

Course Name: Bioclimatic Architecture: Futureproofing with Simple and Advanced Passive Strategies

Professor: Dr. Iyer Vijayalaxmi Kasinath

Department of Architecture,

School of Planning and Architecture, Vijayawada

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Lecture 01

Cool

Roof

Hello everybody, in our last class, we saw the concept of double roof as an advanced passive strategy. Today we will see another way in which we can deal with the roof and have a advanced passive strategy. So, today we will see the cool roof. What is a cool roof? What is its working principles? How do we benefit from it? What are the challenges and considerations? What are the options we have? And what are the code compliances and ratings? We will also see a few case studies. So a cool roof is designed to reflect more sunlight than a conventional roof, absorbing less solar energy. This lowers the temperature of the building just as wearing light colored clothing keeps you cool on a sunny day.

This can save energy and money in buildings with air conditioning or improve comfort and safety in buildings without air conditioning. This happens by reducing heat flow from the roof into the occupied space. Most cool roofs have high thermal emittance, the ability to shed heat by giving off thermal infrared radiation. A cool roof is a roofing style that features a light-colored outer membrane or coating, such as white, light gray, or tan, which also has some heat-insulating properties.

So, unlike traditional dark-colored roofs, white roof systems reflect a substantial amount of sunlight and quickly release any heat collected by the roofing membrane or coating. A lower roof temperature implies less heat enters the building through the roof membrane or coating lowering cooling costs and increasing roof service life. Cool roofing is an effective approach for lowering building energy expenditures, greenhouse gas emissions and the urban heat island effect. Cool roof membranes or coatings can be created from a variety of materials, including PVC, polyvinyl chloride, thermoplastic polyolefin, EPDM, ethylene, propylene, diene, terpolymer, and so on. They include unique pigments that reflect sunlight and protect the roof membrane from UV rays.

If we look at thermoplastic polyolefin. This is a single-ply roofing membrane that is one of the fastest-growing commercial roofing systems in the market. It is an extremely durable

synthetic rubber proofing membrane. The ethylene polypropylene dienine polymer is an extremely durable synthetic rubber roofing material widely used on low-slope buildings in the US and also worldwide. Let us look at the working principle. A white-colored roof works similarly to wearing light-colored clothing on a sunny day.

White roofs are made with solar reflective materials that absorb less sunlight than a conventional dark roof. Less heat absorption means a lower surface temperature. This directly reduces heat gain through the roof and air conditioning demand and leads to significant energy savings. So basically, A cool roof comprises or has the characteristics of high solar reflectance and high infrared Because of high solar reflectance, less solar radiation is absorbed and because of high infrared emittance, faster release of heat or infrared radiation happens. Both of these give rise to a lower surface temperature.

This makes less heat penetrate into the building and less heat transferred to the ambient air. Now, what is solar reflectance index? SRI, the efficiency of cool roofs is measured using these primary indicators. First is SR, which is the solar reflectance. Solar reflectance is also known as albedo. It refers to a material's surface capacity to reflect both visible and non-visible solar radiation.

Solar reflectance varies from 0 for black surfaces to 1 for white surfaces. White surfaces have high solar reflection but low absorption, whereas dark surfaces have low reflectance and high absorption. The second property is thermal transmittance. It refers to a surface's capacity to emit infrared heat radiation. Thermal emittance varies from 0 to 1 depending on the substance.

The greater the emittance, the cooler the surface temperature will be. Metal coatings offer lower emittance than polymeric synthetic. Let us look at the working principle. A reflective roof, or cool roof, is basically a roof that reflects and emits the sun's rays back to the sky. It prevents the transferring of this heat into the building below.

Further, as cool roofs present very high solar reflectance and also have high infrared emittance, they have the ability to keep the temperature of the roof down. This leads to substantially reducing the heat conduction to the building. The amount of solar radiation that gets reflected by a roof which is treated to be a cool roof surface is extensive because of its high reflectivity. These two surface properties that affect the thermal performance of these roof surfaces are solar reflectance, which is reflectivity or albedo, and infrared emittance, or emissivity. The solar reflectance index SR reflects a roof material's ability to reflect back solar radiation.

