 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.

Madhya Pradesh Climate analysis: Semi-arid Madhya Pradesh has composite climate that has four distinct seasons:

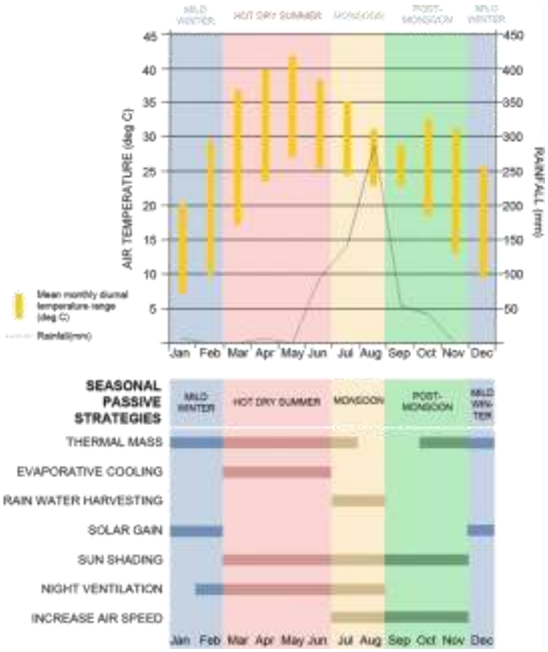
Summer: March – June are characterised by low humidity levels (20 – 25 per cent) and high solar gains resulting in high temperature peaks. There is a diurnal temperature range of over 10^{o}C, through these months with maximum daytime temperatures of 32^{o} – 45^{o}C, and night time values of 27^{o} to 32^{o}C. The intensity of solar radiation is very high in summer with diffuse radiation amounting to a small fraction of the total. The region receives winds that are hot and dusty in summer.

Monsoon: July – August are characterised by rainfall and hence high humidity levels. The diurnal temperature range is less than 10^{o}C. Temperatures remain below 35^{o}C and high humidity ranges between 55 - 95 per cent.

Post monsoon: September-November are characterised by moderate temperature and humidity. Diurnal range temperature is around 10^{o}C.

Winter: December–February are characterised by lower temperatures and low humidity but have a diurnal range of temperature above 10^{o}C. In winter, the values are between 10^{o} to 25^{o}C during the day and 3^{o} -10^{o}C at night.

Figure 13 : Seasonal Passive Strategies for semi-arid MP



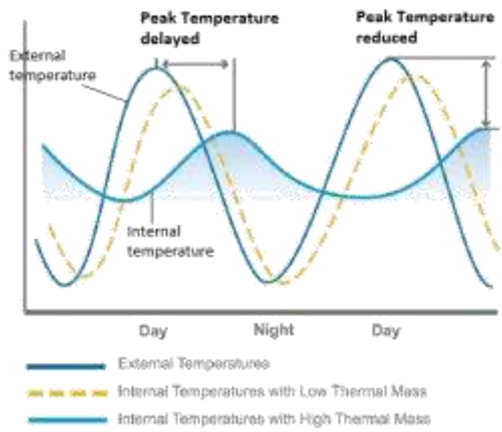
Seasonal Passive Strategies

Passive design implies that space design and material choice for building construction is guided by the primary motive of thermal comfort of the inhabitants through natural means. The focus of passive design in the context of semi-arid climate of Madhya Pradesh should be on the hot dry summer and the cold winter.

During the summer season, the building must minimise its heat gain and employ passive cooling techniques. During the monsoon months the building needs to have increased ventilation and effective rain sheltering. During the winters, the building envelope must capture daytime sun to maintain comfortable conditions in the colder evening. Some design strategies that are specifically useful here are :

Use of high thermal mass: Building materials of high thermal mass have the capacity to store thermal energy for extended periods and release the stored heat after a time lag. Hence, thermal mass can be used effectively to absorb daytime heat gains (reducing cooling load) and release the heat during the night (reducing heat load).

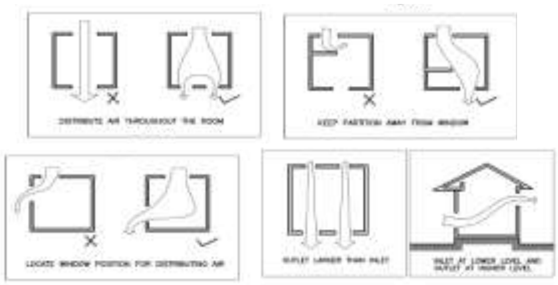
Figure 14 : Effect of High Thermal Mass on Temperature



Using thermal mass to moderate temperature fluctuations is effective only when the diurnal range of temperature is over 10^{o}C. In the case of semi arid Madhya Pradesh it can, hence, be effectively employed during the summer, post monsoon and winter seasons (see Figure 14).

