BHUTAN GREEN BUILDING GUIDELINES

Draft 3

Department of Engineering Services,
Ministry of Works and Human Settlements
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Foreword

The Honourable Minister
Ministry of Works and Human Settlements,
Thimphu, Bhutan.

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INTRODUCTION

The Bhutan Green Building Guidelines has been developed by the Ministry of Works and Human Settlements in line its strategies of positive design and construction in Bhutan that protects environmental conservation. This Guideline supports Bhutan's development principles inspired by Gross National Happiness (GNH) which ensure the integration of equitable economic development with environmental and cultural conservation.

Principles of Green building design and construction is a simple yet extremely effective way of allowing people to become responsible with energy and natural resources while building their home and cities.

The need for sustainable development in the building design and construction sector has become significant in the last decade due to the major resource consumption and contamination buildings generate. As yet there is no sustainable design model or guideline in Bhutan principally building design and construction.

The Guidelines is intended to meet this gap by providing practical and easily applied information and design elements that can be readily introduced into the design and construction sector of Bhutan.

The Guidelines accordingly provides information on various components that will help to ensure green and sustainable outcomes in the various processes of design and construction of buildings in Bhutan.

OVERVIEW OF THESE GUIDELINES

OBJECTIVES OF THE GUIDELINES

The Bhutan Green Building Guidelines has been primarily prepared with the intent to enhance the positive impacts of the built environment on the natural environment and to boost public health, and general wellbeing. It provides simple yet practical information and recommendations to Architects, Engineers, builders, owners, and agencies on how to integrate and apply principles and practices of sustainable green design and construction in buildings built in Bhutan.

SCOPE OF THE GUIDELINES

a. The Bhutan Green Building Guidelines simply provides information, recommendations, and guidance to incorporate sustainable green principles into new design and construction of buildings in Bhutan.
b. The Bhutan Green Building Guidelines will not be mandatory but rather a source of information and encouragement.
c. It will be used in conjunction with other Acts, Codes, Regulations, and Standards related to the built environment in Bhutan and environmental considerations. It is the responsibility of those seeking approval for construction of buildings to ensure that they are aware of all related current Acts, policies, and regulations and take these into consideration for guidance and approvals from relevant authorities
d. It will serve as a source of information for the enforcement of the Bhutan Green Building Codes should that come into enforcement.
e. Acknowledging that sustainability is an ongoing process rather than an endpoint, the Guidelines will provide a starting point.
f. The intention is that the Guidelines is amended and promulgated on a 2 year cycle to allow for the integration of new design and construction ideas, strategies and technologies. New designs, material, technologies, or strategies not specified in the Guidelines may be allowed provided that such measures meet the core intent of the green buildings. This provision should be endorsed by jurisdicted officers (with professional experience in this field) or a committee of appropriate professionals with relevant experience depending on the magnitude and significance.

HOW TO USE THE GUIDELINES

This Guidelines are not intended to prevent the use of any techniques, designs, material, method of construction, or any new and innovative approach not specifically prescribed herein, provided that such construction, design, system or innovative approach are within the minimum standards in Guidelines and explicitly demonstrate in the proposal through design, illustration and presentation the improved techniques/design.

The intention is to allow and encourage the use of innovative approaches, techniques, and technology as long as they achieve compliance with the intent of the Guidelines.

Above all, the Guidelines are in the end meant to encourage proposals to exceed the compliance standards to ensure high levels of sustainability of design and construction of buildings in Bhutan.

ADMINISTRATION AND ENFORCEMENT

The Administration of these Guidelines will be lead by the Ministry of Works and Human Settlements in consultation with relevant agencies and stakeholders.

The Ministry of Works and Human Settlement will identify the offices within the Ministry for the propagation and processes relevant to the Guidelines.

These offices will subsequently formulate necessary regulations and activities to take these Guidelines forward within the different sectors and Districts of Bhutan.

ASSESSMENT ROUTES AND RATING SYSTEMS

The offices identified under the Ministry of Works and Human Settlements will be responsible for the formulating the assessment routes and rating systems for Green Buildings design and construction in Bhutan.

SECTION 1

PRE DESIGN FOR SUSTAINABILITY

SECTION 1: PRE-DESIGN FOR SUSTAINABILITY

Measures taken in this Section is fundamental in the planning and design decisions. The choices made in this Section will have a profound effect on the project's success from a sustainable green perspective.

