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

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Lecture 03

Double skin green facade

Hello everyone. So, in the last class, we saw how to use thermal mass as a strategy to keep the indoors comfortable. Today we will look at another interesting topic that is slightly somehow related to it, maybe not directly; you could relate to it directly if you want as a designer, and today we will look at a double-skin green facade. Now why do I say if you want you can relate it to the previous topic, which is thermal mass, because having a double-skin green facade could probably increase the thermal mass of the wall if you want to design it that way? So, what is a double-skin green facade? It is a type of green wall that offers both thermal performance and psychological benefits. It consists of a ventilated air cavity between two layers of glass or other building materials, with the outer layer often being operable for natural ventilation. Now research has been conducted on modeling and evaluating the energy efficiency of double-skin green facades.

This architectural feature is designed to enhance the sustainability and comfort of buildings by providing insulation, shading, and a connection to nature. Double-skin green facades offer a unique opportunity to combine sustainability, aesthetics, and occupant well-being in building design. Let us look at the classification of green walls. Now green walls can be classified into two types.

You could have green facades and living wall systems LWS green facades could be direct or indirect, whereas direct systems can be the traditional green facades, whereas indirect could be with the help of continuous guides and modular trellis. Living wall systems could be continuous or modular. And the continuous living wall systems could be on lightweight screens, while the modular living wall systems could be on trays, vessels, planter tiles, or flexible bags. So, what did I mean by any of those? So, direct traditional green facades could be ground-based systems. In this, what happens is that the climbers are planted on the ground on soil, and you have self-climber vegetation that will move to its own convenience and direction that it chooses organically.

Whereas the climber vegetation ground-based system is again planted on the ground, but it is directed to grow based on the trellis or the support that is designed on the wall. The second type is, I would call this the first type, and maybe we will go to the third type before we come to the second type. The third type is a facade-bound system where you could have pots kept on the facade on which vegetation could grow, or it could be vegetation on the living wall. So, on the wall itself, it would grow probably like a moss or probably with the help of boxes or something like a trellis or something. Then there is mixing where you have the pots.

The second one is a combination of the first and third. You have pots on which the plants grow, and you have some vegetation on the ground, which also directs the plant onto the facade. So this is how it looks on the direct traditional green facade. is planted on the ground and it grows on the wall. So, if these are the roots, it grows on the wall.

Whereas the living wall is like moss or something like that, which grows on the wall itself, and the indirect is a combination of having a planter box on the façade. So, this actually becomes a double facade in many ways. You even have an air cavity here in between. Or sometimes you could even have this space between the wall and the trellis, or something can be made wider. to enable a human to stand or use the space as shown in this figure. Now, you could have vertical forms of green facades where the plants grow in a vertical direction against gravity.

Or you could have horizontal forms where the vegetation is restricted in a horizontal manner only. And you can have full-shaded or unshaded corridors. That is fully shaded; from the ground floor to the top floor, it is completely shaded. covered with vegetation or it is consciously done only partially. Then you can have rotated vertical fins.

So, these panels are fixed at angles towards the prevailing wind direction to direct wind inside the structure. This also provides mutual shading, hence obstructing the harsh sunlight. Let us look at the working principle. In a double-skin green facade, the framework is installed at a distance from the wall, creating a gap or cavity here. So, a gap or a cavity is created between the wall and the building and the plants. The distance of the cavity influences the rate of air exchange, which affects the wall surface temperature and indoor air temperature. So, based on this distance, the temperature of the wall and the indoor temperature are influenced or affected. As the distance of the gap increases, the temperature inside the cavity decreases, resulting in a higher wall surface temperature and a lower indoor air temperature. The distance of the gap can be from 0.3 meters to over 1.8 meters, where, in this diagram, you can see it is 1.8 meters and becomes a usable space like a balcony or something. Also, the working principle - If you look at the working principle in terms of the different kinds of facades you could have a facade where the greenery is on

this surface.

Cool air. enters this place, and warm air exits this place. If you have a system to take in the cool air, then the indoors could become cool. There can be another system where you do not open out and the circulation is only vertical because it is a shaft box, kind of a vegetation planter box. Or you can have a continuous corridor where again you can have the warm air exiting and cool air coming in. So, the air that comes in gets cooled, especially because of the plants and the evapotranspiration of the plants.

This could be made to enter inside, or as it becomes warm, it exits on the outside. Let us look at the advantages of having this green wall. First, it helps in reducing the urban heat island effect. So, traditional building materials such as concrete and asphalt tend to absorb, retain, and reflect heat. They contribute to the urban heat island effect, whereas green facades with their living vegetation reflect less heat, helping to mitigate heat built up in the urban areas.