Cross ventilation: All doors and windows are preferably kept open for maximum ventilation for during the monsoon season. These must be provided with shutters, blinds or louvers to shelter the rooms from the sun, as well as for the control of air movement. Openings of a comparatively smaller size can be placed on the windward side, while the corresponding openings on the leeward side may be bigger for facilitating a plume effect for natural ventilation. Outlets at higher levels serve to vent hot air (see Figure 15).

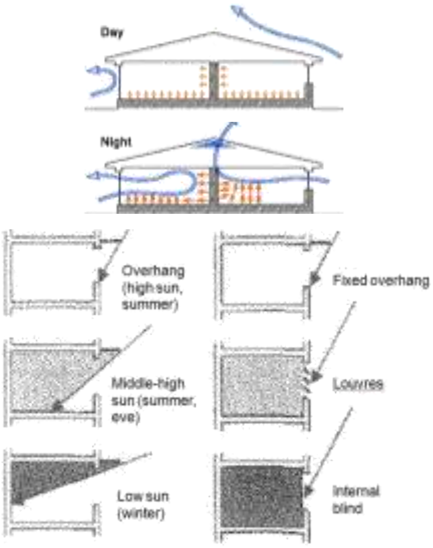
Figure 15 : Wall opening placement and size to allow cross ventilation



Source: Handbook on Energy Conscious Buildings, Nayak and Prajapati, 2006

Night ventilation: Night time ventilation during the warmer seasons in places of high diurnal range of temperature and good prevailing winds is an effective cooling strategy. Night time winds are used for removal of accumulated heat loads of the day through a variety of cross-ventilation schemes that rely on wind-induced flow through windows, stack effect, and/or mechanical ventilation (see Figure 16).

Figure 16 : Night ventilation (Top) and Shading strategies (Bottom)



This strategy could be used mainly for cooling during the hot dry summer season. Also being a coastal region, night-time sea breezes can be used for cross ventilation and naturally cooling the building interior and dissipating any heat gained by the building envelope during the day.

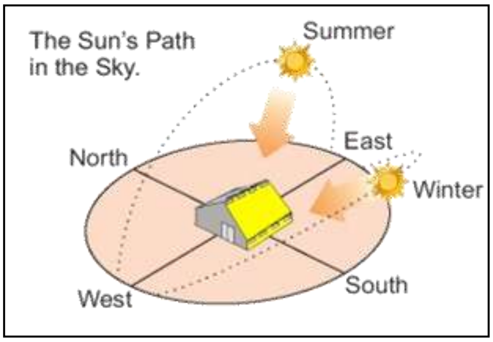
Shading: Cutting down solar radiation during the day time with shading devices is a very effective passive strategy for hot climates, and often, the most simple and cost effective. The shading strategy should be based on the degree and angle of incident solar radiation (see Figure 16). Combined with optimum orientation of the building and sizing of windows, shading devices can very effectively prevent over-heating in the building interior. This can be achieved by various means – horizontal overhangs (sunshades), vertical fins, louvers, operable blinds, screens, etc. The justification for shading devices increases when they are provided for unfavourable orientation such as the west, where it is difficult to block sun till late in the afternoon in summer season.

DESIGN GUIDELINES FOR LCCR CONSTRUCTION

Location and Cluster Design: The natural topography and vegetation of the land should be used to shield the building from solar radiation and heat waves. The building cluster can have many forms which provide mutual shading and help air movement.

Building Shape: Closer and compact built form is more optimum because it reduces volume therefore minimizing heating/cooling needs, reduces amount of building materials needed and is better protected from wind and solar gain. The traditional courtyard morphology in design can be adopted in order to avoid the exposure to sun and store cooler wind, it also assist air exchange during night time.

Figure 17 : Sun Path Diagram for Southern Hemisphere



The schematic plan of Jaisalmer (see Figure 18) shows that the overall built form has many shared walls and therefore has low solar exposure; the building mass is broken up by courtyards and the overall building surface has many articulation of the building surface itself. In University Hostel, Jodhpur (see Figure 19), the building shows the close and compact built form and window orientation to avoid glare.

