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Energy Efficient Landscapes for Tropical Climate

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Abstract: **S**ufficient researches, reinforced with experimental studies are available on heat gain and heat loss in built environment through various landscape design parameters. There is an urgent need to bring awareness and to consider all energy conserving techniques simultaneously while designing/constructing build-up areas. We are using our Earth's non-renewable resources extensively, and if we continue to do the same, all our resources will be exhausted soon. The rapid change in technology has enabled us to construct buildings, almost anywhere on the earth, polluting the Earth in the process. It is high time we adopt energy efficient methods in every field. We try to reduce the amount of energy that is consumed for heating and cooling buildings. 50-80% of the energy can be saved if the building's landscaping and other external features are designed considering the microclimate and the topography of the place. The energy efficient landscape design tools enable decision-making process effectively both at the conceptual and final stage of design of built up areas and it can even be integrated in the decision making matrix with respect to landscape parameters for conservation of energy. Carefully positioned trees can save up to 25% of the energy cooling loads of a typical household use for cooling (U.S. DOE, US department of energy, 2007). This paper gives an idea about landscaping, using conventional methods like Xeriscaping, Heat island effect and Storm water management, which lead to low energy consumption. Refined planning of a landscape considering the implantation of high albedo materials, grouping of vegetation and proper management of the water increases the comfort levels of any microclimate.

Keywords: Xeriscaping, Heat island effect, Micro climate, Storm water, Xeriscaping.

1. INTRODUCTION

Energy-efficient landscaping is new concept designed exclusively for conserving energy. Landscape and Environment are so related to each other in conserving energy, to make comfortable and functional spaces for people and also aesthetically pleasing. The energy conservation potential of landscape parameters and the environment friendly solutions for absorbing dust, heat, light, and shading is achieved through energy efficient landscaping.

2. PROCESS OF DESIGN

The process of design is a composite process which involves the connection between different parameters and the nature. The parameters are: ***Vegetation Pattern:*** Vegetation, specially trees give shade and reduce heat gain and also makes a difference air pressure. As we know that vegetation uses energy in the process of photosynthesis which in turn, cools down the environments. Trees reduced the pressure differences directing the winds towards leeward side and hedges ***make*** minor changes in the airflow. In the Tropical climate, trees can be used to cut off the east-west sun and hot breezes. Trees like deciduous provide comforting shade and shed their leaves in winters as winter sun is not that soothing. Vegetation absorbs and diverts sound, in high frequency bands (1000-2000 hertz, very harmful to the ears). It forces wind upwards making the human level environment calm, forming a boundary sub layer. The sub layer is directly proportional to the height of the vegetation. Vegetation purifies the environment by reducing dust, smoke, and other pollutants. Trees like Pipal Pakur, Banyan, Sal etc., are very good in reducing the dust of the environment around them .

Ground cover: The incident radiation from sun falls on different ground covers and they respond to it respectively—absorption, reflection, partly radiated or reradiated later sometime. The light colored smooth surface reflects more radiation than the dark coloured rough surfaces. Such surfaces store up the radiation and emits most probably at night, which in turn, can be utilized in an efficient way.

Water bodies: Water is one of the good absorbents, which takes in large amounts of radiation, which allows water to be cool due to evaporation. Water in the environment is cooler during daytimes and it is also emits a large amount of radiation during nights. Water bodies have to be avoided in warm and humid regions. Putting the water body with the built environment can assign to the low temperature and its capability to provide comfortable conditions for the hot & dry regions.

Open Spaces: Open spaces make a lot of difference in the free movement of air and a bad usage of the open spaces may create heat gain or loss. Open spaces take in lot of radiation during the day, but the same space if covered with green then less heat is reflected. The proportion of open space and its built-up edges should be designed such that it ensures winter solar access and summer ventilation.

Landform: There are three basic forms of landforms—flat, sloping or undulating. Cooler air usually gets settled in

depressions and dips. As Thermal comfort conditions have become a concern several research organisations have been focused their study of heat Transfer in the built environment. The building fabric itself can be utilised to control the inside environment.