SITE SELECTION

Site selection for Green Buildings is crucial to ensure that green principles are incorporated right from the beginning of the project.

In order to effectively reduce the overall impact of the built environment on the natural environment, it is necessary to first consider a building's siting, both in terms of its location as well as on the site itself. Within a broader context, sustainable development looks to maintain as much open space as possible within communities through the selection of previously developed land, the re-use of areas that seem unusable, and locating buildings in areas of existing development where infrastructure already exists

Sites should be developed to be compatible with the role of protecting these conservation values. Sites that have been disturbed or have existing buildings and structures will be the most obvious sites for proposed new purposes or expansion of existing uses. However, existing disturbance and the degree of modification is only one factor to be considered. Other features of a site and surrounding locality must also be taken into account.

Environmental assessment including identification of the ecology of the site and its context and whether the proposal will be compatible with the existing settings including the physical, social and management of the characteristics of the site and its immediate surrounding landscape context is necessary to ensure sustainable development of sites.

THE DESIGN AND BUILDING PROGRAM

In normal standards of project selection for construction in Bhutan, there is no attention to the design and building program apart from what it will be in terms of design to the occupants or clients of the building. Within the parameters of green principles, the design and building program must be assessed and planned according to green principles. This means that:

- besides the design requirements of the clients, the overall impact of the design and construction on the context and the overall location of the building within the community must be considered.
- How the design and construction will impact the local impact must be channelled to ensure positive impacts on not just the occupants of the particular building but also the local surroundings.

STANDARDS OF DESIGN TEAM

The development of the design and proposals for infrastructure in the context of green buildings requires sensitive and higher standards than typical building proposals.

If the design team does not have any training and experience in green design and construction principles then the subsequent results will not match the standards required for the development of green design and construction in Bhutan. Therefore, the services of qualified and experienced professionals are necessary for the preparation of the design and construction proposals.

PROFESSIONAL DESIGN TEAM SELECTION

For a green building project, the client must ensure that certain standards of professional team selection are maintained. This means that for each project, the criterion for selection of the professional design team must be clearly specified right from the start of the program and within the project proposal.

This selection of competent and appropriately qualified team will automatically ensure that principles of green design and construction are maintained right from the start of the project and through out the project planning stage till the completion of the project.

The standards for selection of the professional design team may be decided according to the complexities of the project.

One of the positive outcomes of the selection of an appropriate professional design team will also be that these professionals will not only provide the right guidance but will also ensure that principles and methods that were overlooked within the project program will be subsequently be enhanced.

CONSIDERATION OF LEGISLATION AND CODES OF BHUTAN

The Guidelines should be read and applied in conjunction with all existing and applicable Regulations, Codes, Standards, Acts, and Guidelines for land, buildings, products, infrastructure, and environmental conservation. Some of the relevant Acts, policies, and regulations include:

1. Bhutan Building Rules 2002
2. Traditional Architectural Guidelines
3. Attic Rules 2009
4. Bhutan National Urbanization Strategy 2008
5. Thimphu Municipal Development Control Regulations 2004
6. Thimphu City Development Strategy 2008
7. Local Area Plans
8. Urban Structure Plans
9. Bhutan Schedule of Rates 2011
10. Land Act, 2007
11. Forest and Nature Conservation Act, 1995
12. Forest and Nature Conservation Rules, 2006
13. Thromde Rules of Kingdom of Bhutan 2011
14. Local Government Act 2009
15. The National Environmental Protection Act of Bhutan, 2007
16. Environment Assessment Act, NEC, 2000
17. Environmental Monitoring regulations of NEC
18. National Environment Strategy 1998
19. Regulation for Environmental Clearance of Projects from NEC
20. Environmental Codes of Practice (ECOP) for Storm water Drainage Systems, NEC 2004
21. Waste Prevention and Management Regulation 2012
22. The Water Act of Bhutan 2011
23. Renewable energy Policy, MoEA 2012

PROJECT BUDGET

In standard practices in Bhutan, there is no consideration of incorporating green design and construction principles within the budget of a project.

This consideration is only incorporated or considered at a later stage only as a singular clause during the formulation of the Design Brief while hiring the professional design team.

However, it is recommended that in order to ensure green building design and construction in Bhutan, that the requirement for the building design and construction to be green should be incorporated and enshrined within the project budget right from the initial estimating stage for the project to be approved by the funding authorities.

PROJECT SCHEDULE

In standard practices in Bhutan, there is no consideration of incorporating green design and construction principles within the schedule of a project.

