Sustainable Architectural Design - The GRIHA Approach

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Content

Defining Sustainable Architecture - from the eyes of a sustainable consultant

What does GRIHA say to achieve sustainable architecture- Description of GRIHA Criterion

Examples of Sustainable architecture - a few demonstration projects of TERI
Architectural design that provides comfort to occupants using nature’s resources with minimal impact on the environment.
Criteria 4: Design To Include Existing Site Features

4.1 Commitment

• 4.1.1 Carry out a comprehensive site analysis to identify site characteristics that can be used to harness natural resources (like solar energy, wind, and water)

• 4.1.2 Locate various activities of the scheme after careful site analysis and assessment so as to protect ecologically sensitive areas and reduce damage to the natural ecosystem.

• 4.1.3 Identify areas of the site that were damaged during construction and take steps to mitigate the harm and improve the natural site conditions.
ITC Guntur - Residential Township in Andhra Pradesh
Higher wind speeds for better comfort in outdoor, semi outdoor and courtyard spaces and by adding a stilt, bridges and intermediate courts and landscape elements.
ITC Bhadrachalam - Residential Township

Solar irradiation analysis - high rise dense development
GRIHA - Sustainable Architecture

Criteria 13: Optimize Building Design to Reduce Conventional Energy Demand

13.1 Commitment

- 13.1.1 Appropriate climate responsive design strategies should be adopted such as: orientation, placement of fenestration and buffer zones, shading devices.
- 13.1.2 Window Wall Ratio (WWR) to be limited to maximum 60%, and Skylight Roof Ratio (SRR) to be limited to a max of 5%.
- 13.1.3 Demonstrate that the effective Solar Heat Gain Coefficient (SHGC) is compliant with the maximum SHGC prescribed by ECBC-2007.
- Ensure daylight area is ≥25%. Every 25% increase in daylight area – upto a maximum of 75%- shall fetch one additional point.
To apply climate responsive building design measures, including day-lighting and efficient artificial lighting design, in order to reduce the conventional energy demand.
Window Wall Ratio

Window-Wall-Ratio (WWR) : The Window Wall Ratio refers to the ratio of the total fenestration area to the gross wall area.

ECBC in a prescriptive approach recommends a maximum WWR of 60%.

The portion of the glazing which lets in light is same in both cases. This is why WWR is important. The rest of the glass does not contribute to daylight, only permits more heat inside.
Climate Analysis

Hourly weather file processing from daily data acquired from meteorology department

**Psychrometric Chart**
- Location: Bhadrachalam, IND
- Frequency: 1st January to 31st December
- Weekday Times: 00:00-24:00 Hrs
- Weekend Times: 00:00-24:00 Hrs
- Barometric Pressure: 101.36 kPa
- © Weather Tool

**SELECTED DESIGN TECHNIQUES:**
1. exposed mass + night-purge ventilation
2. natural ventilation

Blue dots show outdoor climate of Bhadrachalam

Thermal comfort band and extended adaptive comfort bands after integrating passive strategies
Solar Irradiation data

15th December

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India Solar Resource
Global Horizontal Solar Resource

This map depicts model estimates of annual average global horizontal irradiance (GHI) at 10 km resolution based on hourly estimates of radiation over 7 years (2002-2008). The inputs are visible imagery from geostationary satellites, aerosol optical depth, water vapor, and ozone.
UHI Study- Air Temperature at 1.2m lvl on a typical day during March

Base Case- Asphalt Roads & Cement concrete paving

Design Case- with vegetation and landscape elements recommended

Adding vegetation and landscape elements reduces air temperature by 3 to 4 deg C
Solar analysis for High-rise structures

- Increase in daylight and decrease in shading factor especially in rooms facing inner courtyards - as we go up in dense developments

- No additional shading for lower floors and an optimized shading for upper floors is recommended to maintain uniform thermal and visual comfort conditions across the floors

Average DF:
- Ground Floor: 1.8
- Fifth Floor: 2.0
- Ninth Floor: 3.8

Shading Factor:
- Ground Floor: 1
- Fifth Floor: 0.83
- Ninth Floor: 0.56
Daylight Autonomy

It is essential to provide daylight in Kitchen, especially between 08:00hrs and 10:00hrs to reduce energy demand on artificial lighting.

Daylight Autonomy (DA) is calculated and found that 26.6% of the day time in a year, lighting level of 225 lux (with 60% VLT) is present in the space on the first floor.