3. XERISCAPING

70 % of the earth is saline water and the fresh water as being very scarce resource now in the world because of excessive usage of water. Xeriscaping is a design that gives qualitative landscape and saving a good amount of water. This landscaping is based on seven principles.

Planning and design: Planning of the landscape is very important taking into account, the microclimate, topography, intended use of the property, and the grouping of plants according to their water intake.

Appropriate plant selection: Selection of local and regional plants is beneficial as they require less irrigation water for they are established there, and also known for their beauty, water efficiency, and resistance to disease and pests.

Practical turf areas: As turf lawns are major use of water and maintenance, it should be used where there is a practical function or to highlight few parts of the building. Drought resistant grass type becomes abeyant in hot, dry climates.

Efficient irrigation: To avoid the water runoff --- Drip irrigation is the most beneficial methods for Plants, shrubs, herbs and groundcovers. Grouping of plants is necessary to provide water to the whenever it needs, conditions like boosting of the root growth in the time of drought. Drought-tolerant landscaping can cut back on water use by 50-75%.

Use of mulches: Mulches are generally wood bark chips, wood grindings, pine straws, nutshells, small gravel, or shredded landscape clippings. They encourage greater retention of water, reduce weed growth, and prevent erosion.

Appropriate maintenance: Optimum usage of water and fertilizers, i.e., when required. Grass when it reaches two to three inches grass has to be cut to promote root growth deeper; avoid using nitrogen fertilizers as they make plants demand more water.

On the whole Xeriscaping creates beautiful landscape without harming the environment and very limited usage of water.

4. HEAT ISLAND EFFECT

Heat island is referred to as an hot umbrella of air surrounding the buildings which is warmer than the surrounding air. As a result of heat island effects, ambient temperatures in urban areas are artificially elevated by 10 F when compared to sub urban areas or the villages away from it. This has increased in a demand for cooling equipment's (HVCA) or building services during the summers.

Solar radiation and Albedo: Solar radiation is usually categorized into three spectrums ultraviolet spectrum, visible spectrum and infrared spectrum. Ozone layer takes in Ultraviolet rays, Plants takes in visible rays for photosynthesis and surfaces and vegetation reflect the infrared rays. Leaves reflect 10% visible rays, 50% infrared rays and still 30% of total sun radiation is under the leaves. (Fig 7) Albedo is a reflection coefficient and is defined as reflection of solar radiation by leaves can be generalized by defining the fraction of sunshine reflected by any surface as its **"ALBEDO"**.. It is expressed in percentage, and is measured on the scale reading ' 0 to 1' zero being absolutely no reflecting power (Black surface) to perfect reflection.(white surface)

Urban Surfaces	Albedo (%)	Emissivity (%)	Thermal Admittance ($J/m^2s^{1/2}K$)
Asphalt	5–15	95	
Concrete	10–50	71–90	
Brick	20–50	90–92	950
Stone	20–35	85–95	
Tar and gravel roof	8–18	92	
Tile roof	10–35	90	
Slate roof	10	90	
Thatch roof	15–20		
Corrugated iron	10–16	13–28	
White paint	50–90	85–95	
Red, brown, green paint	20–35	85–95	
Black paint	2–15	90–98	

Fig 1: Albedos, Emissivites, and Thermal Conductance often found in urban surfaces. (Source: Microclimatic Landscape Design, John Wiley & sons – 1995)

Natural Design strategies to come over heat island effect

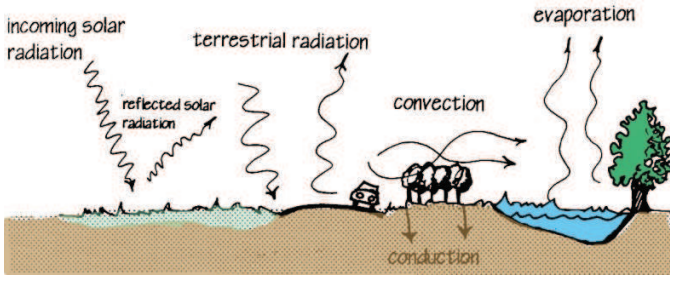

Fig 2: An energy budget of any surface considers all the flows of energy toward and away from the surface. It is useful to consider the magnitudes of the flows through each avenue. For example , if there is no water available for evaporation, then the energy must be shared among the remaining streams of energy .

