HEATWAVE ACTION

HOUSE OWNERS' GUIDE
TO

ALTERNATE ROOF COOLING SOLUTIONS

National Disaster Management Authority

Heatwave Action: House Owners' Guide to Alternate Roof Cooling Solutions, April 2021

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The House Owner's Guide has been adapted in part from
The Handbook on Achieving Thermal Comfort Within Built Environment, TARU, 2014

The authors would like to thank Shri Anup Kumar Srivastava, Senior Consultant, NDMA for his valuable contribution in reviewing this Guide.

Introduction

As average rise in temperatures are set to reach 1.5 degrees, the number of heatwave spells in the country are rising rapidly. During peak summer seasons, indoor temperature can rise up to 45 degrees. With heat island effect in urban areas, the impact is far more severe on people's health, family expenditure, and productivity.

This handbook aims to guide home owners with roof cooling solutions using techniques and material that is affordable and easy to use in existing homes. Due consideration has been made for prevailing building typologies and varying geo-climatic zones across India.

House owners can use this handbook to select solutions that are best suited to their location, affordability and ease of implementation. It is generally advised to implement under professional supervision. All safety precautions may be taken while carrying out such works. Those who may be planning to build a home in the future may refer to the last section for general tips on mitigating effect of heat gain through sensitive planning, orientation and design layout of their homes.

Contents

IMPACT OF HEATWAVE

HEALTH

Extreme temperature events have profound - even fatal - impacts on human health. Rapid rise in heat gain due to exposure to hotter than average conditions compromise the body's ability to regulate temperature and can result in a surge of illnesses.

Physical

Dehydration & Heat Strokes

Cardiovascular & respiratory disorders

Children & elderly are at higher risk

During a heatwave, there is a significant increase in stress, anxiety, and depression that may trigger or exacerbate mental, behavioural, and cognitive disorders.

Mental

Lack of concentration & focus impacting performance

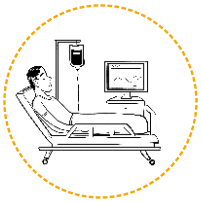
Rise in domestic abuse and violence

Increased alcohol and drug abuse

LIVING COST

Health and Medical

Health implications and disorders due to extreme temperatures may induce huge medical expenses. These further exacerbate the monthly budget of a household.



Unforeseen medical expenses

Healthy diet and supplements post illness

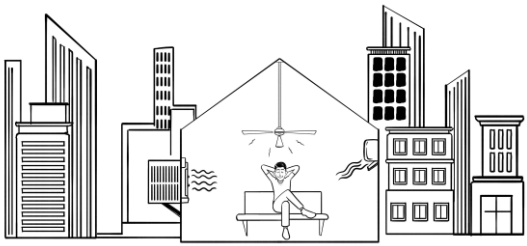
Leaves and workload may affect jobs

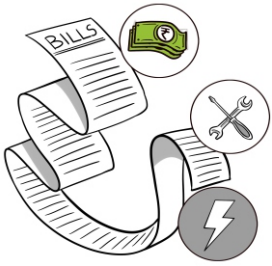
*On an average Indian family spends Rs 1000-2500 per month towards health expenses which increases during summers

Energy

"on an average, electricity bills increases by 15%-20% during heatwave for an urban household"

Temperature rise has led to an increase in need for space cooling. The power demand in urban areas during summers peak with "cooling load" due to the use of air conditioners, coolers and fans contributing to maximum consumption of electricity.





Extreme temperatures exacerbate the demand for mechanical cooling and air-conditioners, leading to increased electrical consumption impacting the average expenditure for a household.

Home Owner's Solutions for
RESILIENCE STRATEGIES AGAINST HEATWAVE

Building orientation and design can improve the impacts of heat waves, urban heat islands and local air pollution. Thermal comfort in buildings through low-energy consuming means complement each other in making comfortable living a reality.

COOLING SOLUTIONS FOR EXISTING HOMES

Cool Roof

- Bamboo/Thatch Screening
- Green Net Shading
- Roof Paint
- Gravel Roof
- Heat Insulation Tiles
- Hollow Concrete Tiles
- Broken China Mosaic
- Mud Phuska
- Lime Concrete
- Inverted Earthen Pots
- Extruded Polystyrene (XPS sheets)
- Modified Bitumen
- Cellulose Fibre
- Thermo Crete
- Mist Cooling System

Cool Walls

- Paints & Finishes

RESILIENCE STRATEGIES: Parameters

The guidelines develop a matrix of best sustainable & passive practices which improves living environment, increase comfort levels, and reduce economic & energy loads as per varying parameters. Geographic, Building Typology, a region's climate, and hazard context.

Locations

Geographic location plays an important role in defining the climate and related activities of the region.

Skill & Expertise

Present day techniques have evolved to a large extent defining different sets of application modes based on time, cost & expertise.

Do It Yourself

Technical expert

Building Typology

Building typology further defines the appropriate practice to be adapted for cool roof and passive techniques.

Sloping Roof

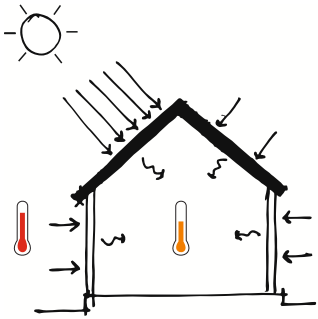
Flat Roof

Existing

New

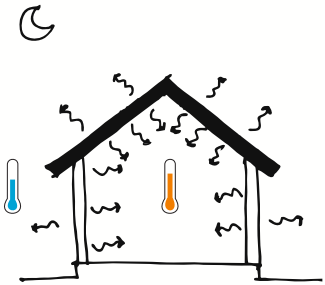
Alternate Roof Cooling Solutions: The Working

Roof contributes up to 70% of the heat gain of a building during high temperatures. Solar radiation striking a surface is either reflected, absorbed, or transmitted.