Second is their thermal performance. The air gap between two layers between the vegetation and the wall acts as an insulating barrier, helping to regulate the building's temperature by reducing heat gain in the summer and heat loss in the winter. Improved thermal performance can lead to energy savings on heating and cooling, contributing to overall energy efficiency. Third is energy efficiency. The reduced heat absorption from the outer layer of vegetation can result in lower cooling loads during hot weather, leading to decreased energy consumption for air conditioning.

Air quality improvement. Vegetation acts as a natural air filter. It traps the pollutants, especially particulate matter such as dust. Thus improving the air quality both indoors and outdoors. The plant also absorbs carbon dioxide and releases oxygen, contributing to a healthier indoor environment.

Fifth is the aesthetic appeal. Double-skin green facades enhance the visual aesthetics of the building, providing a lush and green appearance. This can improve the overall aesthetic appeal of the structure and the surroundings. Sixth is noise reduction. The vegetation helps to absorb sound.

It reduces noise pollution from the surrounding environment and gives acoustic insulation. This is particularly beneficial in urban areas where noise levels can be very high. Then seventh, it can increase the property value. If maintained properly and also when integrated into the building design, this can have a very good appeal and sustainability for the structure. Eighth is long-term durability of inner facades.

The green facade can protect the building and envelope from harsh weather conditions, potentially extending the lifespan of the facade materials and reducing maintenance costs over a period of time. Ninth is growing adoption of both new and existing buildings. So retrofitting of old buildings is also possible, and this can be incorporated as a design feature in new buildings also. Tenth is integration with smart technologies for automated control and monitoring, and eleventh is the intangible and psychological well-being. So, studies have shown that exposure to greenery can reduce stress, improve mood, have a positive impact, and boost creativity.

So, these can add a lot of value to the quality of life. Next, we will see the limitations or disadvantages. First is its high initial cost. The installation of a double-skin green facade can be more expensive compared to traditional facades. The cost includes not only the structural components but also the planting materials, irrigation systems, and other specialized elements.

Second are its maintenance challenges. Green facades require regular maintenance to ensure the health and aesthetic appeal of the vegetation. Pruning, watering, and monitoring plant health can be labor-intensive and may require specialized knowledge. Double-skin green facades require more maintenance than traditional green facades as there are two layers to clean. You have to inspect them, service them, add manure, provide fertilizer, give the pesticides, and so on.

The third one is that this can add load to the structure. The additional weight of soil, plants, and supporting structure can place a significant load on the building's structure. It is crucial to ensure that the building is designed to handle this extra load to prevent structural issues over a period of time. Fourth is its water usage. Maintaining a healthy green facade often requires regular watering, especially this becomes a problem in dry climate where there is an existing water crisis.

So, this can be a concern in regions where there is water shortage or scarcity. Fifth is limited applicability in certain climates. Double skin green facades may not be suitable for extreme climates with harsh weather conditions such as strong winds or heavy snowfall or intense heat which can affect the health of the vegetation. Sixth is limited insulation in cold climates. While green facade can provide insulation in moderate climate, their effectiveness in extremely cold climates may be limited.

The vegetation may not provide sufficient thermal protection during the winter months. Seventh is the complex design and installation. The design and installation of double screen green facades is more complex compared to conventional facades. Proper engineering and coordination is required to ensure the success of the system.

Eighth is aesthetic changes over time. The appearance of the green facade may change over time as plants grow and evolve. This could lead to variations in the intended aesthetic and may not always align with the original design concept. Ninth is space consumption. They take more space than traditional green facades which can reduce the amount of carpet area or plinth area or rentable space in a building. Now, here let us look at the materials that can be used for a double skin facade.

A double skin green facade requires vertical structural support such as a modular trellis or stainless-steel cables or stainless-steel mesh to guide the plants to climb along the wall of the building like a second layer of skin. The green facades could be integrated with the shading units on the building facade such as trellis or mesh wire units, perforated plate units, tensile cable systems etc. Typically glass or metal or ethylene, tetrafluoroethylene, ETFE. These membranes can be used for the outer skin and a variety of option for the other outer skin including the plants. So, you can have varying materials for containers as shown here and for the mesh.

You also need to have space for humans to access in order to add fertilizers or maintain, add pesticides and so on. So, you can have a cable and a wire rope system like this on which the plant will grow itself or you can have Stainless steel wires on which the plants will attach itself. Let us look at the design consideration for double skin green facades. First is the climate. Adapting the system to the specific climate conditions of the building location is very important.

Second is plant selection. Choosing plants that thrive in the given light, temperature and humidity conditions based on leaf area index is important. Third is irrigation and drainage. Designing a system for efficient watering and drainage to prevent water damage. Next is maintenance. planning for regular maintenance of the plants and the facade system is equally important.

Next is one must have an understanding of the leaf area index. So, leaf area index is the ratio of the total area of the leaves on a plant to the area of ground covered by the plant. This characterizes the indication of canopy density and is used to monitor growth infestation. The higher the LAI or leaf area index the less solar radiation is transmitted to the building facade.

