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 managing effect of heat gain through sensitive planning, orientation and design layout of their homes.

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 materials that are affordable and easy to use in existing homes. Due consideration has been made for prevailing building typologies and varying geo-climatic zones across India.

NDMA would like to thank SEEDS and the Global Network of CSOs (GNDR) for their support in design and development of this House Owner's Guide.

Published by:
National Disaster Management Authority (NDMA)
Ministry of Home Affairs Government of India
NDMA Bhawan A-1, Safdarjang Enclave
New Delhi - 110029

April, 2021

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.
The "handbook" aims to aid the houseowners and community with information on traditional methods, new technology, native practices and cost-effective solutions on cool roofing and passive ventilation considering different building typology & geographic locations across India.

Extreme temperature events have profound impacts on human health – even fatal. Rapid rises 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.

Contents

Impact of Heatwaves       01
Resilience Strategies       03
Alternate Roof Cooling Solutions: The Working       05
  Cool Roof: Lime Concrete
  Cool Roof: Mist Cooling System
  Cool Roof: Inverted Earthen Pots
  Cool Roof: Cool Roof Paint
  Cool Roof: Broken China Mosaic
  Cool Roof: Extruded Polystyrene (XPS sheets)
  Cool Roof: Cellulose Fibre
  Cool Walls: Paints & Finishes
  Cool Roof: Green Net Shading
  Cool Roof: Thermoplastics Membrane
  Cool Roof: Hollow Concrete Tiles
  Cool Roof: Heat Insulation Tiles
  Cool Roof: Mud Phuska

Planning and Orientation

Fenestrations and Shading

Cool Roof: Bamboo/Thatch Screening

Cool Walls

Cooling Solutions for New Homes     24

Maintenance       30

Cooling Solutions for Existing Homes    07

Cool Walls

Published by: National Disaster Management Authority of India (NDMA)
The "handbook" aims to aid the houseowners and community with information on traditional methods, new technology, native practices and cost-effective solutions on cool roofing and passive ventilation considering different building typology & geographic locations across India.

Extreme temperature events have profound impacts on human health – even fatal. Rapid rises 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.

Contents

- Impact of Heatwaves 01
- Resilience Strategies 03
- Alternate Roof Cooling Solutions: The Working 05
- Cooling Solutions for Existing Homes 07
  - Cool Roof: Lime Concrete
  - Cool Roof: Mist Cooling System
  - Cool Roof: Cool Roof Paint
  - Cool Roof: Gravel Roof
  - Cool Roof: Modified Bitumen Membrane
  - Cool Roof: Thermoplastics Membrane
  - Cool Roof: Heat Insulation Tiles
  - Cool Roof: Hollow Concrete Tiles
  - Cool Roof: Inverted Earthen Pots
  - Cool Roof: Mud Phuska
  - Cool Roof: Extruded Polystyrene (XPS sheets)
  - Cool Roof: Lime Concrete
  - Cool Roof: Broken China Mosaic
  - Cool Roof: Cellulose Fibre
  - Cool Walls: Paints & Finishes
- Cooling Solutions for New Homes 24
  - Planning and Orientation
  - Fenestrations and Shading
  - Cool Walls
- Landscaping 29
- Maintenance 30

Published by: National Disaster Management Authority of India (NDMA)
Health implications and disorders due to extreme temperatures may induce huge medical expenses. These further exacerbate the monthly budget of a household. Temperature rise has led to an increase in need for space cooling. The power demand in urban areas during summers peaks with “cooling load” due to the use of air conditioners, coolers and fans contributing to maximum consumption of electricity.

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

Health and Medical

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.

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

![Diagram showing heat absorption during the day and night.](image)

**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.

![Diagram comparing standard roof and cool roof.](image)

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

**COOL ROOF**
- Reflection - HIGH
- Absorption - LOW
- Thermal Comfort - HIGH
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. Cool roofs are designed to reflect more sunlight and absorb less heat than a standard roof, lowering roof temperature, through reflective paints, sheet covering, reflective tiles, traditional or industrial insulation.