DAY

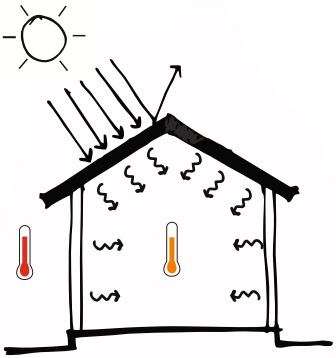
Heat is absorbed by the buildings in the daytime



NIGHT

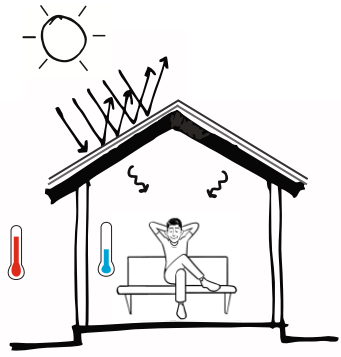
Radiates it in night increasing the internal temperature

Cool Roofs through use of reflective materials and techniques, help in reducing heat absorption and improving overall thermal comfort of the building.



STANDARD ROOF

Reflection - **LOW**
Absorption - HIGH
Thermal Comfort - **LOW**



COOL ROOF

Reflection - **HIGH**
Absorption - LOW
Thermal Comfort - **HIGH**

ALTERNATE ROOF COOLING SOLUTIONS

Bamboo, Thatch & Palm Leaves Roof Screen

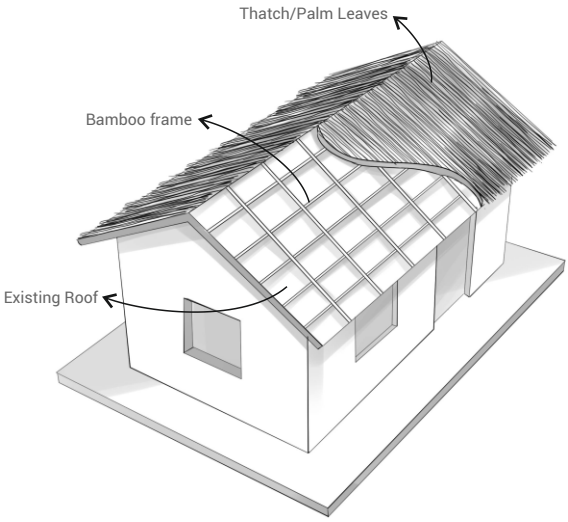
Bamboo, Thatch & Palm leaves are locally available across India and can be installed as a secondary roof screen thereby reducing the heating effect.

CLIMATIC ZONE — HD WH CM

BUILDING TYPOLOGY

SKILL SET

- Materials are readily available
- High insulating capacity, maintains comfortable indoor temperature
- Light weight
- Comparatively expensive to hard materials
- Ridge is the weakest point of thatch roof
- Prone to fire risk



Medium to High

6 - 8 Months

< Rs 100/sqft

Clean the roof surface to remove dust and particles

Fix the bamboo frame on to the roof

Lay the thatch/leaves on the frame and tie with rope

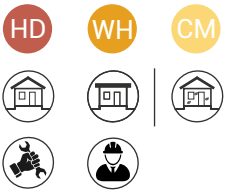
Green Net Shading

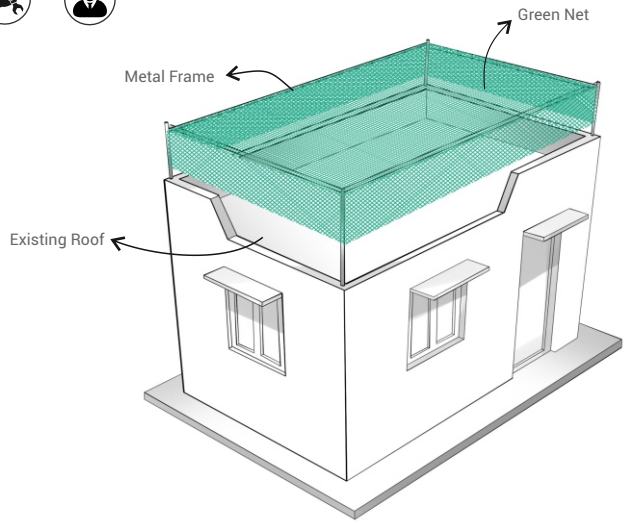
Green Net shading is the most basic strategy to achieve thermal comfort. Depending on its design and positioning, varied degree of thermal comfort can be achieved.

CLIMATIC ZONE

BUILDING TYPOLOGY

SKILL SET





Highly durable to weather conditions

Light weight

Comparatively expensive to hard materials

Medium

2-3 Years

Rs 150-200/sqft

Clean the roof surface to remove dust and particles

Fix the metal frame on roof

Install the Green net on to the frame

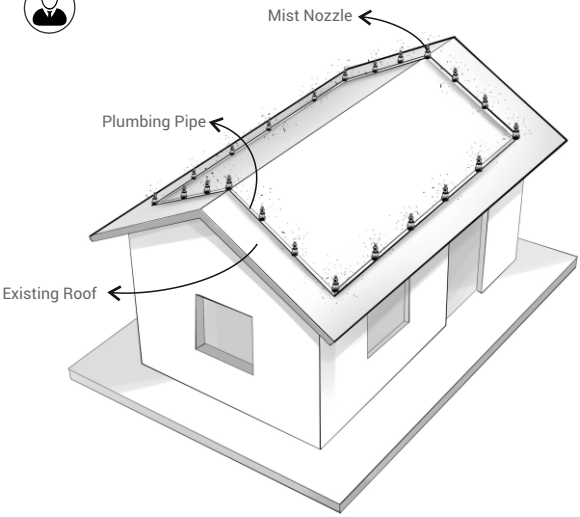
Roof Mist Cooling

Roof mist cooling system reduces the roof surface temperature by spraying an extremely small amount of water across the roof. Spraying allows to cool the roof as the water evaporating from the surface captures the heat.