It is defined so that the standard black color has a value of 0 and the standard white

reflectance has a value of 1. The higher the solar reflectance the better the material is for using as a cool roof. Solar reflective index is determined by using solar reflectance as well as IE values specified by ASTM 1980 standards. A study was conducted in Algeria, which is again a hot climate, where the performance of various roof types was analyzed. The roof types that were used for comparison were the reference roof type.

This is the reference roof material. This is the outdoor value, outdoor temperature value. Under these conditions, three types of roofs were compared with the reference roof. One is the cool double-skinned ventilated roof, another is the cool roof, and the third is the cool tiles. So the cool tiles showed this as its temperature, whereas both the double-skin ventilated roof and the cool roof showed a much lower indoor temperature.

So it can be seen that at the peak at the peak maximum there is a difference of about 7 degree centigrade lowering of indoor temperature between a cool roof and a conventional roof. Let us now look at the benefits of cool roof. So cool roof can increase occupant thermal comfort by keeping the building cooler during hot summer months. So, it increases occupant comfort. increasing its durability and life.

It addresses air pollution and global warming by lowering carbon dioxide and other emissions associated with the number 5 associated with the reduced use of air conditioners because if the indoors is cool, then the need for air conditioners also decreases. It reduces UHI, reduces urban heat island effect and a This is done by reflecting heat back to the atmosphere. It helps with the local code compliances, if any, in terms of overall thermal transfer value or any other local code compliance. It is easier to achieve the thermal transfer values with cool roofs. Now, let us look at some of its challenges.

First is its installation cost. Initial investment costs a lot. So, cool roof materials, especially advanced reflective coatings and membranes, can be more expensive than traditional roofing materials. Professional installation and proper installation are crucial for the effectiveness of cool roofs. The need for skilled professionals may add to the overall installation costs.

Second are geographic and climatic factors. Climate suitability. The effectiveness of cool roofs can vary based on climate. In colder climates, the reflective properties may reduce winter heat gains, which could be a disadvantage. Snow and ice accumulation can happen in certain areas.

In such areas with heavy snowfall, the reflective surface may hinder the natural melting of snow, leading to accumulation and potential structural issues. Third is the maintenance requirement. which leads to durability. Cool roof materials may have different durability

characteristics compared to traditional roofing materials. It has certain cleaning challenges.

So over time, dirt, debris, and biological growth can affect the reflectivity of cool roofs. So, to discuss the need for regular cleaning and maintenance to ensure optimal performance becomes important and mandatory. Fourth is its compatibility with existing structures. So, when you have retrofitting to be done, it could be a possible challenge. Retrofitting existing buildings with cool roofs can be logically challenging and could require modifications to accommodate the new roofing materials.

For example, if there is a building with a pottile roof, then it becomes very difficult unless you carry out certain modifications. Structural considerations are another important challenge to assess how the additional weight or different thermal properties of cool roof materials might impact the existing structure of buildings. Next we move on to the code compliance and rating systems. So, sometimes there is a chance that each country could have some code compliance on the U value, or the amount of heat that should be permitted to enter the building from the roof. So, under ECBC, there is a code 4.

3.1.1, which says vegetated and cool roofs. All roofs that are not covered by solar photovoltaics or solar hot water or any other renewable energy system or utilities and services that render it unsuitable for the purpose shall be either cool roofs or vegetated roofs. So for qualifying as a cool roof, roofs with a slope less than 20 degrees shall have an initial solar reflectance of no less than 0.70 and an initial emittance no less than 0.

75. Solar reflectance shall be determined according to ASTM E90396 and emittance shall be determined in accordance with ASTM E40871 RA1996. For qualifying as a vegetated roof, the roof area shall be covered by living vegetation greater than 500 millimeters high.

Under this clause, 4.3.1.1 clause A falls under cool roof, and having a cool roof can benefit by being compliant with this code. The IGBC also has a specific comment and a remark for site selection and planning, which is heat island reduction through roof. SSP credit 7 carrying points 1 to 2 says the intent is to minimize the heat island effect so as to reduce the negative impact on microclimate. The compliance option says option 1 is a high-reflective material. Use materials with a high solar reflective index to cover at least 75% of the exposed roof area, including covered parking.

