Sustainable Architectural Built Environment

- A Presentation
Contents

- Approach to Sustainability
- Energy Efficient Design & Process
- Design Strategies in Various Climates zones of India
- Introduction to Renewable Energy sources

A case study on Indira Paryavaran Bhawan
Approach to Sustainability

- Climate responsive
  - hot-dry, warm-humid,
  - composite,
  - temperate
  - cold climate
  - sun path movements, annual wind directions, rainfall

- Selection of building materials shall be based on local Architecture.
Energy Efficient Design & Processes

- Climatic zone of the site
- Adopt passive architectural design
- Reduce the hard paved areas
- Retain the mature trees.
- Use of low energy or passive heating or cooling.
Site Design & Development

• Protect
  – Agricultural lands
  – Floodplains
  – Forest areas
  – Water bodies such as lakes, ponds etc.

• Preserve top soil and existing vegetation.
Site Planning

• A well-planned and optimally oriented building:
  - Passive solar heating
  - Solar heat gain.
  - Natural ventilation.
  - High-quality day lighting
  - Storm water runoff.
  - Protect open space.
  - Reduce the risk of soil erosion.
Passive Architecture Design

- Based upon climate considerations
- Attempts to control comfort
- Orientation of the building
- Building envelope (plan, section) to control air flow
- Uses materials to control heat
- Maximizes use of free solar energy
- Maximizes use of free ventilation for cooling
- Uses shade (natural or architectural) to control heat gain
Differentiating Passive vs. Active Design

Passive design results when a building is created and simply works “on its own”.

Active design uses equipment to modify the state of the building, create energy and comfort; ie. Fans, pumps, etc.
Climatic zones of India

- Hot & Dry
- Warm & Humid
- Composite
- Temperate
- Cold
Design Strategies in Hot & Dry Climate

- Large openings
- Windows area.
- Internal courtyard for cross ventilation & thermal buffer
- Radiation barriers in the form of canopies, chhajjas, long verandahs etc.
Design Strategies in Warm & Humid Climate

• Orientation should preferably be in North-South direction.
• Provide maximum cross ventilation in the building.
SUSTAINABLE ARCHITECTURAL BUILT ENVIRONMENT

CA(NDR), CPWD

Vegetation gives shade from low-angle western sun but does not block the breezes

Prevailing summer wind

Tall palms do not block the breezes

Main verandah on windward side of house

Open for cross-ventilation

Steps to high-set house

Open plan living area

Overhead fans

Verandah

BR

BR

BR

BR

B

D

E

F

L

K

G

H

I

J

C

N

Design for a warm/hot humid climate
Design Strategies in Composite Climate

- Plan the building around the courtyard.
- Reduce heat gain in the building through building envelope.
- Plan water bodies
- cavity walls, terrace gardens, light shelves.
Design Strategies in Temperate Climate

- cavity walls, terrace gardens, green roof, light shelves

- Roof insulation using insulation material, china clay or clay pots is advisable.
Design Strategies in Cold Climate

- Glazing windows up to 25% floor area
- Double glazing to avoid heat losses during winter nights.
- Adopt Trombe walls.
- Sunspaces
Building Envelope

• Reduction in energy consumption by HVAC system.
• The thermal energy efficiency of the building Internal Heat Gain Factors:
  – **Solar Heat Gain Coefficient (SHGC):**
  – solar heat that passes through the glazing
  . The lower the SHGC, the lesser the direct incident heat gains from the glazing surfaces.
# Strategies for Designing Building Envelope

<table>
<thead>
<tr>
<th>Climate</th>
<th>$\text{WWR} \leq 40%$</th>
<th>$40% &lt; \text{WWR} \leq 60%$</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Maximum SHGC</td>
<td>Maximum SHGC</td>
</tr>
<tr>
<td>Composite</td>
<td>0.25</td>
<td>0.2</td>
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<tr>
<td>Hot and Dry</td>
<td>0.25</td>
<td>0.2</td>
</tr>
<tr>
<td>Warm and Humid</td>
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<td>0.2</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Cold</td>
<td>0.51</td>
<td>0.51</td>
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</table>
Solar Radiation

Reflected off of the glass.

Absorbed into the glass.

Initial transmission through the glass – as once the heat is in, it is IN.
Solar Transmission through Varying Types of Glass

**Clear Glass**
- Most of the incident solar radiation is: **Transmitted**
- Heat Gain: 

**Heat Absorbing Glass**
- Most of the incident solar radiation is: **Transmitted + ReRadiated In**
- Heat Gain:

**Reflective Glass**
- Most of the incident solar radiation is: **Reflected**
- Heat Gain:
Solar energy received on the different facades and roof of a building.

A horizontal window (skylight) receives 4 to 5 times more solar radiation than south window on June 21.