This consideration is only incorporated or considered at a later stage only as a singular clause during the formulation of the Design Brief while hiring the professional design team or the construction contractor.

In order to ensure that green design and construction principles are part of the backbone of a project, activities for this consideration should be incorporated right from the start within the schedule of a project.

SECTION 2

PLANNING AND DESIGN

SECTION 2: PLANNING AND DESIGN

The green approach to design in architecture is not a new concept within the built environment of Bhutan. Our local vernacular architectural traditions of Bhutan are excellent examples of buildings that embody sustainability in design and construction.

With extremely sensitive and holistic approach to the environment, our local traditional vernacular buildings are located on sites selected carefully. Local and natural resources are usually used and they are designed to have orientations, spaces and forms that are in tune with the local climatic conditions, solar and daylight accessibility.

There are two main principles for green design planning. These include

1. Passive Strategies

2. Active Strategies

For Bhutan in order to achieve effectiveness through practical and cost efficient methods, passive measures as recommended as opposed to active mechanical or technical measures which uses power and fuel to operate:

The main passive measure includes:

1) Passive solar design with local climate considerations.

PASSIVE SOLAR DESIGN WITH LOCAL CLIMATE CONSIDERATIONS

The basic idea of passive solar design is to allow natural daylight, heat, and airflow into a building when beneficial. The objectives are to control or enhance the entrance of sunlight and air flow into the building at appropriate times and to store and distribute the heat and cool air so it is available when required.

Many passive solar design options can be achieved at little or no additional cost. Others are economically viable over a building’s life-cycle.

Studies show that passive solar buildings use almost 47% less energy than conventional new buildings and 60% less than comparable older buildings.

Properly designed and constructed, passive solar buildings offer many benefits to building owners and occupants, including:

- Energy Performance:
- High economic return on the incremental investment on a life-cycle cost basis and greater financial independence from future rises in energy and fuel costs.
- Greater thermal comfort, less reliance on noisy and expensive mechanical systems, solid construction (more thermal mass), sunny family friendly interiors, and floor plans.
- Low Maintenance: Reduced building maintenance costs resulting from less reliance on mechanical systems.
- Environmental conservation and less pollution: Reduced energy usage and reliance on fossil fuels.

Successfully integrating passive energy design strategies requires a systematic approach that begins in the **pre-design phase** and carries on throughout the **entire design process.** It is critical that the building owners and the design team agree to integrate passive solar design considerations during the appropriate project phases.

The main design considerations include:

1) Careful siting of Buildings for solar accessibility

2) Careful siting of Buildings on the site for shading in hot climates

3) Sensitive Building orientation

4) Building massing for thermal storage

5) Designing for day lighting

6) Natural ventilation

7) Building form and sealing of building envelope where necessary

PASSIVE SOLAR DESIGN STRATEGIES

1. **Placement of Buildings on the Site**

   The buildings will be located to take advantage of the solar energy from the sun. The structures could be located more towards the northern side of the site to leave more space towards the South for gardens and views.

2. **Building orientation**

   The building should consider orientation towards solar radiation in cold places (and opposite in hot areas) to maximize exposure to the sun's heat for solar gain and light which is necessary in cold places in the many Parks of Bhutan.

3. **Insulated and air tight construction**

   The building should feature appropriate insulation levels and will have double glazing where possible to ensure no warmth from the building escapes outside and the cold doesn't seep in so there is no unnecessary heat loss.

   All doors and windows are to be airtight as far as possible so provisions for timber to be seasoned should be considered to prevent cracks between timber elements.

   Weather stripping used to close gaps around openings will also help prevent heat loss.

4. **Thermal Mass.**

   Thick stone masonry or rammed earth walls may be used to serve as thermal mass to insulate the building and to also absorb solar gains to heat the building.

5. **Orientation of rooms**

   In cold areas, all the main living areas where applicable are best orientated to the south to get as much as possible the natural benefits of the sun, while other areas like toilets, corridors, etc., could be located at the northern side.

   Main windows and balconies should be designed to face South and South-east for solar gain. North facing windows could be limited as there is no solar gain towards this direction.

6. Building Form

The form of the buildings is best designed to try to expose as little as possible to the cold external temperatures in colder areas. Therefore it is not a sprawling or rambling building but will have a larger floor area when compared to the area of the walls and roof.