Thus it provides better shading effect. So you need to choose plants that have better LAI or leaf area index along with the other considerations of maintenance, growth rate, etc. Let us now look at one case study. This case study is in Hanoi, Vietnam by Vo Trong Nghia Architects. It has a gross floor area of 388 square meter and is a private residence in a warm

temperate climate. A 15 year old existing house located at a city center at a corner of a street on southwest and an alley on northwest had suffered from dim, dark, wet and moldy environment and which is a typical condition for many of the old houses in Hanoi.

This house had been secured and closed by security bars and shutters, making balconies unused spaces. To remedy this situation, the house was renovated to live with green and abundant light. So what was done? Old security fences were removed and replaced with galvanized steel trellis attached to the existing balcony on which climbers grow. So the unused balconies are transformed into space for greens keeping the privacy and security for the residents. From the interior, every room can enjoy the view of green and get fresh air through it.

The green facade is not only for residents but also for neighbours providing a comforting visual environment to the streets. The green facade and the roof garden function together to reduce energy consumption. They protect the building from the harsh western sunlight. Many kinds of vegetables and fruits are planted here and on the green roof, as well as a tree. This can reduce the urban heat island effect through increased greenery.

This project is a modest attempt to green a tropical building where the benefits of a healthy green home can be shared by the occupant and can have a positive impact on a city. Let us now look at the KMC corporate office in Hyderabad. This office building is in Hyderabad, designed by Rahul Mehrotra Architects, with an area of about 14,000 square meters. It's a corporate office building in a composite climate. You can see this building has the kind of trellis that is used in this building made up of metal on which the greenery grows and then the greenery is planted.

You can see here the coverage of the greenery along with flowering plants with special considerations to the sun needs, the flowering colors, and so on, so that the facade changes its color annually. Here the inner layer of reinforced concrete frame with a standard aluminium window is detached from its outer skin layer or facade. The facade is inspired by the principle that allows the modulation of light and air through the building. By virtue of the colour of the flowers, the facade also changes its colour. The aluminum trellis has an integrated misting system to passively cool the building and cleanse the facade of dust in the hot and windy summer months of Hyderabad.

By doing so, the facade not only serves as an aesthetic element but is also functionally performing as it serves the principles of a green wall that also humidifies the air entering the building considering that it is a composite climate. The trellis is integrated with both the misting system and hydroponic trays and drip irrigation for the plants. Access to the facade through a system of catwalks is available at five levels. Here we see a study done

by seven people in varying climate zones that shows the reduced temperature because of having a green wall. A study done by Sunakorn and Yimprayoon for a tropical rainforest climate showed a reduced temperature by 9.93 degrees Celsius, approximately 10 degrees Celsius. Whereas, a study by Jim in a humid subtropical climate showed a temperature reduction of 5 degrees centigrade on the inside. Kontoleon and Eumorfopoulou for a temperate oceanic climate showed a study and showed that temperature differences in rooms along 4 orientations varied from 2 degrees to 17 degrees. So, we could take along the east; it was 11.

So, 17, 11, 16 and a half, and approximately 2. Again, Coma J. and others have done a study where the average temperature reduced between 14 and 11 degrees Celsius. Perini K and others did a study in a temperate region and showed that there was a temperature difference of about 0.13 degrees centigrade. Da Jesus and others showed that there is a difference of 1.5 degrees Celsius, and Takuya Koyama and others did a study that showed that there was a temperature change of 4 degrees Celsius between the outside and the inside.

Now, these are such varying ranges of temperature. So, what can we understand by it? The reason for these differences could be a series of factors, such as climate zones; they were all done in varying climate zones; there were varying building typologies; there were varying time periods; the season where the measurement happened; and the nature of the plants that were used. and so many other reasons because nothing was the same, the leaf area index was varying but it shows that there is potential for reduction in temperature if we choose the correct species in the correct climate type so the potential for building an HVAC system or energy consumption reduction is possible by use of this double wall, the green double wall, because it has shown effectively to have a reduction in temperature, but we are not able to compare the studies because no two factors remain the same in the different studies. So, in terms of climate adaptive design, the transitional space can potentially optimize the thermal environment, protect against rain and direct solar radiation, and create openness for wind flow, providing a space for occupants to interact. The application of green facades that shade the transitional space is understood as an adaptive and integrated strategy for thermal environment optimization. So, the green facade can definitely function as an advanced passive strategy.

So, today we saw how green facades are classified. How can they be executed either from the ground or on the facade itself? We saw some case studies. We saw its advantages and disadvantages. And we saw studies that were more or less random because we were not able to compare the studies. But all the studies showed a reduction in indoor temperature because of using green facades. With this, we stop today's class, and we will continue next class with yet another advanced technology. Thank you.