Study of Daylight Glare Indices
Indoor Air Movement in Employee Quarters

1.6 m/s SW to NE @ 1st Floor Level

Earth Science and Climate Change
Decentralized Electricity Solutions
Sustainable Habitats
Environment Education & Youth Services
Energy Environment Technology Development
Environment & Industrial Bio-Technology
Sustainable Habitats
Water Resources
Bio-Technology & Bio-Resources
Resources Regulation & Global Security
Modeling & Economic Analysis
Industrial Energy Efficiency
Sustainable Development Outreach
Social Transformation
Conceptual Sketch and actual CFD model of Window System Proposed For Non Ventilated Spaces

Conceptual sketch

AIRFLOW IN ITG BHADRA CHALAM RESIDENTIAL UNITS

CFD Model

Conceptual sketch

CFD Model

Conceptual Sketch and actual CFD model of Window System Proposed For Non Ventilated Spaces
Power Grid Corporation of India Limited
Campus at Bangalore

Project Details
Site Area : 12 acres
Built-Up Area : 17,305 Sq.m

Courtesy: Klimart
Solar analysis of PGCIL building for window optimization

Window design optimization to respond to solar angles and achieve daylight

Solar Analysis and Daylight availability Studies

Optimize design to achieve glare free daylight with minimum external heat gains

Daylight levels inside the work place.
Window design optimization for PGCIL Buildings, Bangalore
Integration of light pipes in PGCIL headquarters

Courtesy: Skyshade Daylights
Solar radiation intensity analysis to design jallis for British School, Delhi
Shading Design- Option 2: Screen on West to cut the sun all round the year - EMPRI Project in Bangalore

Schematic View
Criteria- 14: Optimize energy performance of building within specified comfort limits

Appraisal

14.3.1 Compliance with Energy Conservation Building Code as per clause 14.2.1 (6 points).

14.3.2 10% Reduction below the Energy Performance Index as in Table 14.1 to 14.2 and the thermal comfort criteria are fully met as per clause 14.1.7 and 14.1.8 (2-10 points). Achievement of benchmarked EPI shall fetch 2 points and every 10% reduction in EPI for respective cases shall fetch 2 additional points to a maximum of 10 points (50% reduction in EPI from the benchmark).
## Building envelope optimization for Air conditioned and Non Air conditioned spaces

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Roof U-Value (W/m²K)</th>
<th>Wall U-Value (W/m²K)</th>
<th>Glazing View Window U-Value (W/m²K)</th>
<th>SHGC</th>
<th>VLT</th>
<th>Reduction in TR Load (%)</th>
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<td>0.37</td>
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<td>6.17</td>
<td>0.815</td>
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<td><strong>4 Glazing optimised Case</strong></td>
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<td><strong>6 Cumulative2 (Under Deck)</strong></td>
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<td>1.59</td>
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first principles can be fairly simple and are universal

e.g. solar heating processes which happen everywhere

sun on roof surface leads to temperature rise and temperature rise to heat transfer which occurs on both sides affecting the outdoor environment as well as room temperature below and everything gets involved…
1.2 Hypotheses
Implementation of Urban Heat Island (UHI) mitigation measures for various urban surfaces will reduce the ambient air temperatures. Energy savings in air conditioned buildings will possible due to improved micro climate around the buildings. Increased permeability of the urban surfaces will reduce the storm water runoff.
Sustainable Urban Development: Minimizing urban heat island effect and imperviousness factor
Sustainable Urban Development: Minimizing urban heat island effect and imperviousness factor
Integration of Renewable Energy

5MW Solar Photovoltaic system project for the Presider

SOUTH

PHOTOVOLTAIC PANELS

SECTION AA

Earth Science and Climate Change
Decentralized Electricity Solutions
Environment Education & Youth Services
Energy Environment Technology Development
Environment & Industrial Bio-Technology

Sustainable Habitats
Water Resources
Bio-Technology & Bio-Resources
Resources Regulation & Global Security
Modeling & Economic Analysis

Industrial Energy Efficiency
Sustainable Development Outreach
Social Transformation

5MW Solar Photovoltaic system project for the Presidential Estate
Green interventions not limited to high end buildings.....
Solar Passive Silkworm rearing house, Bangalore

Thermal comfort requirement: Chawki room: 25 to 28 deg C with 70-90% RH

Rearing room: 23 to 25 deg C with 70-80% RH

Non uniform heating/cooling leads to loss in 50-70% of yield
Solar passive silkworm rearing house for enhanced productivity

Strategies for summer:
- Roof pond with insulation
- Insulated wall and roof
- Wall shading
- Solar chimney on south wall with adjustable vents (to improve ACH in the rearing room)
- Air Inlet from north wall covered with wet gunny bags for added humidity
Details of the constructed solar passive silkworm rearing house

Floor plan for silkworm rearing house

View of the constructed house at SSTL campus
Constructed solar passive silk worm rearing house

Building section for silkworm rearing house
Details of the constructed house
Thank you

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