7. Building Envelope

The building envelope plays an important part in keeping out the external cold and keeping in warmer air inside the building. Therefore the building envelope is best designed to be air tight as much as possible.

8. Natural Ventilation

Natural ventilation through strategically placed window openings used for cooling and natural breezes for hot summers helps with natural ventilation therefore reducing the need for electrical appliances for cooling. Design must be sensitive and creative so that there is less dependency on fuel or power supported HVAC systems or fans.

PASSIVE SOLAR AND COOLING DESIGN

The following passive solar design strategies should be included during the building-design process.

- Site Selection:
  Evaluate building site options/positions for solar access and use of landscaping elements.

- Programming :
  Establish energy-use patterns and set priorities for energy strategies (e.g., daylighting versus efficient lighting); determine base-case conditions and conduct life-cycle cost analysis; establish an energy budget.

- Schematic Design:
  Maximize site potential by considering orientation, building shape, and landscaping options; conduct a preliminary analysis of representative building spaces as they relate to insulation, thermal mass, and window type and location; determine the available daylighting; decide on the need for passive heating or cooling load avoidance, lighting, and HVAC systems. Determine the preliminary cost effectiveness of options and compare the budgets.

- Landscaping
  Landscaping can be aesthetic while designed as an integral part of the program by providing assistance through design use of critical shading or direction of natural air flow.

CRITICAL DESIGN AREAS TO BE USED AS A GUIDE FOR DESIGN

These include the following:

- Thermal Protection: Provides appropriate levels of insulation and minimal air leakage.
- Windows: Transmit heat, light, and air between interior space and the outside environment.
- Daylighting: Reduces lighting and cooling energy use; creates a better working environment, leading to increased comfort and productivity.
- Thermal Mass: Stores excess heat in winter; in summer, cools down during the night and absorbs heat during the day. This can help to shift peak cooling and heating to off-peak hours.
- Passive Solar Heating: Allows heat to enter the building during the winter months and rejects it during the summer months through the use of appropriate amount and type of south-facing glazing and properly designed shading devices. Most valuable in cooler climates.
- Energy-Efficient Lighting: Uses efficient lamps, ballasts, controls, and luminaries coordinated with daylight and color of interior space to provide the requisite level of light.
- Internal Heat-Gain Control: Minimizes heat gain generated by lights, people, and equipment through the use of daylighting, thermal mass, efficient equipment selection, and venting.
- Passive Cooling with Natural Ventilation: Incorporates controlled air exchanges through natural or mechanical means. Helps to increase energy performance of buildings in most locations.
- Energy-Efficient HVAC System: Reduces system load by integrating above-listed design strategies and using measures such as efficient motors, heat pumps, variable speed drives, and sophisticated building controls.

CLIMATE CONSIDERATIONS

Assess the local climate (using typical meteorological-year data) to determine appropriate envelope materials and building designs. The following considerations could be taken into account, depending on the climate type.

Hot/dry climates

In hot/dry climates use materials with high thermal mass where appropriate. Buildings in hot/dry climates with significant diurnal temperature swings have traditionally employed thick walls constructed from envelope materials with high mass, such as adobe and masonry. Openings on the north and west facades are limited and large southern openings are detailed to exclude direct sun in the summer and admit it in winter.

A building material with high thermal mass and adequate thickness will lessen and delay the impact of temperature variations from the outside wall on the wall's interior. The material's high thermal capacity allows heat to penetrate slowly through the wall or roof. Because the temperature in hot/dry climates tends to fall considerably after sunset, the result is a thermal flywheel effect-the building interior is cooler than the exterior during the day and warmer than the exterior at night.

Hot/moist climates

In hot/moist climates use materials with low thermal capacity. In hot/moist climates, where nighttime temperatures do not drop considerably below daytime highs, light materials with little thermal capacity could be preferred. Roofs and walls could be protected by plant materials or overhangs. Large openings protected from the summer sun could be located primarily on the north and south sides of the envelope to catch breezes or encourage stack ventilation.

Temperate climates

In temperate climates, select materials based on location and the heating/cooling strategy to be used. Determine the thermal capacity of materials for buildings in temperate climates based upon the specific locale and the heating/cooling strategy employed. Walls should be well insulated. Openings in the skin could be shaded during hot times of the year and unshaded during cool months. This can be accomplished by roof overhangs sized to respond to solar geometries at the site or by the use of awnings.

Cold climates

In colder climates design wind-tight and well-insulated building envelopes. The thermal capacity of materials used in colder climates will depend upon the use of the building and the heating strategy employed.