(Source: Microclimatic Landscape Design, John Wiley & sons – 1995)

Terrestrial radiation: There is another set of long wave radiation called terrestrial radiation which has harmful effects on the environment. These radiations are emitted by the objects on the earth's surface, by clouds and by sky itself. Terrestrial objects on the earth emit energy and is because all the terrestrial molecules are in constant motion emits infrared spectrum. The energy-temperature relationship should obey the Stefan and Boltzmann equation.

Design strategies to come over heat island effect Heat island effect can be considerably reduced through adaptation of following strategies

- Shade has to be provided wherever the site is not roof covered and also impervious.
- Light colored or high-albedo materials (reflectance of at least 0.3) like cement surfaces, white coloured surfaces, etc., on impervious surfaces.
- Use of underground space for parking and open grid pavement system.

Technologies

Roofing: Light colored membrane and metal roofing is a good solution for less emittance of the radiation. Metal roofing has the basic structure usually made of steel or aluminum. Steel roofing is usually coated with a galvanic galvanic corrosion protection coating of zinc or zinc/aluminum coating and this in turn coated with polymeric coat . This coat hides the low emittance of the bare metal and makes the roof cooler.

Vegetative shading: Use of local climate tolerant vegetation for shades in the landscapes with proper design strategies increases the albedo of the site surface. ***Paving material:*** Paving materials should be replaced by Green pavements whose permeability is excellent with the usual concrete and asphalt pavers.

Terrace gardens: Terrace gardens have surfaces with vegetation reduces the heat island effect. It also captures rainwater in an efficient way and also loose water back into the atmosphere through transpiration.

5. STORM WATER MANAGEMENT

The volume of storm water generated on a site depends on the amount of impermeability factor of the surfaces. Impermeability factor is the proportion of the total rainfall received on the surface which gets discharged into the storm water drainage, after the initial absorption though evaporation, vegetation and other losses. The net flow reaching the storm water drain is called as runoff. Problem: Because of the new construction methods for the urban settlement, there has been a reduction in the amount of pervious surfaces. The runoff from the urban areas is polluted and cannot be used for any other alternative work. So, therefore municipal cooperation has to consider storm water treatment seriously. The generation of the storm water volume recharges natural aquifer.

Imperviousness (%) is calculated as:

- Impervious area on ground and roof (m2) = Surface area X Runoff coefficient
- Imperviousness (%) = Total Impervious area / Total site area
- Factors that reduce storm water are:

Bio-swale: A swale is low-lying, grassy, compost or rip raped linear depression that diverts and carries the water through and away from the site. They are designed to remove the silt and pollution from the runoff water. This drainage course has gently sloped sides (less than 6%).

Pervious pavements/Green pavements:

Using pervious paving reduces storm water runoff by allowing precipitation to infiltrate the undersurface through voids in the paving materials. Systems can be applied to pedestrian traffic surfaces as well as low vehicle traffic areas such as parking spaces, fire lanes and maintenance roads. In addition to reducing runoff, this effectively traps suspended solids and filters pollutants from the water. It helps to recharge the ground water table. There different types of green pavements: Pervious concrete,Plastic Grids, Porous asphalt, Single-sized aggregate, Porous turf, Permeable interlocking concrete pavements, Permeable clay brick pavements, Resin bound paving, Bound recycled glass porous pavement.

Riparian buffer: Riparian buffers stop top layer of the land which is rich in nutrients. It has the capacity to stop 95% sediment of the surface water and nutrient by 60%. They stabilize stream banks by reducing bank erosion. The root of the buffer vegetation increases the water holding capacity of soil, and reduces the speed of flooding and recharges groundwater table. They help in recharging the aquatic ecosystem of fresh water bodies.

Bio-Filters: Encourage natural processes of evaporation and infiltration. Designing a smaller foot print and Storm water runoff volumes can also be reduced by designing the building with underground parking, a strategy that also reduces heat island effects.

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