CLIMATIC ZONE

BUILDING TYPOLOGY

SKILL SET



Reduces the cost of insulation and water proofing

Light weight

Only effective in low relative humidity

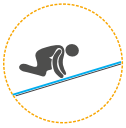
System is unfavorable for areas with water supply problems

Good

3-5 Years

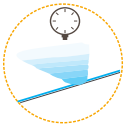
Rs 100-150/sqft

Step 1



Install the mist cooling system on the roof

Step 2

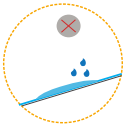


Adjust the pressure of water to create mist environment

Step 3

Controlled quantity of water is sprayed to ensure evaporation quickly

Step 4



Avoid ponding of water on roof surface to prevent damage to roof

Cool Roof Paint

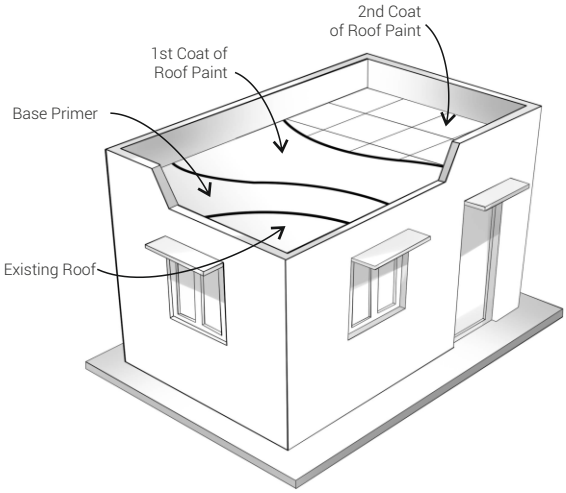
Cool roof coatings are applied to steep as well as low sloped roofs in good condition. Coatings can be field applied to both new roofs and existing roofs.

CLIMATIC ZONE — HD WH CM

BUILDING TYPOLOGY

SKILL SET

- Less costly as compared to other cool roof options
- Coating is easily applicable
- Coating acts as waterproof membrane
- Not damaged by freezing temperatures
- Can be damaged through human movement & objects
- Water based coating cannot be applied in winter and rainy season
- Susceptible to frost damage



Good

3-5 Years

< Rs 100/sqft

Step 1 — Clean the roof surface with water and remove dust

Step 2 — Add water to requirement with paint and stir thoroughly

Step 3 — Use brush or roller for application of paint

Step 4 — Apply first coat and allow it to dry for 3-4 hours

Step 5 — Apply second coat and allow it to dry for 48 hours

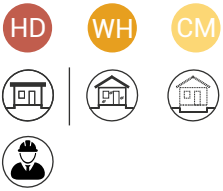
Gravel Roof

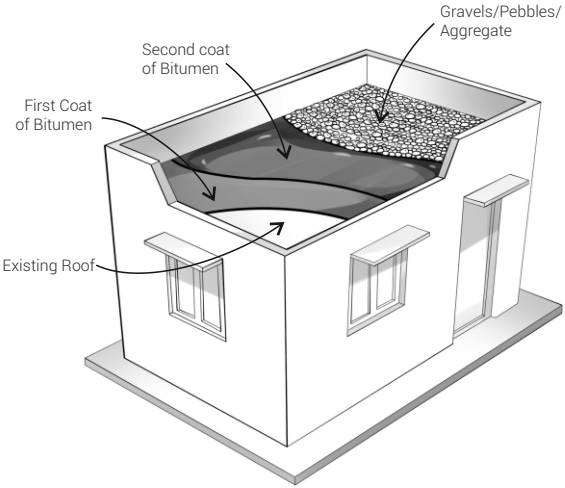
Tar and gravel roof is also termed as Built Up Roofing (BUR). It is easy to apply and repair and is inexpensive to install. Bitumen provide the water proofing agents and adhesive properties of the system.

CLIMATIC ZONE

BUILDING TYPOLOGY

SKILL SET






Excellent water proofing protection


Ultraviolet protection


Higher installation cost


Hazardous during installation

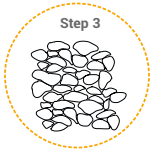

Medium to High


10 - 30 Years


Rs 150 - 200/sqft

Clean the roof surface with water and remove dust

Apply the asphalt or bitumen as base layer on roof surface



Apply marble chips or white gravel for more reflectivity

Modified Bitumen Membrane

Modified bitumen roof is one of the most common cool roof option for low sloped or flat roof. They come in pre-coated colors which increases the solar reflectance resulting in better cooling properties.

CLIMATIC ZONE

BUILDING TYPOLOGY
First coat of Bitumen

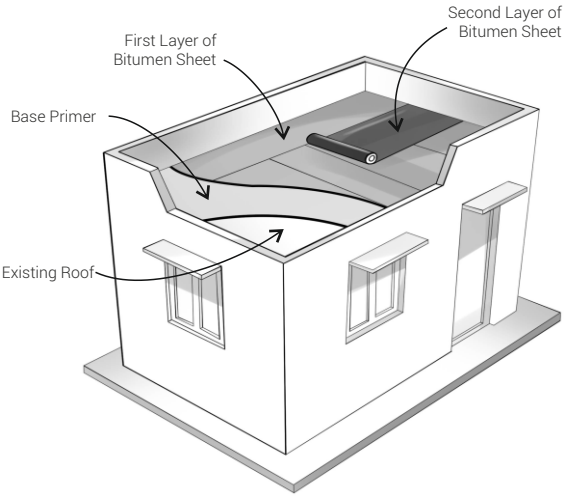
SKILL SET


Excellent water proofing protection


Ultraviolet protection


Higher installation cost


Hazardous during installation




Medium


10 - 30 Years


> Rs 200/sqft

Step 1


Clean the roof surface to remove dust and other particles

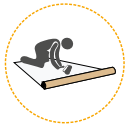
Step 2


Roll down the sheet on roof surface

Step 3


Fix the bitumen sheet with cold adhesive or hot asphalt using torch down method

Step 4


Apply white coating to make roof reflective

Thermoplastic Membrane

Thermoplastic membranes are made from plastic polymers.