Orientation: Maximize north and south façade exposure for daylight. Reduce east and west facade exposure, as these are difficult to shade. Internally, the spaces that need direct solar gain during the winter are oriented towards the south. These can be shaded well during the summer (Figure 17).

Figure 18 : Schematic plan of Jaisalmer town

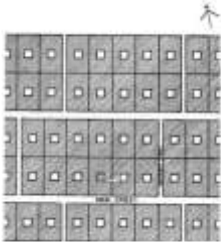


Figure 19 : University Hostel, Jodhpur

Roof Design: Flat roofs are ideal in this region as heavy rainfall is not a major concern. A reflective and insulated roof accounts for less transmittance of heat.

Wall Design: Hollow or cavity wall construction: it reduces transfer of heat from building envelope to indoor areas. Thicker and heavy construction materials of high thermal mass are also recommended (as in Figure 20)

Fenestration Design: Operable window opening must be provided on the north and south facades with minimal openings to the east and west. Opening size is based on daylighting and ventilation requirements on specific spaces inside (Figure 21). Kitchens and living room need maximum daylight. Kitchens and bathrooms need maximum ventilation. Horizontal overhangs (sunshades), vertical fins, louvers, operable blinds, and screens should be used to control and filter daylight and reduce indoor glare.

Figure 20 : Cavity wall having infill of thermally inert material (left) fenestration design guidelines (right)

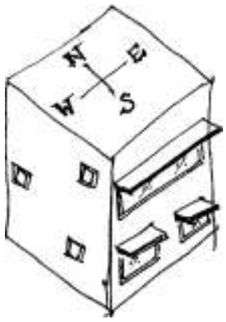


Figure 21 : A composite shading device consists of vertical and horizontal shading elements.

Source: A. B. Lall Architects; Best Renewable Energy Development Agency (WBREDA).

Wind-catchers: They can be used in a variety of sizes to suit specific breezes which provide effective convective cooling. A typical cross section (in Figure 23) through a wind catcher serving main summer rooms of a house in Iran, (A-Living, B-Basement and C-Courtyard).

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 winter.

Figure 22 : Seasonal use of Deciduous Trees

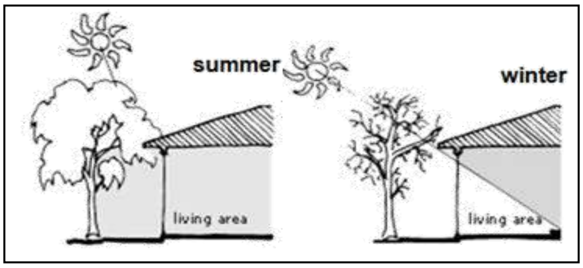
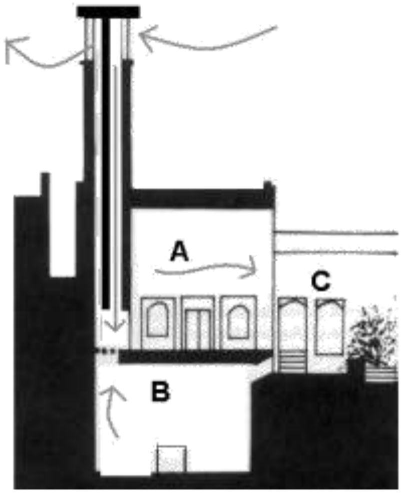


Figure 23: Cross section through a wind catcher



Source: Badgir, Encyclopaedia Iranica, Dec 1988, Roaf S.

External Finishes: Light colored and reflective materials are recommended as they reflect surface radiation and therefore reduce heat collection and transfer.

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 cross ventilation and its utilization for space cooling is a basic requirement for passive cooling design of buildings in hot and arid regions.
- Arid regions, typically being dry and barren can be suitability landscaped.

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 air to keep the interiors comfortable during the summer? 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?

Notes

Chapter 6: Alternate Building Technologies for Hot and Dry 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

Stabilized Compressed Earth Blocks (including interlocking blocks)

Principle: Stabilized Compressed earth blocks/compressed stabilized earth block called CSEB is environmentally sound method of building blocks. (CEBs/CSEBs) are mechanically compressed block of local soil. The soil is mixed with a binding material such as cement, lime, rice husks or straw. The blocks are produced by compaction through machine. Before using these blocks in any structure they need to be tested for various parameters like strength, resistance to weathering etc. In warm regions with very little timber available to fuel a kiln, these blocks are generally sun dried. These blocks are produced by small infrastructure, which contains space for raw material and product procurement, a pressing machine and manpower to operate.

