

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

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Lecture 04

Double

Roofing

Hello everyone! In our last class we saw an advanced passive technique, which was high-performance glazing. Today we will move on to another interesting topic, which is an advanced passive strategy, and that is double roofing. Roofs are directly exposed to the outer environment and they are an important external envelope. They play a very important role in absorbing solar heat, especially during the hot summer months. In a traditional building, the surface temperature of the roof can easily reach even 60 to 65 degrees centigrade. Some studies have shown that the heat gain through vertical facades and roof surfaces accounts for nearly 64% of the total air conditioning system's energy consumption in a 12-story residential building in Singapore, which is a tropical climate.

Further, the roofs absorb about three times higher solar radiation than the vertical facades, which is the wall. This indicates that the solar heat gain through the roof is one of the main sources of building's heat gain. Thus, to reduce the cooling load of an air conditioning system, it is essential to reduce solar heat gain through the roof of a building. Besides, building roof surfaces with high solar reflectance and high thermal emittance materials employing ventilation, air layers in building roofs called as double skin roof is an effective way to improve the thermal performance of buildings.

This is specially true in hot climates during the summer months in the tropics where direct sunlight is the largest contributor to building cooling loads. Because a roof receives the most direct sunlight over a day, a double roof or shade structure above the roof will reduce the cooling requirements. In hot climates, It is important to incorporate a double roof structure separated by an air cavity and extend the roofing to shade exterior walls to create shaded outdoor living spaces. A double roof structure located high above the roof can also provide shading for an outdoor roof garden or terrace. What is a double roofing? Double roofing typically refers to a construction technique where there are two layers or levels of roof.

So, there are two levels or levels of roof. Basically it is a structure located just above the roof, shading the roof and allowing warm air buildup between the roof and the structure to escape. It is mostly equipped in hot climates as a passive cooling strategy. So, here in double roofs, there is a main structural roof, functional roof for the room and there is another roof covering it. There is a air gap.

And this air gap has wind flowing through it which ensures that this roof does not transmit heat below because the roof itself does not get heated up. If we look at the sloped roof, there is inlet, there is actually one structural roof. And the double roof on top of it and through this air gap the heat that could probably be built up in the space is dissipated and let out. So, it comprises of a structural roof for the room. And in some buildings where lot of heat is generated inside, there is also a fan.

This is called as an attic fan. And fresh air enters the building and the hot air which rises up gets sucked out because of this attic fan through this gap. Besides, this double roof on top also helps and prevent heat gain inside hitting this roof. So, it sorts of protects the outer roof and protects the inner roof from direct solar radiation so this double-skinned roof consists of number one this solid roof and number two another roof, which is separated by an air gap The lower roof or the downside roof layer, is called as the primary roof so this is the primary roof and the upper one is called the secondary roof, which shields the primary roof from direct solar radiation. And the air layer can be either open-ended or closed-ended.

If the air layer is a closed ended type, it acts as an insulation layer. In the case of an open ended air layer, the air moves from bottom to the top of the layer under the buoyancy effect or with the help of the attic fan which takes away the heat accumulated. In the air layer from solar heat gain, hence heat gain into the indoor environment through the primary roof could be reduced, especially in summer. Internal ventilation in walls and roofs is capable of carrying heat and moisture effectively to the outdoor environment and keeping the internal part of the roof cool and dry. So, this design can serve various purposes.

First, it enhances insulation because there are two layers with an air gap, which acts more like an insulant as well as a medium to drive away heat. Provides improved ventilation because if there is an opening and a fan, then there is ingress of air, which causes ventilation, gives sound insulation, has an aesthetic appeal, and addresses specific requirements and structural requirements. You can see a traditional house that is raised on this stone, through which air movement can happen, and there is a primary roof and a secondary roof causing wind movement inside and ventilating it. Now, how does a double-roof system work? A double-roof system involves two separate roof layers or skins of structures. The upper layer is typically lightweight.

It should be made of frame materials. It should be made of timber or metal as a frame and can have a decking of wood or metal sheet covering it. The lower roof layer often uses massing materials like regular concrete. So, this is how the picture shows how the functioning of a double roof . In a conventional roof, there is only a single roof, and this single-layered structural roof absorbs the outdoor heat and radiates the heat through conduction and convection inside.

Whereas when we have a double roof there is this air gap inside. between the lower layer of the roof and the upper layer of the roof. This air gap protects this primary roof, and due to ventilation, the heat is driven out or flushed out before it reaches the lower roof. So, there can be two types of roof. One is a ventilated roof and one is a non-ventilated roof.