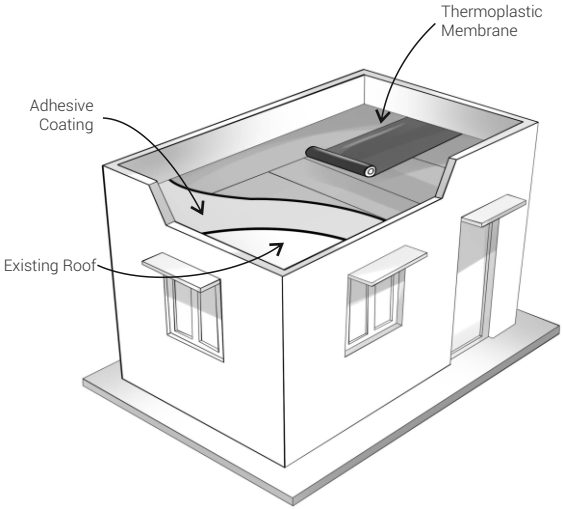
The membranes do not require any coating as the product itself is integrated with cool roof properties. They are manufactured with self cleaning and mold resistant polymers to maintain solar reflectance.

CLIMATIC ZONE

BUILDING TYPOLOGY

SKILL SET

- Weather resistant
- Good reflective properties
- Light weight
- Low installation cost
- Toxic properties
- Susceptible to water retention problems



Good

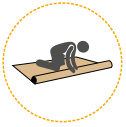
20 - 30 Years

> Rs 200/sqft

Step 1

Clean the roof surface to remove dust and other particles

Step 2



Roll down the sheet on roof surface

Step 3

Fix thermoplastic membrane using adhesive & heat welding

Heat Insulation Tiles

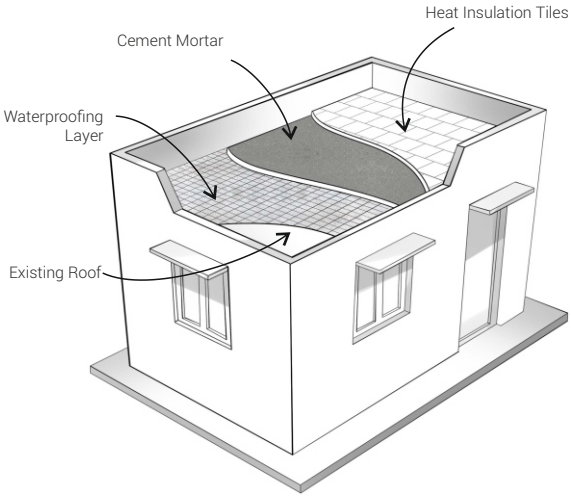
Tile is a resilient material and is able to withstand hail, wind and fire. Heat Insulation Tiles are made from PCM (Phase Change Material) Technology designed to control the flow of heat from roof and used as surface resistant.

CLIMATIC ZONE

BUILDING TYPOLOGY

SKILL SET

- Recyclable
- Provide thermal insulation
- Low maintenance
- Highly durable to weather conditions
- Heavy, hence structural evaluation is necessary
- Ceramic tiles are fragile



Good

30 - 50 Years

Rs 150-200/sqft

Step 1

Prepare and apply mortar with cement - sand ratio of 1:4 on roof

Step 2

Spread cement slurry on mortar layer for bonding

Step 3

Wet the rear side of tile with water and put them on mortar

Step 4

Clean the tiles with wet sponge and allow it to dry for 48 hours

Step 5

Fill the joints with pointing material (white cement+ pigment)

Hollow Terracota/ Concrete Tiles

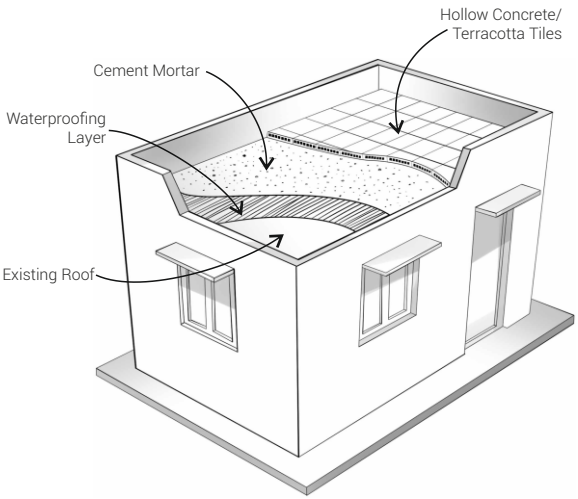
Hollow concrete/terracota tiles have high thermal insulation and sound insulation property which is very effective in limiting heat flow. The air inside the cavities provides the insulation to heat.

CLIMATIC ZONE — HD WH CM

BUILDING TYPOLOGY

SKILL SET

- Fire resistant
- Recyclable
- Energy efficient
- Low maintenance
- Highly durable to weather conditions
- Heavy, hence structural evaluation is necessary for concrete tiles
- Clay tiles are fragile



Good

30 - 50 Years

Rs 150 - 200/sqft

Step 1
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Spread cement slurry on mortar layer for bonding

Step 3
Wet the rear side of tile with water and put them on mortar

Step 4
Clean the tiles with wet sponge and allow it to dry for 48 hours

Step 5
Fill the joints with pointing material (white cement+ pigment)

Inverted Earthen Pots

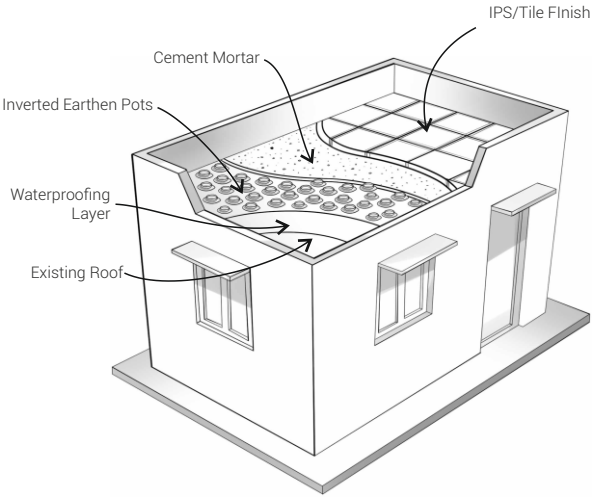
Using earthen pots to keep roofs cool has been traditionally practiced in hot and dry areas. Locally available earthen clay pots are affordable and exhibits high thermal insulation property.