Figure 24 : Stabilized Compressed Earth Blocks – Projects. (Clockwise from top left) – Multi-storeyed apartments in Auroville, Tamil Nadu, CEB block types, Residential building by IISc. Bangalore, Zero energy residential development in Bangalore by BCIL

Low carbon climate resilient features:

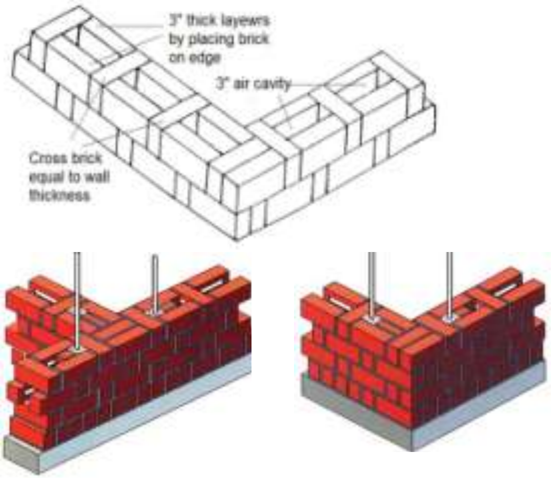
Low Carbon Climate Resilient Features
▪ Lower embodied energy material due to minimal use of high energy material and non-requirement of burning. ▪ Low environmental impact as there is no burning involved. ▪ Thermally efficient nature imparted by soil which is a main constituent.

Design: It can be used in the construction of various structures like wall masonry with arched openings, jack arches and domes for roofing. The component made of these blocks needs protection from water and tensile forces; hence walls made of these blocks should have appropriate overhangs from chajja or roof.

Rat-trap Bond

Principle: Rat-trap bond is a masonry technique in which the bricks are laid in such a manner that a discontinuous cavity is formed between two faces of the wall. Typically, a 75mm cavity is formed in a 230mm thick wall. This is done by placing the bricks on edge in a modular fashion (as shown). The technique needs good quality bricks with neat and straight edges and has been practiced in housing on a large scale in Kerala for over two decades.

Figure 25 : Rat-trap bond brickwork with burnt clay bricks and Structural strengthening of brickwork in Rat-Trap bond.



Source – UNDP Reference manual

Low carbon climate resilient features:

Low Carbon Climate Resilient Features
▪ This technique reduces the number of bricks by at least 20 per cent. and saves at least 30 per cent mortar. It reduces the overall cost of wall by at least 25 per cent.
▪ It improves the insulating capacity of brickwork and this property can be further enhanced by incorporating low-cost insulation such as waste thermocol in the cavity.
▪ On account of its lesser use of materials, it results in nearly 30 per cent less emissions from brickwork as compared to a conventional English bond brick wall.
▪ This technique is well suited to structural strengthening by reinforcing parts of masonry such as wall corners and T-junctions. This improves the brickwork's capacity to withstand forces of water surge during floods. The technique has been proposed by UNDP as a disaster resistant practice for post-Tsunami housing.

Figure 26 : Cyclone resistant community building in Rat-trap bond by Orissa Development Technocrat's Forum, Right – House in Kerala in Rat-trap bond

Design: This technique can be used construction of upto double storeyed load bearing masonry, wherever burnt clay brickwork is used. As infill walls, rat-trap bond walls can be used in multi-storeyed buildings. This has been certified by Anna University. It is very well suited to exposed brickwork because of its neat appearance. Ideally, the bricks used in this technique should have minimum compressive strength of 50 kg/cm^2 with neat and straight edges. There is a very rich vocabulary of residential architecture and community buildings in rat-trap bond in Kerala which have performed very well for over 30 years.

Cavity Wall

Principle: A cavity wall consists of two layers of masonry, separated by a cavity of varying dimensions ranging from 50 mm to 100 mm. 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 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 cavity, ranging from 50 mm to 75 mm in width, may or may not contain insulation.