In this the air has to move unit directionally whereas when the vents on top are opened out the air can move and escape through the top opening on top. Here are some of the examples of double roofs. So double roofs can be used in a variety of buildings. It can be used in a resort, for the deck, or for a school building. So it is used here in a resort or a swimming pool deck; it could be any office or private building.

It can be used in residences or resorts. It can be used in schools. It can be used for private residences too. So, the application is quite vast. Let us look at one case study now.

This is the case study of the Economic and Agriculture Learning Centre at Thailand by Vin Varavarn Architects. It is a hot-humid climate, and as you can see, the building structure is here with its primary roof. And there is a large secondary roof all over the building, protecting it on all sides. So, this is a large, faceted steel-framed roof. So, this is the frame steel frame of the roof.

This is the building first floor. And this is the building plan axonometry on the ground floor and this is the covering of the roof. So, a large faceted steel frame roof is clad with bamboo shingles. So, the covering is with bamboo shingles, under which lie two storeys of activity centers, open workshop spaces, and a canteen. So, the concept is primarily living under a hut, and it is a reflection of the local culture and also an amalgamation of contemporary architecture.

So, on the double roof, you can see the steel frame before the bamboo shingles are placed. So, this functions as providing for shade, enhancing ventilation, and providing rainwater harvesting. The roof structure is designed to direct water into small channels close to the structure, which in turn leads to the reservoirs on the site being used during drought season. It provides shade to the structure as well as immediate outdoor spaces. The next, I won't say case study, but I have indicated a couple of buildings.

One is at SRM Amaravati. Amaravati is in Vijayawada, and it's an extremely hot place. The summers can be tormenting and unbearable, with temperatures reaching even between 45 and 49 degrees Celsius. 45 degrees is quite casual. So, in which case it is important that the roof of the building, which is the major envelope component that transmits heat into the building, be shaded.

In that context, in Amaravati, they have used this double roof. So, there is this building that is covered with a double roof but has an air gap in between. Also, because the roof is so large, it needs to be given some kind of flexibility or some cuts for the air to escape out. So, there are various points through which the hot air that builds up between the primary roof structure and the secondary roof structure actually escapes out.

So, designed by P.T. Krishnan Associates, it is a well-thought-out building. Then the other examples are a secondary school in Burkina Faso and a Panyandan school in Thailand. This is just to show that many hot and humid countries around the world adopt double skin facades. Let us look at a scientific study done using a double-skin roof. We will look at the study done on the energy-saving potential with a double-skin roof ventilated by natural convection in Djibouti.

It is a sub-Saharan African country in its extremely hot desert-like climate. Now, it is known that about 67 percent of energy is used in a standard home, and the split-up of energy you can see from figure A. So, the example of a building with the largest share of energy use is shown here, which is primarily a sheet metal or concrete tile roof. What happens is a standard roof is taken, which is a single roof, and a ventilated roof is taken. So, this is the single roof used in the study.

This is a ventilated roof that has two roofs, 1 and 2, with an air gap in between, and the third is a ventilated and isolated roof, which has two layers. These are the three cases that were studied, and it was found that with respect to the standard roof, the ventilated roof showed a reduction of 50 percent in heat flux, and the ventilated and isolated roof showed an 85 percent reduction in heat flux. The other small examples which I have taken is if you look at the king post roof truss- in a small way, that also acts like a double roof in the sense that this is not actually an air cavity, but then it does provide some kind of insulation. This is a primary health center at Dharmapuri.

Built by White Elephant architects, and it is on a plain barren land with extremely high radiative heat, and this double roof definitely helps in mitigating the impact. So, from this study, it was found that double roof system demonstrates a 50% reduction in heat flux, meaning only half of the heat energy enters the building. Inclusion of insulation in the

lower roof further increased heat flux reduction, reaching an impressive 85% reduction from the original roof structure. This study suggests a significant potential for cooling homes by implementing these heat reduction measures. So, today we have seen how double roofs have been used in India and worldwide to combat the impact of heat flux through the most contributing envelope material of heat, which is the roof, which can contribute anywhere between 50 and 60 percent of the indoor heat.

How is it combated? Traditionally also it was combated using the double roof system. And here today we have seen the contemporary examples and contemporary ways in which the double roof can be implemented, can be used to create comfortable indoors. This double roof is valid for all typology of buildings. From residential buildings to large and long spanned structures like industries and factories.

It is still effective. Can be done with a fan, attic fan. Can be done without an attic fan too. So, these variants are up to your imagination how we can use them. So, with this I stop today's class. And we will move on to the next lecture in the forthcoming class with yet another topic on advanced passive systems. Thank you.