CLIMATIC ZONE — HD, CM

BUILDING TYPOLOGY

SKILL SET

- Provide thermal insulation
- Low maintenance
- Highly durable to weather conditions
- Heavy, hence structural evaluation is necessary



Good

20 - 30 Years

Rs 150 - 200/sqft

Step 1

Spread cement slurry of roof surface for bonding

Step 2

Lay inverted earthen pots over wet slurry

Step 3

Prepare and lay cement concrete over the pots

Step 4

Finish the surface with IPS or Tiles

Cool Roof

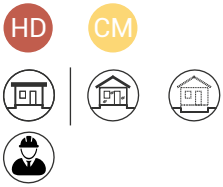
Mud Phuska

Mud-phuska is prepared from puddle clay mixed with “bhusa” (chopped straws) and cow dung. It is equally suitable to hot as well as arid regions and is commonly used over R.C.C roofing.

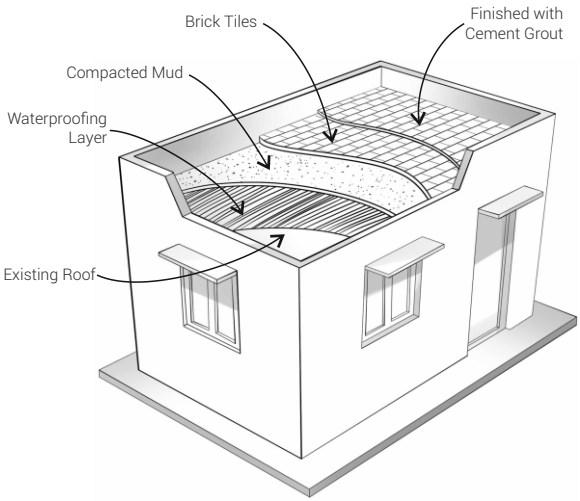
CLIMATIC ZONE

BUILDING TYPOLOGY

SKILL SET



- Recyclable
- Provide thermal insulation
- Energy efficient
- Less expensive to install
- Heavy, hence structural evaluation is necessary
- Ceramic tiles are fragile




Medium to High


20 - 30 Years


Rs 150 - 200/sqft

Step 1

Prepare mud phuska and lay it over the waterproofed roof slab

Step 2

Manually level and compact the mud

Step 3

Lay brick tiles over the compacted mud

Step 4

Fill the gap in brick tiles with cement grout admixed with waterproofing grout

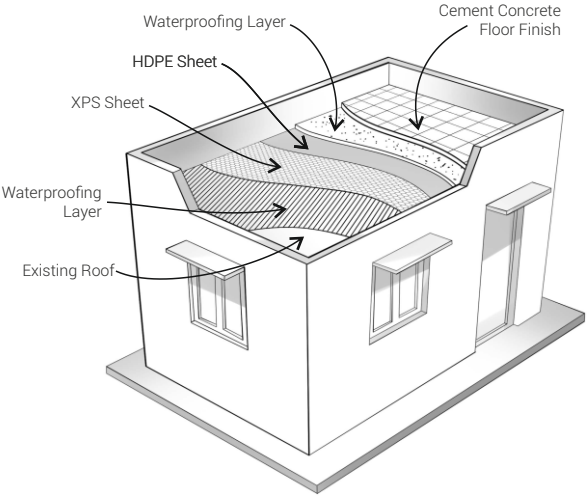
Extrude Polystyrene (XPS Sheets)

Polystyrene foam has a good resistance to flow of heat and sound and is a commonly used raw material for insulation boards in construction industry.

CLIMATIC ZONE — HD WH CM

BUILDING TYPOLOGY

SKILL SET



- Recyclable
- Provide thermal insulation
- Light weight
- Comparatively expensive to hard materials
- Cant put much load due to softer inner core

Medium

20 - 30 Years

< Rs 150-200/sqft

Step 1 — Lay cement mortar bedding layer for bonding

Step 2 — Lay XPS sheets over the bedding mortar

Step 3 — Place the vapour barrier plastic sheet over XPS sheets

Step 4 — Lay cement concrete over waterproofing layer

Step 5 — Finish the floor with IPS or tiles.

Lime Concrete

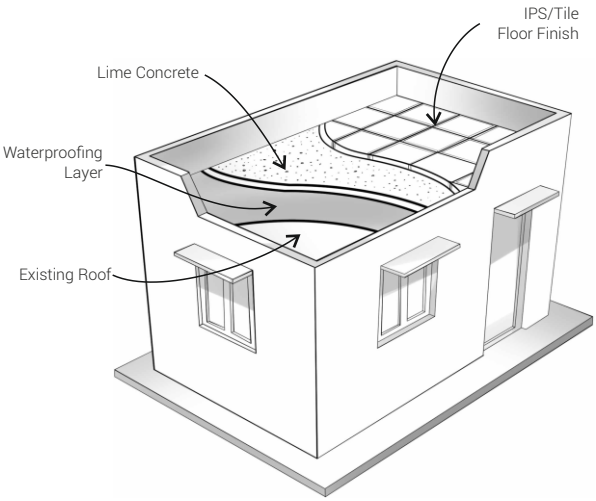
Brick jelly-lime concrete has traditionally been used as a weathering layer over roofs. The principle is to install a layer of concrete made with lime-surkhi mortar with broken brick as coarse aggregate.