It says materials with high solar reflectance index include white or light-colored broken china mosaic tiles, white cement tiles, or other high-reflective materials or coatings. Minimum solar reflective index values for different roof types are also suggested and provided under the IGBC code. So, having a cool roof makes it easier to be compliant with codes. Now let us look at the cool roof options. So, the options for materials with cool roofs

are

many.

First, we will look at asphalt shingles. This material that makes up asphalt shingles is fiberglass web-coated on filled asphalt or filled modified asphalt and covered in colorful ceramic-coated rock. Shingles are arranged in successive rows, overlapping each other. This allows the shingles to breathe or release underlying moisture and aids in the roof's water-shedding process. The cool option is to select an asphalt shingle with a cool-colored granule surface or light-colored granules if the darker hue is preferred. It is not advised to field coat previously installed asphalt shingle roofs in order to make them cooler since this might lead to problems with moisture retention and could void the guarantee provided by the shingle manufacturer.

The second is using wood shingles. The wood pieces that are overlapped to cover the various roofs are called wood shakes or manual splits, and wood shingles, which are machine sawn. The cool choice would be wood shakes and shingles, which are cool-colored materials by nature. The third is polymer shingles. These are synthetic or composite shingles, also referred to as polymer shingles. These are made of polymer that has been molded to resemble slate, wood, clay, or concrete tiles, as well as asphalt or wood shingles.

The roof is covered by them overlapping. Select a polymer shingle that has pigments in light or cool colors at the manufacturing stage. Clay tiles. This comes in two variants: unglazed, which is like terracotta, and glazed, which increases water resistance and offers a color selection. Cool choices include selecting a clay tile with a factory-fired glaze that is either light or cool-colored or terracotta clay, which is usually a natural cool colour. Retrofitting glazed clay tiles also involves applying a light or cool-colored polymer coating in the field during the tile installation process.

Next are concrete tiles. These are typically formed from grey cement concrete. They can be integrally coloured with pigments or surface coloured with slurry coatings, which are pigment plus white cement, or with a pigmented polymer coating. The cool options include choosing a concrete tile with a factory-applied light or cool-colored slurry of polymer coating. Concrete tiles can also be retrofitted with field-applied light or cool-colored polymer coating.

Slate tiles can also be used. These are split from the metamorphic rock and overlapped to cover the roof. These are usually not cool by themselves unless otherwise you coat them. Metal shingles or tiles are metal pieces that are often shaped to resemble asphalt shingles, clay tiles, wood shingles, or concrete tiles. These overlap to cover the roof, and they can be unpainted, factory painted, or factory surfaced with mineral granules. And their cool options include a metal shingle or tile that is factory coated with light or cool coloured

paint or factory surfaced with reflective mineral granules.

Unpainted metals are typically good solar reflectors but poor thermal emitters and get hotter in the sun than painted metals of comparable solar reflectance. They are not the best choice. Metal shingles or tiles can be retrofitted with field-applied paint. But oven-baked factory-applied paint is more durable and economical than field-applied paint.

Let us now look at the advantages of cool roofs. Cool roofs give us an endearing advantage of reducing energy bills by decreasing air conditioning needs. So, cool roofs can reduce energy bills because the air conditioning demand can be reduced. They help the older inefficient or undersized air conditioner to provide enough cooling for today's hotter summers, especially with climate change. They make it possible to downsize the capacity of new air conditioning equipment, thereby saving money and increasing cooling efficiency. They also provide improved indoor comfort and safety for spaces that are not actually air conditioned.

They decrease the roof temperature, which can extend the roof service life and maintenance costs. They lower the local outside temperature, thereby lessening the urban heat island effect. Cool roofs slow down the formation of smog from air pollutants, which are temperature-dependent, by cooling the outside air. They reduce the peak electricity demand, which can help prevent power outages. They can decrease power plant emissions by reducing the demand for energy to cool the buildings, and they contribute to reducing global warming by reducing greenhouse gas emissions, GHG emissions due to decreased use of air conditioners.

So, in today's class, we saw how cool roofs can be used, what are the various materials with which cool roofs can be constructed, what are its benefits, what are the challenges in using cool roofs and how the most energy-transmitting component of a building, which is the roof, needs to be protected and for that, what are the ways, including the cool roof as a way to protect the roof from transmitting heat inside the building. Finally, we saw its advantages. So, with this, we stop today's class, and in the next class we will continue with another advanced passive strategy. Thank you.