A building that is conventionally heated and occupied intermittently should not be constructed with high mass materials because they will lengthen the time required to reheat the space to a comfortable temperature. A solar heating strategy will necessitate the incorporation of massive materials, if not in the envelope, in other building elements. Where solar gain is not used for heating, the floor plan could be as compact as possible to minimize the area of building skin.

Assess the site's solar geometry: Solar gain on roofs, walls, and the building interior through window openings can be either a benefit or a hindrance to heating, cooling, and occupant comfort. A thorough understanding of solar geometry specific to the site is crucial to proper envelope design and should be applied.

BUILDING SHAPE AND ORIENTATION

- Choose the most compact building footprint and shape (as per the context of the site) that work with requirements for daylighting, solar heating and cooling, and function.

  The greater the amount of building skin in relation to the volume of space enclosed, the more the building is influenced by heat exchanges at the skin. Excluding consideration of window openings and glazing choices, if two building designs under consideration enclose the same volume, the one with the more compact plan will have greater thermal efficiency.

  A square floor plan is considered more thermally efficient than a rectangular one because it contains less surface area over which to lose or gain heat.

  However, this may not be the most efficient or desirable form when other considerations such as views, daylighting, passive solar heating and cooling, need for temperature variation, and occupant use patterns are included.

- Site and orient the building so as to minimize the effects of winter wind turbulence upon the envelope.

  The shape and orientation of the building shell has an impact upon wind turbulence and opportunities for infiltration through the envelope. However, an orientation that minimizes winter wind may also limit opportunities to make use of cooling breezes in summer. An understanding of the site-specific microclimate is needed.

DRAFTING OF OUTLINE BRIEF FOR SUSTAINABILITY

The Outline Brief for sustainable green buildings should be incorporated as part of the Project schedule right from the time of the drafting of the project program and project estimate. This will ensure that sustainable principles are not left as only a special consideration within the project but are rather considered as heart of the building design and construction.

The drafting of the Outline Brief should be taken up by appropriate professionals who have the necessary training and education to ensure that the Outline Brief is not drafted and put together in a haphazard manner that will then jeopardize the project in the end and defeat the purpose of ensuring a green building not just on paper but also within the actual design, and construction.

The Outline Brief for a green building must be drafted to ensure that all design elements and construction activities are within the parameters of green design principles and goals rather than tacking green principles on as just a component of the Program.

DESIGN STRATEGY WITHIN GREEN PRINCIPLES

The normal practice in Bhutan for building design and construction projects is to incorporate green principles within the overall design strategy. However, for a green building, the design strategy must be within guided foremost by green principles rather than having green design principles tacked on as a mere component of the overall design strategy.

This ensures that all components and elements of the building are green right from the start including the allocation of activities and subsequent spaces, doors, windows, finishing, landscaping, etc.

SECTION 3

BUILDING SITE DEVELOPMENT

AND LAND USE

SECTION 3: BUILDING SITE DEVELOPMENT AND LAND USE

The objective of site analysis during the site selection process is to identify the best site based on the physical, cultural, and regulatory characteristics of the site and its surroundings, as well as the site's adaptability to and compatibility with the proposed program. The main components for building site development and land use in the context of green buildings includes the following:

1. Survey of the ecological value of a site
2. Environmental clearance
3. Site analysis for green design and construction
4. Protection of ecological features
5. Ecological enhancement
6. Consideration of appropriate Materials, equipment and methods for site development
7. Minimising of the building footprint within the site
8. Situating new elements and buildings in context with local site conditions
9. Ensuring Sustainable landscaping design
10. Effective Storm-water management within the site
11. Sustainable parking design considerations

Some of the main principles that should guide sensitive site development include:

1. The building design should be in harmony with those beneficial site conditions and strive to save, reinforce, amplify, and improve on what is existing.
2. The main aim should be to minimize negative environmental impacts and to protect, restore and enhance the natural features and environmental quality of a site.
3. The chosen building site should add to the comfort and energy efficiency of the home built upon it

SITE ANALYSIS FOR GREEN DESIGN AND CONSTRUCTION

Site analysis is a vital step in the design process. It is a pre-design research activity which focuses on existing and potential conditions on and around the building site. It is an inventory of the site factors and forces, and how they coexist and interact.

The purpose of the analysis is to provide thorough information about the site assets and liabilities prior to starting the design process. Only in this way can concepts be developed that incorporate meaningful responses to the external conditions of the site.