Figure 27: Cavity wall with waste thermocol infill

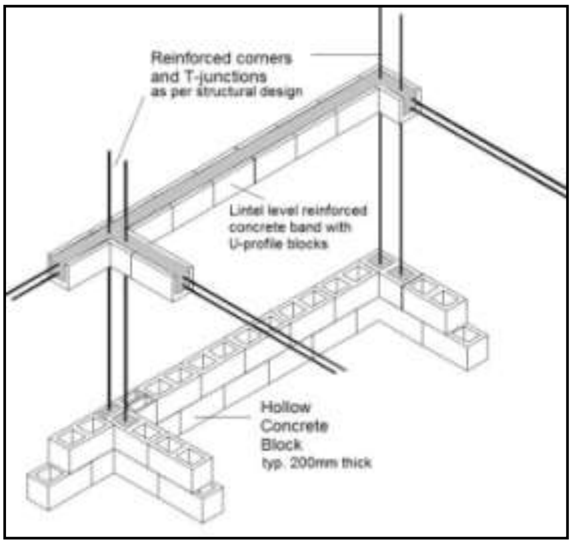
Design: The technique is well suited for both wet and hilly and semi-arid regions where extreme heat or cold are common. Although, it may not be feasible for rural houses, it has good potential for use in public buildings, where significant savings in operational energy can be realized. It requires larger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

Hollow Core Interlocking Blocks

Principle: Hollow concrete block masonry uses lesser concrete as compared to solid concrete blocks and provides better thermal insulation due to cavity. They are best suited to structures with light transverse loading when the cores remain unfilled. Filling some or all of the cores with concrete or concrete with steel reinforcement offers much greater tensile and lateral strength to structures. Head and end joints of units laid in mortar are filled solidly with mortar.

Figure 28 : HCB masonry



This kind of system can also be reinforced; the thickness to the height ratio should not be greater than 1:18 and thickness not less than 200 mm where material is not reinforced. The production of Hollow core interlocking blocks require infrastructure same as that of solid concrete blocks but with different set of dyes, with high economic viability.

Design: These blocks are used in wall masonry and can also be used as roofing blocks along with precast inverted T- beams.

Low Carbon Climate Resilient Features

- This technique reduces dependence on air conditioning and is effective against the climate extremes by significantly improving thermal performance because of the cavity. The performance of walls can further be enhanced by adding insulation.
- Efficient use of materials as the number of bricks is reduced by at least 20 per cent and there is a reduction of at least 30 per cent mortar as compared to a regular masonry wall. It also reduces the overall cost of wall by at least 25 per cent. Solid and hollow concrete blocks may be particularly useful in places where there is scarcity of good quality clay required for burnt clay brick manufacture.
- The aggregate can be resourced locally.
- Hollow Concrete blocks incorporate at least 40 per cent air cavity in gross volume and masonry can be strengthened with steel reinforcement (typically corners, openings), which makes them well-suited for low-rise load bearing construction instead of the RCC frame which is conventionally adopted.

Figure 29 : Low cost housing in Mexico using Concrete Block masonry

Roof Technologies

MCR Roofing

Principle: It is cement based roofing material, is a high grade alternative to conventional options such as burnt clay country tiles (*khaprail*), biomass and CGI sheets. Micro concrete is a type of cement concrete which uses fine aggregate – typically less than 6mm size, which is then moulded as a roofing tile which can be used as a cladding material for sloping roofs.

Low Carbon Climate Resilient Features

- Low environmental degradation during extraction and production.
- Utilises waste such as filtered extracts from sand, waste from stone quarry etc.
- Low embodied energy due to less use of cement.
- Low scale production requirement.

Figure 30 : A roof made of Micro Concrete Roofing Tiles (left) and MCR tile roof in semi-arid Bundelkhand as an alternative for burnt clay country tiles

Design: With an appropriately designed under structure, MCR roofs can be used for a variety of applications in low cost housing, institutional buildings, factories and parking areas.

Plank and Joist Roofing

Principle: This is a system which uses precast concete elements to construct a roof. It consists of two main elements – 1. Reinforced Cement Concrete (RCC) plank which represents smaller sections of the slab and therefore of reduced thickness and reinforcement, and 2 Partially precast RCC. Joist which is a beam spanning across the room to provide bearing for the planks. The planks can be made in standard sizes of 0.3m x 1.5m and the joists can be 0.15m x 0.15m in size for a roof span upto 4 metres. The planks are supported over partially precast RC joists side by side and then joined together with in-situ concrete poured over the entire roofing area. The technique has been developed by the Central Building Research Institute (CBRI) and validated by the BMTPC (Building Materials and Technology Promotion Council). Both elements of the roof – planks and joists can be manually produced at site using a wooden moulds. Alternatively, given the context of a large scale use such as housing project, they can be produced in a small enterprise mode using steel moulds mounted on vibrating tables.

