Course Name: Architectural Approaches to Decarbonization of Buildings

Professor: Dr. Iyer Vijayalaxmi Kasinath

Department of Architecture,

School of Planning and Architecture, Vijayawada

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Lecture 03

Role of Landscape and water in Passive Design - Part 2

Dear students, welcome back to the class on understanding the impact of vegetation and water bodies in enhancing indoor thermal performance. Last time we had stopped with this class where we saw that certain researchers have indicated that indirect evaporative cooling can offer thermal comfort by even up to reducing two and a half degree centigrade of indoor energy, indoor temperature, depending on the outdoor condition. The traditional spring houses in Iranian architecture have always used water bodies to kind of cool the environment. There are examples of fountains kept inside a room and by virtue of the air circulation, they cool the air. There have been examples of water body adjacent to openings and when warm air flows over it, It gets laden with the moisture and the cool air comforts people inside. Placing pools or water features near windows or in courtyards pre-cools the air through water evaporation, extracting heat and enhancing cooling.

In public buildings, pools and fountains combined with cross ventilation and cooling. Cooling towers can pre-cool ventilation. It can reduce mechanical system workload. This is effective in hot and dry climate and evaporative cooling proves essential for energy efficient cooling strategies.

Placing pools, ponds and water features in close proximity to windows or within courtyards serves to pre-cool the air entering the house. The process involves the evaporation of water which extracts significant amounts of heat from the surrounding air. In public buildings, incorporating pools and fountains can contribute to cooling, especially when combined with cross ventilation through strategically positioned openings. Additionally, cooling towers can be employed to evaporate and pre-cool ventilation air for one or more air handling units, thereby reducing the workload on mechanical cooling system. It is important to note that evaporating cooling is most effective in hot and dry climate.

Because in warm and humid climate the air is already humid and laden with moisture and hence adding more moisture to the already moist air will only increase discomfort

unless it is handled prudently. In this picture You can see that water body is enclosed inside a building and it is enclosed inside a courtyard. The air which passes over the water body gets cooled and if there are openings the air moves and causes ventilation due to the cool air. Here is a case where the spray devices and screens have been used. What are spray devices? Spray devices are small devices which spray mist.

So this is actually mist that is sprayed, and the breeze passes through this misty air and what you get is air which is laden with moisture. The shade water bodies to further reduce temperature of the water, and enhance its capacity to absorb heat from incoming air and this air cools the building and it rises and escapes through the shaft, solar chimney. So evaporative cooling can be made more efficient by coupling it with solar chimney to increase air movement and velocity through the building. This is also being used in the Iranian houses Because the wind catchers along with the water bodies help in keeping the indoors cool. Now let us look at the term plant carbon sequestration.

Plant carbon sequestration is a process where plants absorb carbon in photosynthesis, storing it in structures and soil for nutrient cycling. Carbon is transferred to the soil through roots and litter, forming organic matter through microbial breakdown. Nutrients released support growth of other plants and some carbon is naturally returned to the air during decomposition. In simple terms, it is the process where plants absorb carbon in photosynthesis, store it in its structures and soil for nutrient cycling. Some carbon is released naturally.

So, the processes involved include 1. carbon absorption, plants take in carbon dioxide during photosynthesis. So, plants Trees, grass take in carbon dioxide during photosynthesis. 2. Second step is incorporation into plants.

That is, the absorbed carbon becomes part of the above ground shoots and below ground roots. So the absorbed carbon is used for photosynthesis as well as in the roots. 3. Third is contribution to soil. Carbon is transferred to the soil through roots and litter.

So, the leaves that fall down becomes litter and it decomposes. This organic material or organic matter goes into a labile seapool and the litter gets partly decomposed, while some part of the litter gets converted into lignin cellulose and hemicellulose. Now, in the microbial breakdown, soil microbes breakdown, soil microbes break down plant material utilizing carbon from roots and litter. So, this soil microbial community, it breaks down plant material using carbon from roots and litter. The soil and food web works in such a way that other soil organisms consume microbes and byproduct creating a cycle.

So, this cycle gets created. The nutrient release happens during the breakdown of plant

growth and the carbon returns into the air during decomposition due to respiration. So, from human respiration carbon dioxide is further released into air. Now, let us look at know functional plant functional traits and diversity. Understanding plant functional traits is essential for designing landscapes to capture and store carbon.

Plant traits including functional traits and performance traits independently influence a plant's fitness and overall performance. These traits such as growth form and internal processes, impact size, survival rates and seed production contributes to functional diversity. Diversity in functions play a crucial role in complex adaptive systems, especially when designing landscapes to capture and store carbon. To understand the role of functional diversity, the following components must be understood. First is plant traits.

This is defined as independently measurable features of a plant. they impact performance which in turn affects the plants fitness. So there are functional traits and these functional traits are characteristics like growth form or internal process which indirectly influence a plants fitness through effects on whole plant performance. These include the leaf area, the rooting depth, the amount of nitrogen it can intake. Whereas performance traits are direct measurements of an entire plant's performance and it includes size, survival rates and seed production.