Site analysis services may be performed by an interdisciplinary team or by an individual capable of directing the work of others. The skill in the initial evaluation of the physical features and quality of a site is fundamental. The designer leading a site analysis effort must be able to evaluate the site in terms of climate, topography, geotechnical and soil characteristics, utilities, natural features and surroundings, transportation and access, and other factors including historic preservation and landmarks

The typical site analysis includes the following:

1. Site location and size,
2. Neighborhood context,
3. Zoning,
4. Legal aspects,
5. Geology,
6. Physiography (natural and man-made features),
7. Hydrology,
8. Soils,
9. Vegetation,
10. Wildlife,
11. Climate,
12. Culture,
13. Pedestrian and vehicular circulation,
14. Access, utilities,
15. Historic factors,
16. Density,
17. Sensory stimuli,
18. And any other factor deemed appropriate for the particular site.

CLIMATE ANALYSIS OF A SITE

The climate analysis of a site is vital for green design strategies

The following points are usually taken into consideration:

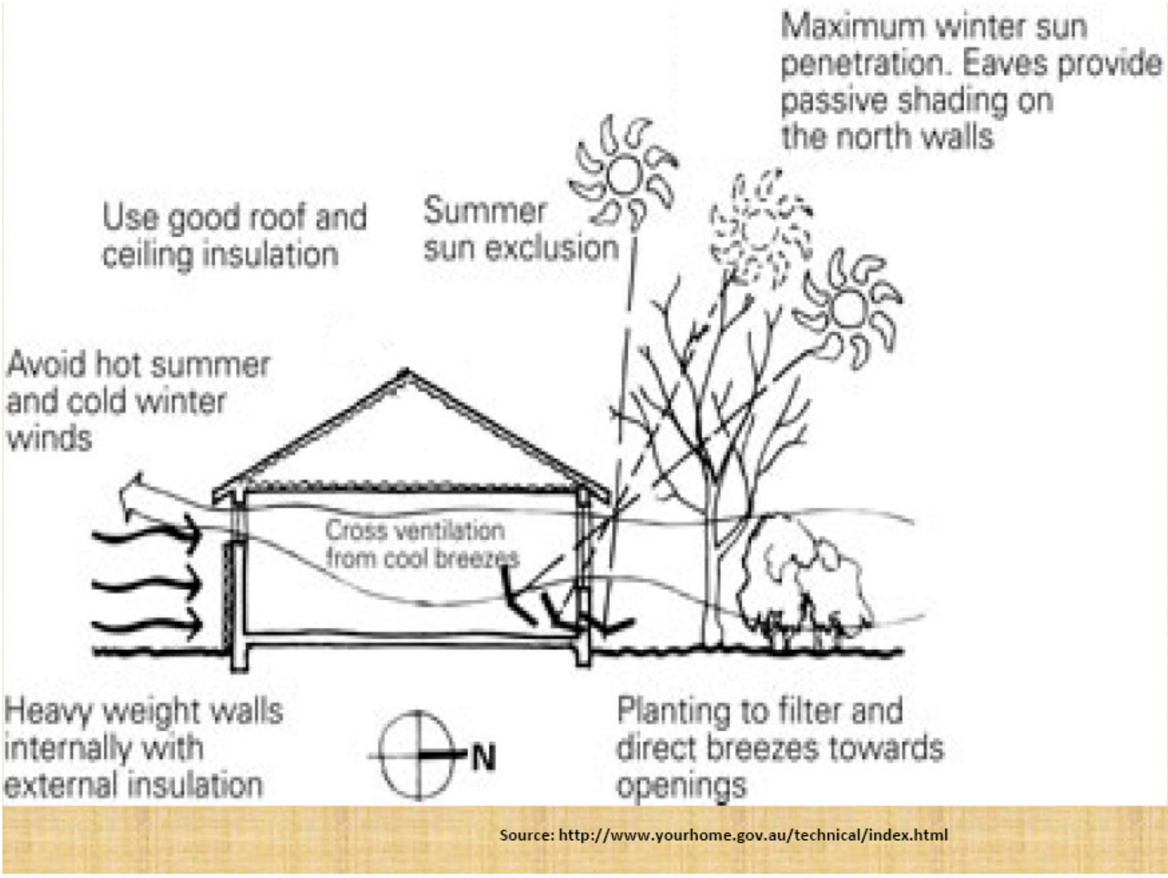
_ The path (vertical and horizontal angle) of the sun during the year

_ The annual rainfall amount and annual distribution

_ The wind intensity, direction and occurrence

_ The most likely direction of storms, cold or strong winds

_ The most common directions of good breezes.