Figure 31: Plank and Joist Roofing

Low Carbon Climate Resilient Features

- Simple technology for a flat roof which is not vulnerable to damage by cyclones.
- Reduces At least 25 per cent low embodied energy as compared to a conventional RCC roof.

Design: The roof can also be used an intermediate floor. The building should be designed keeping in mind the modular size of the planks – essentially, the longer span of the roof will be in multiples of 1.5 metres and the shorter span should preferably not exceed 4 metres to maintain an economical section of the joist.

Figure 32 : EWS housing at Narela, NCR Delhi (left) and Low Cost rural housing at Bathinda, Punjab.

Source: EWS Housing, BMTPC, New Delhi (right)

Precast Arch Panel Roofing

Principle: Arch Panel roofing is a building system, in which the roof is constructed with pre-cast panels made with burnt clay tiles placed on pre-cast reinforced concrete beams. The arch profile imparts lateral or transverse strength to the panels for distributing the roof load through compressive forces. The panels serve as a lost form work for the finished roof, after topping concrete has been laid over the pre-cast components.

Low Carbon Climate Resilient Features

- Simple technology to replace conventional RCC roof for moderate spans.
- Low embodied energy because of 40 per cent less steel- however; the energy content is ultimately determined by the embodied energy of the brick tiles.
- Finishes like plaster or paint are not needed.

Figure 33 : Precast arch panels in community building (above), view of the ceiling

Design: It can be used economically till a span of 5 metres beyond which the beam section becomes uneconomical and it becomes difficult to manually lift the beam. It is recommended for areas where burnt clay products are commonly used and produced in good quality – both the semi arid and coastal study area.

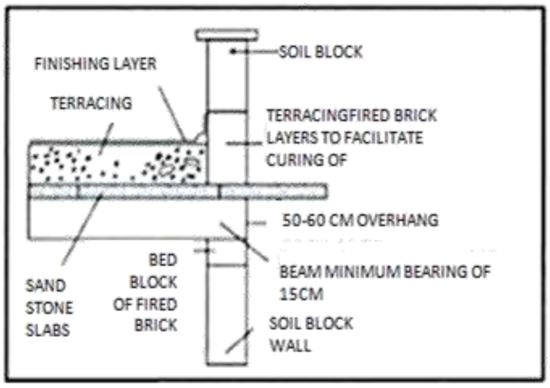
Stone *Patti* Roofing

Principle: It is a flat roofing system with sandstone slabs resting over steel or slender RCC section beams. The slabs are laid over with terracing for insulation and to provide a slope for rainwater drainage.

Low Carbon Climate Resilient Features

- Simple technology to replace conventional RCC roof for moderate spans.
- The use of locally available stone reduces the embodied energy.

Figure 34 : Sectional Detail of Stone *Patti* Roofing



Design: It is appropriate where sandstone slabs are available and is more economical than RCC slabs. Further the impact load distribution and thermal insulation is obtained by *kharanjha* distributors and lime terracing over it. Where larger granite stone *pattis* are available like in Madhya Pradesh, the beams are not needed and can rest on walls.

Ferrocement 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. 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 upto 20 per cent saving in cost, because of reduction in steel quantity and elimination of coarse aggregates and shuttering.

Figure 35 : Ferrocement channel roof

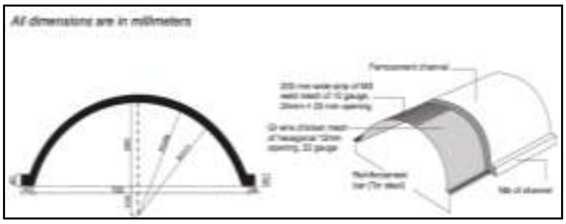


Figure 36 : Manual Production of Ferrocement Channel (above) and Office Building in TARA Gram, Orchha (below)

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.

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. Also, it can have provisions for false ceiling if required.

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 bricks, tiles, cellular concrete blocks. 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 filler slabs also result in fewer loads getting transferred to the load-bearing walls and the foundations. The air gap in between the tiles makes it a good heat insulator and the ceiling looks attractive as well.