ALTERNATE ROOF COOLING SOLUTIONS: The Working

<table>
<thead>
<tr>
<th>Reflection</th>
<th>Absorption</th>
<th>Thermal Comfort</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>HIGH</td>
<td>LOW</td>
</tr>
<tr>
<td>HIGH</td>
<td>LOW</td>
<td>HIGH</td>
</tr>
</tbody>
</table>

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

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

Cool Roof

Step 1
Clean the roof surface to remove dust and particles

Step 2
Fix the bamboo frame on to the roof

Step 3
Lay the thatch/leaves on the frame and tie with rope

Step 1
Step 2
Step 3

Heatwave Action: House Owners’ Guide to Alternate Roof Cooling Solutions
Cool Roof

**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.

<table>
<thead>
<tr>
<th>CLIMATIC ZONE</th>
<th>HD</th>
<th>WH</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING TYPOLOGY</td>
<td><img src="image1" alt="Existing Roof" /></td>
<td><img src="image2" alt="Bamboo Frame" /></td>
<td><img src="image3" alt="Thatch/Palm Leaves" /></td>
</tr>
<tr>
<td>SKILL SET</td>
<td><img src="image4" alt="Highly durable to weather conditions" /></td>
<td><img src="image5" alt="Light weight" /></td>
<td><img src="image6" alt="Comparatively expensive to hard materials" /></td>
</tr>
</tbody>
</table>

- **Highly durable to weather conditions**
- **Light weight**
- **Comparatively expensive to hard materials**

---

**Hands-on Guide**

- **Step 1**: Clean the roof surface to remove dust and particles
- **Step 2**: Fix the metal frame on the roof
- **Step 3**: Install the Green net on to the frame

- **Heatwave Action: House Owners’ Guide to Alternate Roof Cooling Solutions**
- **Medium**
- **2-3 Years**
- **Rs 150-200/sqft**
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.

- **Reduces the cost of insulation and waterproofing**
- **Light weight**
- **Only effective in low relative humidity**
- **System is unfavorable for areas with water supply problems**

- **CLIMATIC ZONE**: HD, WH, CM
- **BUILDING TYPOLOGY**: House, Office, Factory
- **SKILL SET**: HD, WH, CM

**Cool Roof**

**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**

- **Good**
- **3-5 Years**
- **Rs 100-150/sqft**

**Existing Roof**

**Mist Nozzle**

**Plumbing Pipe**

**Base Primer**

**1st Coat of Roof Paint**

**2nd Coat of Roof Paint**

**Cool Roof Coatings**

- Applied to steep as well as low sloped roofs in good condition.
- Can be applied to both new roofs and existing roofs.

- **Not damaged by freezing temperatures**
- **Less costly as compared to other cool roof options**
- **Coating is easily applicable**

- **Can be damaged through human movement & objects**
- **Coating acts as waterproof membrane**
- **Water based coating cannot be applied in winter and rainy season**
- **Susceptible to frost damage**

**Heatwave Action: House Owners’ Guide to Alternate Roof Cooling Solutions**

- **Step 1**: Water and remove dust surface with
  - **Step 2**: Clean the roof
  - **Step 3**: Add water to requirement
  - **Step 4**: Stir thoroughly with paint and application of paint
  - **Step 5**: Use brush or coat and allow application of paint

- **Step 1**: Water and remove dust surface with
  - **Step 2**: Clean the roof
  - **Step 3**: Add water to requirement
  - **Step 4**: Stir thoroughly with paint and application of paint
  - **Step 5**: Use brush or coat and allow application of paint
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

**Cool Roof**

- 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
Cool Roof

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

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

Step 2: Apply the asphalt or bitumen as base layer on roof surface

Step 3: Apply marble chips or white gravel for more reflectivity

Gravel/Pebbles/Aggregate

First Coat of Bitumen

Second coat of Bitumen

Existing Roof

HD

WH

CM

Cool Roof

Medium to High

10 - 30 Years

Rs 150 - 200/sqft

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.
**Cool Roof**

**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**

- **HD**
- **WH**
- **CM**

**BUILDING TYPOLOGY**

- **First coat of Bitumen**

**SKILL SET**

- **D**
- **WH**
- **CM**

**Excellent water proofing protection**
- **Ultraviolet protection**
- **Higher installation cost**
- **Hazardous during installation**