East and West glazing collects almost 3 times the solar radiation of south window.
A simple roof overhang acts as a shading device.
External Heat Gain Factors

**U – Value:**
Amount of heat that gets transmitted through a unit area of a material for a unit difference in temperature.

The lower the U-Value of the material, the lesser the heat transfer, and better the thermal efficiency. ECBC recommends the U-values for glazing:

<table>
<thead>
<tr>
<th>Climate</th>
<th>Maximum U-factor (W/sq.m.-°C)</th>
</tr>
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<tbody>
<tr>
<td>Composite</td>
<td>3.3</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>3.3</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>3.3</td>
</tr>
<tr>
<td>Moderate</td>
<td>6.9</td>
</tr>
<tr>
<td>Cold</td>
<td>3.3</td>
</tr>
</tbody>
</table>
Reduction in Overall Embodied Energy

- low energy materials for construction.
- Promote the use of low energy materials in interiors to maintain indoor air quality.
- sealants and adhesives used are water based rather than solvent based or have low solvent content.
Renewable Energy

Types of Renewable Energy:
- Solar
- Biomass
- Wind
- Water
- Geothermal
Solar Energy

• Solar power is used for hot water & for generating Electricity.

Disadvantages
• Cost very high.
• Require large area.
Wind Energy

• Wind is caused due to difference of temperature at the earth’s surface when lit by sunlight.

• Wind Energy can be used to pump water or generate electricity.

  Disadvantages

• Initial Cost is very High.
• Wind Farms are Unsightly and wind turbines are noisy.
• Maintenance of wind mills is very costly.
Waste Management Hierarchy

1. Waste Minimisation
2. Re-use
3. Recycle / Compost
4. Energy Recovery
5. Disposal

Most Sustainable
Least Sustainable
ARCHITECTURAL DESIGN STRATEGIES

CASE STUDY

INDIRA PARAYAVARAN BHAWAN OFFICE BUILDING FOR MINISTRY OF ENVIRONMENT&FORESTS.
ALIGANJ JORBAGH NEW DELHI
Redevelopment Plan Of Aliganj
### PROJECT LOCATION

<table>
<thead>
<tr>
<th>Nearest Highway</th>
<th>• NH-2</th>
<th>3.9 km</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>• NH-8</td>
<td>4.2 km</td>
</tr>
<tr>
<td>Nearest Metro Station</td>
<td>Jorbagh</td>
<td>0.5 km</td>
</tr>
<tr>
<td>Nearest Railway Station</td>
<td>• Lody Colony RS</td>
<td>0.6 km</td>
</tr>
<tr>
<td></td>
<td>• Hazrat Nizamuddin</td>
<td>4.0 km</td>
</tr>
<tr>
<td>Nearest Airport</td>
<td>• Safdarjung Airport</td>
<td>1.2 km</td>
</tr>
<tr>
<td></td>
<td>• IGI Airport</td>
<td>11 km</td>
</tr>
</tbody>
</table>
The excellent location in the heart of Delhi, offers an opportunity to create a link with the Delhi’s Past.
Executing the Design Brief

With the building’s envelope design & Green concepts, it was ready to incorporate not only a Net Zero, but an “Energy-Positive” approach.
Architectural Design Strategies

- Building form wrapped around a pedestrian-friendly shaded green open courtyard.
- A continuous green axis from front of site across the atrium.
- Eco park within the courtyard shall contain a self-sustaining low.
- Large openings in building form on South and North sides.
Architectural Design Strategies

Conservation of natural soil and trees.

Orientation of building has been planned to reduce ingress of solar radiation.

Large openings on North and South faces.

Green areas have been developed on smaller terraces.

Shaded landscape areas to reduce ambient temperature.

Provision of barrier free access.

Surrounding open area parking free by providing adequate parking in the basement.
Architectural Design Strategies

The façade has been designed to receive 70% of natural daylight.

Shading devices East, West and South to take care of the solar radiations especially in summer.

On the Southern side of the building terraces have been created to take the winter sun.

Barrier free access to differently-abled persons.

Automated parking in three level basements.
Site Planning with respect to Nature

- Maximum Ground Coverage Used (30%) to keep building height comparable to the surroundings
- Respecting the Eco-logic of the site. Building Punctures to Aid Cross Ventilation
Energy Conservation Measures

- Energy Efficient Lighting with LPD = 5W/SQM
- Reduction of Artificial Lighting Load
- Remaining Lighting Load supplied by Building Integrated Photovoltaics
- Daylighting Design with Perimeter & Inner Courtyard Fenestration
- Photovoltaics on space frame over courtyard
- Further Cooling Air in Cooling Towers
- Chilled Beam System for Air Distribution
- Functional Zoning to Minimize AC Load
  - Highly conditioned
  - Conditioned
  - Non-conditioned
- Pre-cooling Air through Geo-Thermal Exchange
- Building Envelope Design to Minimize Heat Ingress
Usage of Building configurations for utilizing lessons from nature and traditional built environments