CLIMATIC ZONE: HD CM

BUILDING TYPOLOGY

SKILL SET

- Provide thermal insulation
- Less expensive to install
- Highly durable to weather conditions
- Heavy, hence structural evaluation is necessary



Good | 30-50 Years | Rs 150-200/sqft

Step 1 (48 hrs) — Prepare lime concrete by slaking lime and brick bats

Step 2 — Lay lime concrete over the roof

Step 3 (4-5 days) — Cure the lime concrete for 4-5 days

Step 4 — Spread a layer of cement mortar

Step 5 — Finish the floor with tiles

Broken China Mosaic

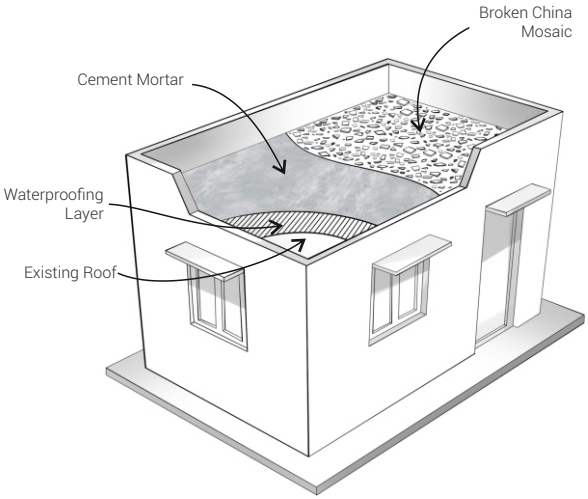
China mosaic terrace provides a reflective layer to the roof which reflects a considerable amount of solar radiation falling on the roof. The reflective layer is formed by broken and randomly sized pieces of light colored ceramic tiles, laid on a cement mortar bed, with joints between tiles sealed with white cement.

CLIMATIC ZONE: HD CM

BUILDING TYPOLOGY

SKILL SET

- Weather resistant
- Provide thermal insulation
- Good reflective properties
- Less expensive to install
- Heavy, hence structural evaluation is necessary for concrete tiles
- Clay tiles are fragile



Medium

20 - 30 Years

< Rs 150-200/sqft

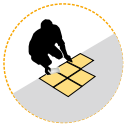
Step 1

Prepare and lay bedding mortar over waterproofing layer

Step 2

Lay broken ceramic tiles over cement slurry

Step 3



Fill and finish the gap with white cement slurry

Thermocrete Insulation

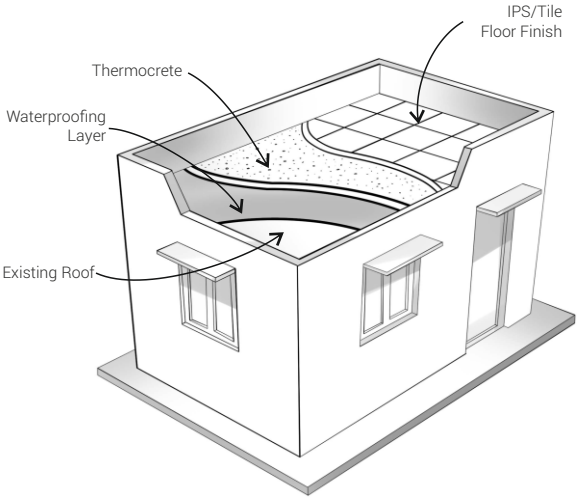
Air cavities inside a material increases its ability to obstruct transfer of heat or cold through it. Cement concrete finish which is conventionally used in terraces can be improved for thermal performance by introducing a layer of thermocrete prepared and poured in-situ at site.

CLIMATIC ZONE — HD WH CM

BUILDING TYPOLOGY

SKILL SET

- Recyclable
- Provide thermal insulation
- Low maintenance
- Highly durable to weather conditions
- Heavy, hence structural evaluation is necessary
- Ceramic tiles are fragile



Good

30-50 Years

Rs 150-200/sqft

Step 1

Prepare and lay cement concrete mixed with thermocol balls.

Step 2

Lay 20 mm thick cement plaster over thermocrete.

Step 3

Finish the surface with IPS/Tiles

Cellulose Fibre

Cellulose is one of the most environment-friendly raw materials for insulation sourced from recycled paper and cardboards. the fibers get coated with cement sand mortar such that on drying, many air pockets are left inside, giving the dried material an insulating property.

CLIMATIC ZONE

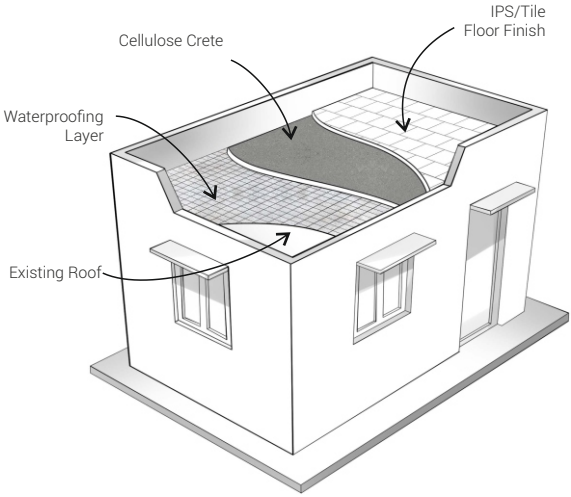
BUILDING TYPOLOGY

SKILL SET

Provide thermal insulation

Low maintenance

Heavy, hence structural evaluation is necessary



Low to Medium

20-30 Years

Rs 150-200/sqft

Step 1

Prepare and lay mortar mix with cellulose fibre and cement

Step 2

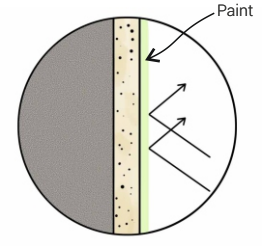
Lay 20 mm thick cement plaster over cellulose

Step 3

Finish the surface with IPS/Tiles

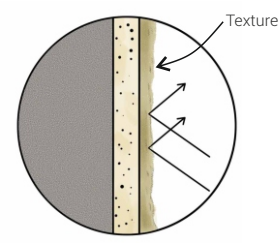
Paints and Finishes

Paint and wall finishes have an important role on solar absorption and thermal emittance of the façade. Wall color and texture can help to reduce temperatures by reducing solar heat gain.