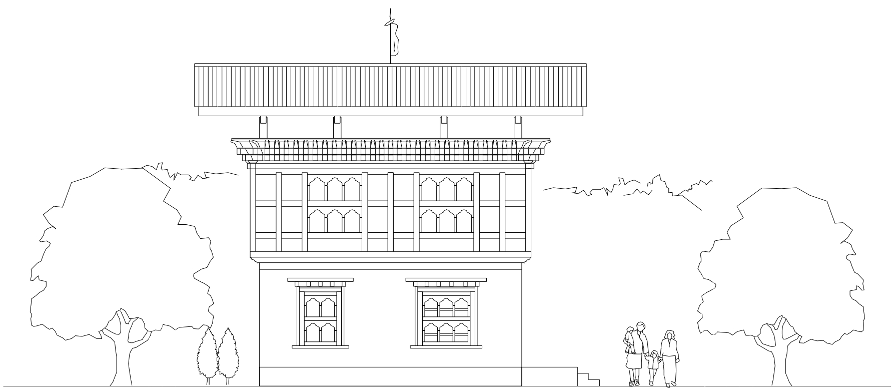


SUSTAINABLE LANDSCAPING DESIGN

Landscaping is an integral component of any sustainable design and should be considered for integration with all other aspects of the building design, construction, and operation.

Some Measures for Sustainable Landscaping Design include the following:

1. Site Analysis Considerations
2. Natural Hydrology considerations
3. Ensuring of Soil stability, quality, and disturbance of vegetation around the site.
4. Design to use the existing topography for landscaping – don't bulldoze!
5. Minimizing negative impact on existing trees and bio-diversity
6. Use of native trees and plants. It is best to avoid the introduction of exotic plants to ensure native trees are not affected.
7. Use of climate appropriate plants for landscaping to minimize watering, pesticide use and maintenance.
8. If it does not grow and thrive well in the local climate don't plant it.
9. Consideration of Permaculture for kitchen gardens or agricultural based use.
10. Effective tree management –consider tree retention, relocation or replacement.
11. Limiting the use of impervious surfaces to allow natural hydrology.



SUSTAINABLE PARKING DESIGN CONSIDERATIONS

Parking is often a significant user of land on sites. Reducing areas used for parking as many positive benefits to the site including the following:

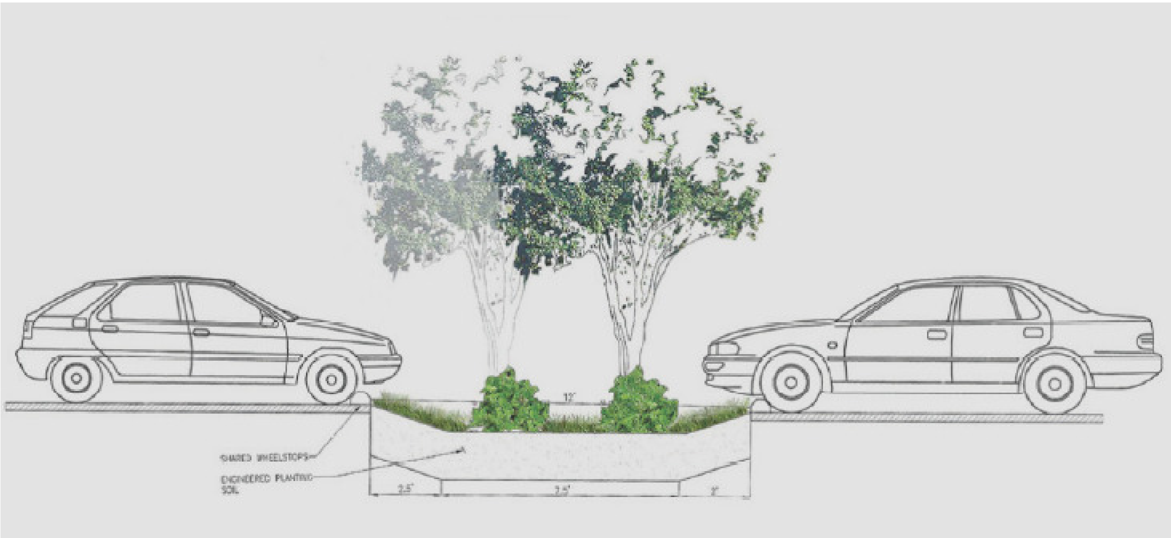
1. Reduction of polluted surface water runoff
2. Greater ground water recharge.
3. Reduced heat island effect and glare.
4. Positive opportunities for creating more natural landscapes and pedestrian friendly environments.