PROJECTIONS INTO THE CENTRAL SPACE FOR SHADING + Shading by Passages

JAALIS IN THE LOBBY TO AID CROSS VENTILATION & PREVENT HEAT GAIN

CROSS VENTILATION AT THE MICRO LEVEL THROUGH OPENINGS
Envelope Design: Natural Ventilation

Natural ventilation due to stack effect

Building punctures are designed to aid cross ventilation
Layout Plan
WALL SECTIONS

High Efficiency Glass, high VLT, low Low U-value
Light Shelves for bringing in diffused sunlight
Use of Eco friendly Materials

- Fly Ash Brick
- Aerated Autoclaved Cement (AAC) Block
- Portland Puzzolona Cement (with 30% fly ash)
- Patterned multi-coloured terrazzo flooring with salvaged stone pieces
- Grass Paver Blocks Pavements
- Local Stone with Marble Strips
- Calcium Silicate Tiles
- Bamboo Jute Composite for Frames & Doors
- Low Volatile Organic Compound Paints
- Natural stone for flooring and cladding
Sustainable Building Features

- Natural ventilation
- Solar power generation
- Solar passive envelope design including walls & roof insulation & fenestration
- Efficient electrical equipment as per ECBC 2007 requirements
- Waste water recycling for Cooling Tower
- Rain water harvesting
- Geo thermal technology for heat rejection of AC system
- Design inside temperature: 26°C
Notable Features of the Building

- A Net Zero Energy Building
  - Energy demand and generation of building is 14 lakh KWH
- Energy Efficiency
  - LPD achieved is 5 watt/sqm as against 11.8 watt/sqm of ECBC 2007
    saving in energy > 50%
  - 450Sft/Tr as against 150sft/Tr in conventional building
  - Electrical load designed as 4.3 W/Sft as against 10W/sft in conventional building
Energy Conservation Measures

- Overall Design Load optimized at 800 KW
- High Efficiency Solar Panels for Net Zero
- Energy efficient T-5 and LED Fixtures
- Innovative Chilled Beam system for cooling
- Water cooled chillers, double skin air handling units with variable frequency drives (VFD)
- Geo thermal heat exchange for heat rejection from Air-conditioning system
Innovation & Design

- Geothermal heat rejection
- Chilled beam system for HVAC
- Regenerative Lift
- High Efficiency Solar panel.
- Mechanized car parking.
- Low energy EM technology for Bio digestion of organic waste.
Showcasing Biodiversity

- Regenerative Architecture keeping the existing balance of nature to connect outdoor greens and the courtyard greens.
Showcasing Bio Diversity

- Showcase green bio diversity from Bio-climatic regions of Hot Dry, Composite, Warm Humid, Temperate, Cold Dry & Cold Cloudy
- Developing Winter Southside sunspaces for office Employees
THANKS
Solid Waste Management

- Minimize waste generation.
- Streamline waste segregation.
- Plan proper storage, and disposal.
- Promote resource recovery from waste.
- At the time of the construction allocate separate space for the collected waste before transferring it to the recycling/disposal station.
Internal Heat Gain Factors

- LPD Level
- EPD Level
- Building Occupancy
Integrated Water Management

• The use of water conservation fixtures.
• Landscaping water requirement reduction.
• Rain water harvesting
• Aquifer recharging
• Waste-water recycling
• Involve use of efficient building and plumbing services components.
• Minimize the consumption of mains supply potable water.
External Heat Gain Factors

- Projection Factor:
  
  \[ PF = \frac{A}{B} \]

- Visible Light Transmittance (VLT):
Salient Features

- Solar power generation
- Solar passive envelope design including walls & roof insulation & fenestration
- Efficient electrical equipment as per ECBC 2007 requirements
- Waste water recycling for Cooling Tower
- Rain water harvesting
- Design temperature: 26° C (S) / 20° C (W)
- Natural ventilation
INTRODUCTION

Land use changed from Residential to Government office

• Named as Indira Paryavaran Bhawan

• Plot of land measuring 9565 sq.M
Types of Radiation

Reflective glazing

SAND OR CONCRETE SURFACE

DIRECT RADIATION

REFLECTED RADIATION

REFLECTED RADIATION
## Glazing Characteristics

### Table 2: Modeled Glazing Characteristics

<table>
<thead>
<tr>
<th>Window Properties</th>
<th>ECBC (Prescriptive Requirements)</th>
<th>“Proposed” glazing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window (Assembly) U-value (in Btu/h.ft²°C)</td>
<td>0.55</td>
<td>0.281</td>
</tr>
<tr>
<td>Visible Light Transmittance</td>
<td>N.R.</td>
<td>.59</td>
</tr>
<tr>
<td>Solar Heat Gain Coefficient</td>
<td>0.25</td>
<td>.32</td>
</tr>
</tbody>
</table>