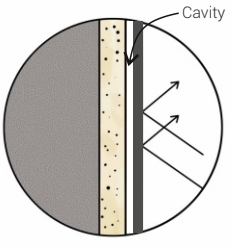
Color

Light colored exterior walls reflects the solar radiations thereby reducing the heat gain.



Texture

Textured surface treatment increases the surface area of the wall and reduces the heat gain.



Cladding

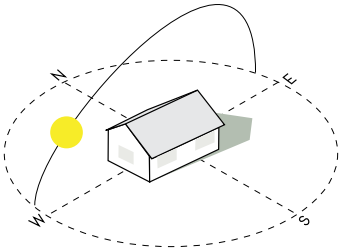
Curtain walls and dry-stone cladding reduces direct heat gain of the walls by creating a cavity between two surfaces.

COOLING SOLUTIONS FOR NEW HOMES

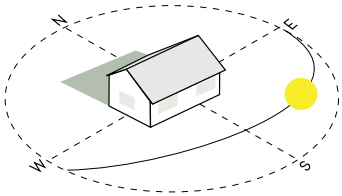
Planning & Orientation	Site Orientation
Fenestrations & Shading	Cross Ventilation Exterior shading devices
Landscaping	Terrace Garden Vertical Greens/Creepers

Planning & Orientation

Orientation of the building plays a crucial role with respect to solar exposure and wind direction. Orientation affects the heat gain through building envelope and thus the cooling demand of the building.



Sun Path: Summer

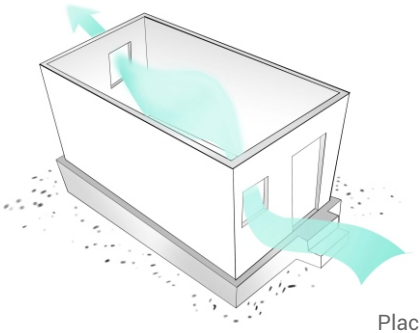


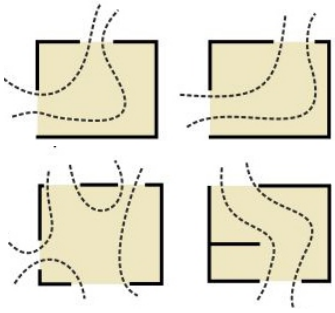
Sun Path: Winter

Fenestrations & Shading

Fenestrations

Properly oriented doors and windows when open provide natural cross ventilation. More cooling can be obtained if air is forced to take the longer path between inlet and outlet.





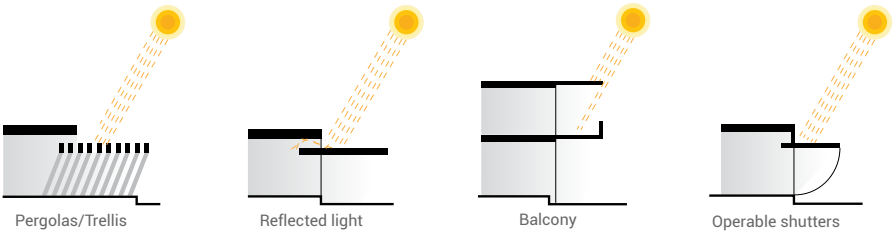
Placement of openings for effective cross-ventilation

Shading

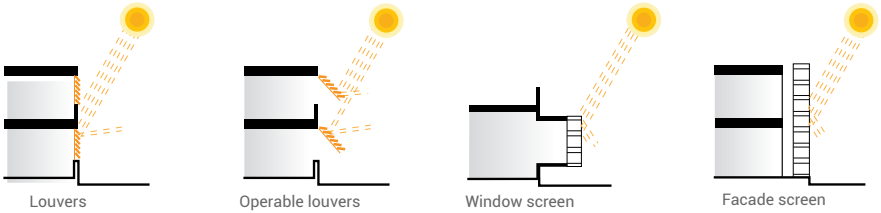
Shading devices are an effective means of cutting down on solar heat gain into the building and thereby reducing the external surface temperatures of the envelope which can easily reach up to 10% higher than ambient temperatures in hot climates.

Exterior shading devices can be provided in a variety of materials and designs, including sunshades, awnings, louvres, bamboo screens, '*jaali*'.

Different Types Of Over Hangings



Different Types Of Screens



Different Types Of Window Shadings

Awnings provide flexibility to span without need of extra support

Properly installed awnings can reduce heat gain by 65% from south and 77% from east

Adjustable louvers can control the sunlight entering into the building

Least cost solution for cutting heat gain into the building

Cool Walls

Walls share the maximum surface area of a building and plays an important role in heat gain of a building. During the day it absorbs the heat and radiates it inside the living space at night. This puts additional load on the cooling needs.

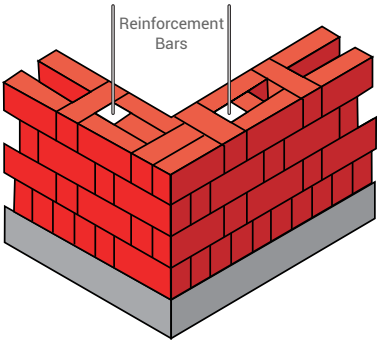
Several factors can be utilized to reduce energy consumption and improve thermal comfort. Design, techniques, material and finishes can together help in reducing the heat gain.

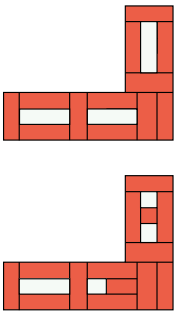
Hollow Walls

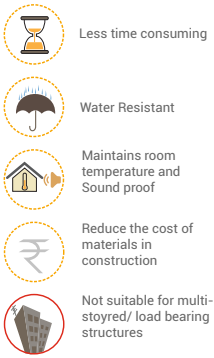
Creating cavities in walls by using different techniques and material have a noticeable impact on the heat gain of a building through walls.

Rat Trap Bond

Rat-trap bond is a masonry technique in which the bricks are laid in such a manner that a cavity is formed between two faces of the wall.