So here the performance traits depends upon the growth rate of a plant, its ability to survive and its ability to regenerate and reproduce itself. For example, a plant with a functional trait of a large leaf with photosynthesis more carbon and have energy to grow faster and that a performance trait it is directly linked to. Then will it have increased fitness. So functional traits lead to performance traits, and that leads to plant fitness because plant reproduction and survival get increased because of the reproduction capacity. So, leaf area, rooting depth, and nitrogen uptake are all measurable features which affect the growth, reproduction and survival.

While direct measurement of plant performance and fitness is growth rate and its ability to survive and reproduce. The next important criteria is- plants like people can feel stressed. Stress for them means not getting enough light or water or nutrients. Some plants are like competitors. They thrive in good conditions.

Stress tolerators have smaller leaves to survive through tough times. They survive during occasions where less water is given. Or for example the plantation on windy beaches. It's under a stressed environment. Ruderals quickly grow after a disturbance.

Plants have different strategies to handle challenges. So stress in plant refers to environmental factors like insufficient light or water or nutrients that limit plant

performance in terms of growth. It can even limit the plant performance in terms of reproduction and survival. Some plants adopt a combination of these strategies showcasing adaptability to different environmental challenges. Plants are classified into three categories.

You have the competitive plants. Competitive plants are adapted to highly fertile environment with low stress and disturbance. They possess competitive characteristics crucial for survival in such favorable conditions. A competitor plant is characterized by large leaves so that it is able to produce more food through photosynthesis.

It is fast growing. It has high nutrient uptake and has good fungal association. This competitor plant is adapted to very fertile environments. So they are adapted to highly fertile environment. They have low stress and disturbance and they possess competitive characteristics. Whereas stress tolerator plants exhibit traits such as smaller leaves because they they are able to tolerate stress.

Which means they are able to thrive in the absence of adequate water or very taxing environment conditions like heat extreme heat they are slow growing because they cannot afford to grow fast and desire more food but They are longer lived perennial. Ruderal or pioneer plants, they are emergent after a disturbance. Either it can be a storm or excessive flooding. These plants grow rapidly and produce abundant seeds. Competitor and ruderal plants lean towards the resource acquisition end of the spectrum, prioritizing the acquisition of resources for growth and reproduction.

Stress-tolerant plants are positioned closer to the conservation end of the spectrum, emphasizing the conservation of resources to withstand challenging conditions. So, ruderal plants produce a lot of seeds because they have to reproduce fast and they are fast growing. They are highly resilient to the vagaries of nature. So, climate positive design helps create landscapes that absorb more carbon than they release.

They combat climate change. It consider landscapes as systems interacting with the environment aiming to store more carbon in plants and soil than emitted. Designers focus on increasing plant life, diversity and protecting stored carbon by covering soil and recycling pruned material. Reducing emissions from construction and maintenance is also crucial. So, climate positive design serves as an effective guiding principle for creating landscapes that actively sequester carbon. In this context, all landscapes function as intricate system interacting with the environment through exchanges of energy, water, carbon, nutrients and various organisms.

To mitigate climate change effectively the carbon flow within the landscape it must be

net positive. Meaning more carbon is stored in biomass and soil than is released through respiration and emission. Human designed and managed landscape should be considered as part of the entire system when assessing carbon fluxes. Neglecting human activities may counteract the carbon sequestration benefits of the landscape. Some landscape architecture projects emit more carbon during construction and maintenance than they sequester, undermining their environmental impact.

Designers practicing climate positive design focus on strategies such as increasing biomass, productivity and vegetation diversity to enhance carbon input. Protecting stored carbon by keeping soil covered with plants and returning pruned material to the site is crucial. Efforts to reduce emissions associated with construction materials and landscape maintenance are also integral to the design approach. Hence, what we understand is plants as well as water bodies are very crucial in having a bioclimatic environment. Vegetation when seen as evergreen or deciduous and when plantation is done with respect to the climatic requirements.

As we have seen the requirements are different for hot dry, hot humid, temperate and cold climates. Use of appropriate trees, shrubs and ground cover to minimize heat gain or minimize heat loss as the case may be goes a long way in passive design and therefore in reducing the load of contraptions which are used to give indoor thermal comfort. Besides, water bodies play a very crucial role because water bodies can act as climate modifiers by virtue of passing on humidity to the air. Combining our knowledge about what we learnt in the design of openings, along with modifying the quality of air that comes in to be either laden with humidity which is relevant in the hot-dry climate and 'not so relevant' in the warm humid climate can further make the indoors very cool. And we have seen this with a number of case studies.

We have also seen what has happened in Jaisalmer. when it comes to openings and we have also seen conceptually use of water bodies along with diverting it inside rooms and use of Jalis in the Ambar Palace at Jaipur. So with these case studies we have learnt how landscaping vegetation and water body have a great influence on indoor thermal performance. So, we will stop the class here and continue next class with yet another interesting topic. Thank you.