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.
- Makes saving on cost of this slab compared to the traditional slab by about 23 per cent.
- Reduces use of concrete and saves cement and steel by about 40 per cent.

Figure 37 : Ceiling of earthen pot filler slab, Auroville (above) and Reinforcement details & earthen pot positions (below)

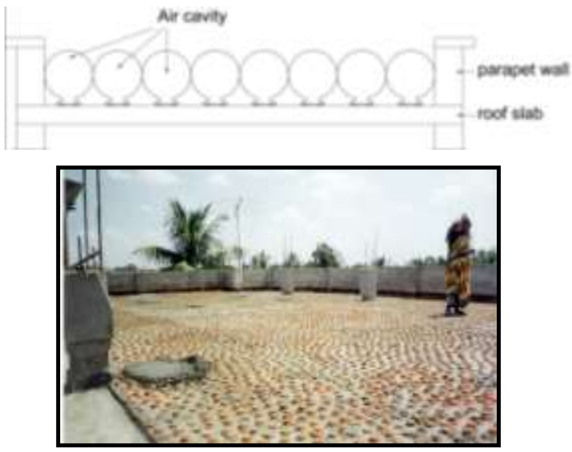
Source: http://wiki.auroville.org.in/

Design: This roofing technique can be used for large spans for 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 are fillers must be utilised.

Inverted earthen pot insulation

Principle: Shading the roof top with inverted earthen pot is an easy and cost effective method to reduce solar gain. In this method roof is covered by inverted earthen pots, the top of earthen pot can be covered with a layer of earth or lime mortar finish or can be left uncovered also. By virtue of air gap they provide good insulation. Earthen pots painted with white paints further reduce the heat load. Pots made with earth are recyclable and regionally available.

Figure 38 : Inverted earth pots on roof



Low Carbon Climate Resilient Features

- Utilises waste as pots which are partially broken can be used.
- Low embodied energy due to properties of soil and less amount of soil required.
- Being made from soil clay, the material for production can be arranged locally and easily.
- Thermal efficiency of this system is very high as thin layer of terracotta covers much volume and trap much air.

Design: As covering of pots made roof unusable, this type of system can be applied at non-accessible flat roof or solid pitched roof.

Mud *Phuska*

Principle: Good quality earth suitable for brick making not containing excessive clay or sand, free from stones, *kankar*, vegetable matter and other foreign matter is used in this system. A layer of puddle mud is mixed with grass straw applied on a sand-bitumen waterproofing layer which is then consolidated and plastered with cow-dung mortar. Tile bricks are laid flat on plastered surface and the joints are grouted with cement mortar. All materials are readily available, economical and non-toxic. Water proofing may be provided by laying bitumen.

Low Carbon Climate Resilient Features

- Utilises waste as straw and husk.
- This system gives optimum thermal efficiency with having low embodied energy due to involvement of Mud, a zero energy material.
- Locally sourced mud can be used.
- Thermal efficiency of this system is high as thermal transmittance of mud is very low.

Design: This type of system can be adopted at any terrace as the finished surface is hard enough and completely usable. The earthy aesthetics of brick tile is an added feature.

Funicular shells

Principle: A Funicular Shell is a 3 dimensional catenary on a rectilinear base. The roofing system consists of doubly curved shells made with materials of good compressive strength such as waste stone pieces and brick tiles, supported on reinforced concrete edge beams. A series of these shells in variable geometric configurations supported on a grid of concrete beams, identical to a coffer slab, provides an attractive roof for small to medium spans.

Figure 39 : Funicular shell – various small shell segments can be cast on a grid of beams

Low Carbon Climate Resilient Features

- Utilises waste stone to provide a roof which can be very well adapted to structural requirements.
- Low embodied energy due to virtual elimination of steel in the slab portion.

Design: Aesthetically pleasing ceilings which can incorporate traditional motifs and don't need plastering/ painting. It is suitable for areas where waste stone is available for utilization. It is particularly well suited for large spans, for instance in community buildings/ halls where a grid of beams can support a variety of funicular shells.

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 40). 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^2) 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 40: Cavity Wall with Waste Thermocol Infill

Source: Cavity wall construction in DA World headquarters in Delhi

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.

Design: The technique is well suited for both wet and hilly and semi-arid regions where extreme heat or cold is 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.