**Cool Roof**

- **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
Cool Roof

**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.

<table>
<thead>
<tr>
<th>CLIMATIC ZONE</th>
<th>HD</th>
<th>WH</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING TYPOLOGY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SKILL SET</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

**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

**Cool Roof**

**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*

<table>
<thead>
<tr>
<th>HD</th>
<th>WH</th>
<th>CM</th>
</tr>
</thead>
</table>

*BUILDING TYPOLOGY*

*SKILL SET*

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

**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

**Cool Roof**

**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.

**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

**Cool Roof**

**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.

**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

**Cool Roof**

**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.

**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

**Cool Roof**

**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.

**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

**Cool Roof**

**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.

**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

Cool Roof

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)

Heatwave Action: House Owners’ Guide to Alternate Roof Cooling Solutions
Cool Roof

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.

<table>
<thead>
<tr>
<th>CLIMATIC ZONE</th>
<th>HD</th>
<th>WH</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING TYPOLOGY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SKILL SET</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 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**: 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)
Cool Roof

**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**

<table>
<thead>
<tr>
<th>HD</th>
<th>CM</th>
</tr>
</thead>
</table>

**BUILDING TYPOLOGY**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>

**SKILL SET**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

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

**Cool Roof**

- **Hollow Terracota/Concrete Tiles**
  - Low maintenance
  - Energy efficient
  - Recyclable
  - Fire resistant
  - Highly durable to weather conditions
  - Heavy, hence structural evaluation is necessary for concrete tiles

**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.

<table>
<thead>
<tr>
<th>CLIMATIC ZONE</th>
<th>HD</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING TYPOLOGY</td>
<td>![Icon]</td>
<td>![Icon]</td>
</tr>
<tr>
<td>SKILL SET</td>
<td>![Icon]</td>
<td>![Icon]</td>
</tr>
</tbody>
</table>

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

**Cool Roof**

**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

- **Climatic Zone:** Medium to High
- **Building Typology:** 20 - 30 Years
- **Skill Set:** Rs 150 - 200/sqft
**Cool Roof**

**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.

<table>
<thead>
<tr>
<th>CLIMATIC ZONE</th>
<th>HD</th>
<th>WH</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING TYPOLOGY</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>SKILL SET</td>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Recyclable**
- **Provide thermal insulation**
- **Light weight**
- **Comparatively expensive to hard materials**
- **Can’t put much load due to softer inner core**

**Cool Roof**

**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.
Cool Roof

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

BUILDING TYPOLOGY

SKILL SET

<table>
<thead>
<tr>
<th>HD</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>📈</td>
<td>📈</td>
</tr>
<tr>
<td>☀️</td>
<td>☀️</td>
</tr>
<tr>
<td>⚭</td>
<td>❌</td>
</tr>
<tr>
<td>🎯</td>
<td>🎯</td>
</tr>
</tbody>
</table>

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
Prepare lime concrete by slaking lime and brick bats

Step 2
Lay lime concrete over the roof

Step 3
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.
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.

Cool Roof

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.

<table>
<thead>
<tr>
<th>CLIMATIC ZONE</th>
<th>HD</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING TYPOLOGY</td>
<td>🏠</td>
<td>🏢</td>
</tr>
<tr>
<td>SKILL SET</td>
<td>🧟‍♂️</td>
<td></td>
</tr>
</tbody>
</table>

- Provide thermal insulation
- Low maintenance
- Heavy, hence structural evaluation is necessary

Cool Roof

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

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.

<table>
<thead>
<tr>
<th>CLIMATIC ZONE</th>
<th>HD</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING TYPOLOGY</td>
<td>🏠</td>
<td>🏢</td>
</tr>
<tr>
<td>SKILL SET</td>
<td>🧟‍♂️</td>
<td></td>
</tr>
</tbody>
</table>

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

Low to Medium
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
Cool Walls

**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 reflect 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".

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.
Cool Walls

**Hollow Blocks**

Hollow blocks are pre-casted concrete blocks designed with inbuilt cavity. They are bigger but lighter than 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-storied/ 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.

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

Air pockets makes it a better insulation material
Cool Walls

**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.
**Landscaping**

Shading with trees (along with evaporation) can reduce the ambient temperature near outer walls by 2°C to 5°C. 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 2°C to 8°C.

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

### 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**