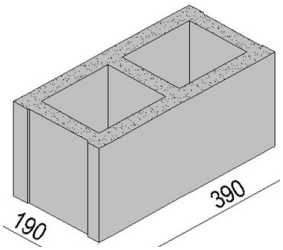


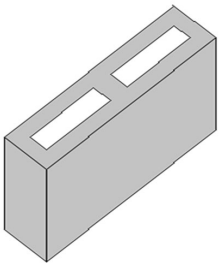




Hollow Blocks

Hollow blocks are pre-casted concrete blocks designed with inbuilt cavity. They are bigger but lighter that brick masonry. Can also be customized as per requirement.

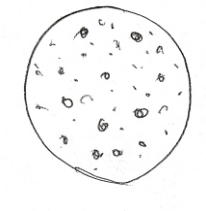




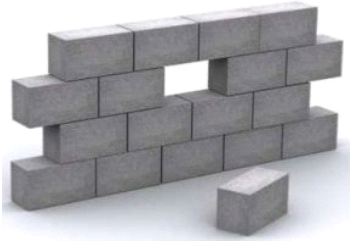
- Less time consuming
- Water Resistant
- Maintains room temperature and Sound proof
- Reduce the cost of materials in construction
- Not suitable for multi-stoyred/ load bearing structures

AAC Blocks

Autoclaved aerated concrete (AAC) is a lightweight, precast, foam concrete building material suitable for producing concrete masonry. Composed of quartz sand, calcined gypsum, lime, cement, water and aluminum powder.



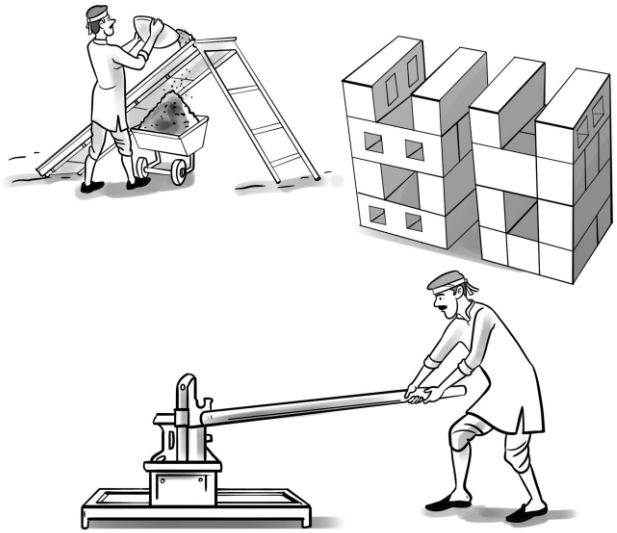
Air pockets makes it a better insulation material



- Less time consuming
- Water Resistant
- Maintains room temperature and Sound proof
- Reduce the cost of materials in construction
- Not suitable for multi-stoyred/ load bearing structures

Compressed Stabilised Earth Blocks (CSEB)

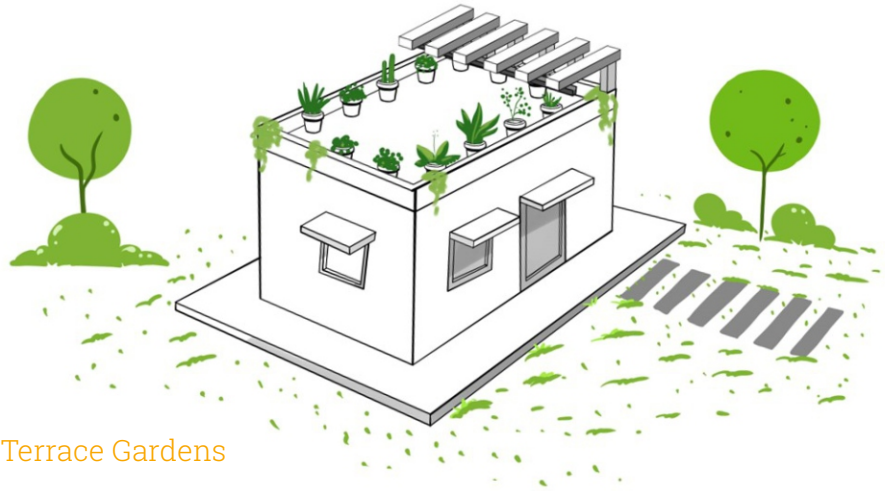
Compressed Stabilised Earth Blocks (CSEB), commonly called, Pressed Earth Blocks, are construction material made using damp soil under high amount of pressure to form blocks. They are an eco-friendly alternate to conventional bricks.



- Water Resistant
- Maintains room temperature and Sound proof
- Reduce the cost of materials in construction
- Not suitable for multi-stoyred/ load bearing structures
- Labor Intensive hence slightly expensive

Landscaping

Shading with trees (along with evaporation) can reduce the ambient temperature near outer walls by 2ºC to 5ºC. Landscaping helps shade south, east or west facing windows from summer heat gain.



Terrace Gardens

Terrace gardens reduce overall heat absorption of buildings and insulate the building against heat & cold. They provide shade by breaking the solar radiations, improves air quality and cools the surrounding air.

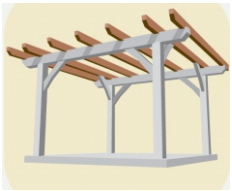
Vertical Green & Creepers

Vertical green has a multi-functional character. It provides shade, improves air quality, reduces building and internal temperatures by 2ºC to 8ºC.

Pergola & Trellis

Pergola not only defines a space but most important they provide shade there by reducing the direct impact of solar radiations resulting in heat gain and improving thermal comfort.

Vertical Green



Pergola

Trellis & Creepers

Maintenance

Buildings and material deteriorate with regular use and time. Timely maintenance not only increases the life of the material but also saves on to future costs.

Roof cooling techniques are surface based solutions which needs timely maintenance and extra care for its efficient and long-term functioning.

Clean the roof regularly with soft broom. Rainwater drains should be free of obstructions

Avoid keeping scrap & heavy items on roof

Do not drag on the surface

Timely repair the small damages

Benefits of Maintenance

Save unforeseen cost

Increases life of the building

Long-term thermal comfort