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 41: Ecosan Toilet on a Raised Platform with Waste Storage below (above), Ecosan Pan for Waste Separation (below)

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 MP 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 MP.

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 12^{th} 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. Madhya Pradesh is among the first few states to develop their State Action Plan for Climate Change (SAPCC) with an aim to strengthen the developmental planning process of the state with policy level interventions favouring low carbon growth. The thrust on institutional capacity building to integrate climate change concerns in planning and actions is a recurring theme in the SAPCC.

MP INITIATIVES

The Government of Madhya Pradesh recognizes the threat posed by climate change. Accordingly, the Environmental Planning and Coordination Organization (EPCO) has been designated as the State Nodal Agency for addressing Climate Change issues. A Climate Change Cell (CCC) has also been established in EPCO to facilitate management of long term climate risks and uncertainties and to build capacities of state officials to mainstream these issues in activities and plans.

The Housing and Environment Department supported by UNDP is working towards strengthening the CCC into a State Climate Change Knowledge Management Centre (SCCKMC) for knowledge dissemination with a people centric approach. Understanding the need for knowledge dissemination and communication, EPCO in association with Technology and Action for Rural Advancement (TARA), The Institute of Development Studies (IDS) and Kings College London, has undertaken an initiative to strengthen the understanding of emerging climate science and research among communities and communicators. It will strengthen community knowledge and voice on climate change impacts and adaptation by increasing their input into local research and policy dialogue and enable communities to share their experiences in coping with and adapting to climate change.

The state has taken steps to study and understand climate change vulnerability and adaptation. In order to gain an in depth understanding of how climate change induced vulnerability fits within the broader vulnerability context and therefore, how relevant resilience building and adaptation measures can be effectively incorporated within the existing development processes EPCO in association with Development Alternatives, has carried out a vulnerability assessment in Madhya Pradesh. Also the Ministry of Environment and Forests, GoI, and GIZ are working together to develop an understanding towards the interventions required to improve the livelihood and adaptive capacities of vulnerable rural communities and formulate strategies for climate change adaptations favouring sustainable development in the rural sector.

LCCR CONSTRUCTION

In the state of Madhya Pradesh, the demands from the construction sector are rather steep with the 2007 Rural Housing Shortage recorded at over 2,00,000[16]. Here, climate change also has direct or indirect implications

[16] 2001 Census Report and assessed by RGI

on the sector in terms of water availability, increased damage to building foundations due to ground shrinkage, etc. Recognizing these stresses, the government has taken proactive steps to seed low carbon concepts in the sector.

Madhya Pradesh has taken proactive steps in introducing alternative eco-friendly construction practices in their rural housing mission. In February 2011, the MP-Chief Minister Rural Housing Mission was launched which envisages fulfilling the large housing gap in the state through quality affordable and eco-friendly building solutions. Under the programme, mason trainings have been conducted in all districts of MP to train them in eco-friendly construction techniques. Demonstration buildings have been constructed as part of these trainings to showcase these techniques and enable other house owners to adopt them.

The Additional Chief Secretary, GoMP has reiterated at various forum the need for alternate building technologies which can not only mitigate the housing shortage across the state, but also lead to reduction in carbon emissions. Development Alternatives has been instrumental in designing training mechanism and is supporting the Madhya Pradesh Government in developing the state level Schedule of Rates (SOR) incorporating alternate building technologies which can not only mitigate the housing shortage across the state, but also lead to reduction in carbon emissions.

Green Governance favouring Low Carbon Societies is the underlying theme of the SAPCC. It has clearly highlighted increasing energy and water efficiency, conserving and replenishing the forest cover and regulating mining activities. Also, rainwater harvesting structure with proper drainage and solid waste management is given importance. . The emphasis is on having a climate change resilient cities and rural areas strategy including sectoral GHG inventorization.

Chapter Summary

- There is National Action Plan for Climate Change which was started in India, under which NMSH(2008) was initiated.
- In NMSH importance is give to developemnt of sustainable habitat and there is a growing understanding on the importance of adopting LCCR strategies.
- In MP various initiatives were taken to study and understand climate change vulnerability and adaptation.
- MP has taken proactive steps in introducing alternative eco-friendly construction practices in their rural housing mission.

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?

Notes

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B-32. TARA Crescent, Qutub Institutional Area, New Delhi- 110016, India.
Ph: 91(11)26544215. Visit us at: www.devalt.org