Green Parking design reduces runoff that is discharged into local water bodies by using:

- permeable paving and
- natural drainage landscapes.

Natural drainage landscapes include:

- Swales, rain gardens, andbioengineered planting strips that can improve water quality and reduce runoff.



STORM-WATER MANAGEMENT WITHIN THE SITE

Storm-water runoff is one of the most significant environmental impacts of a developed site. Storm-water runoff can change natural hydrologic patterns, accelerate stream flows, destroy aquatic habitats, and elevate pollutant concentrations and loadings.

Developing a site can significantly alter the hydrologic cycle for the property and surrounding area.

Our regulations do not address groundwater recharge and the hydrologic cycle within building sites and city planning. Steps can and should be taken to maintain the predevelopment hydrology or even to improve it.

Some of the Issues with Storm Water Management are:

1. When it rains, storm-water runoff that isn't properly managed can flow over impervious surfaces picking up pollutants along the way and washing them into our rivers and streams.

2. Storm-water runoff can also cause flooding and erosion, destroy habitat and contribute to combined sewer overflows (CSOs).

Some ways to Manage Storm Water for Sustainability include the following:

1. Storm-water management systems that mimic nature by integrating storm-water into building and site development can reduce the damaging effects of urbanization on rivers and streams.

2. The storm-water management system design shall be based, in part, on the hydrologic analysis of the building site.
3. The storm-water management system shall not redirect or concentrate off-site discharge that would cause increased erosion or other drainage related damage to adjoining lots or public property.

4. Disconnecting the flow from storm sewers and directing runoff to natural systems like landscaped planters, swales and rain gardens or implementing an eco-roof reduces and filters storm-water runoff.

Some Activities that will minimize Storm-water runoff from your property include the following:

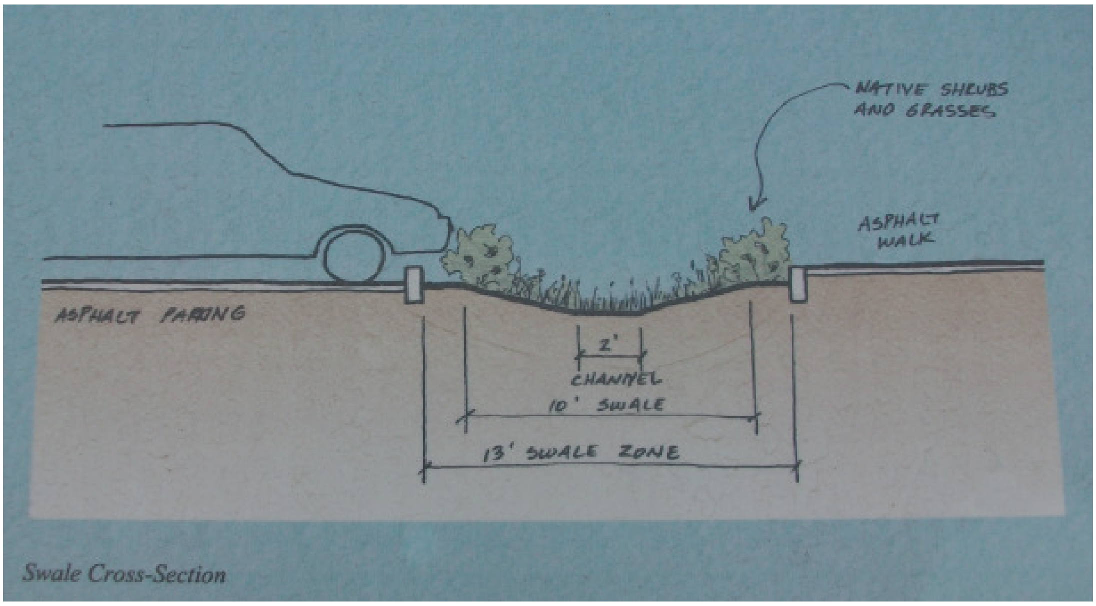
1. Limit the amount of impervious surfaces in your landscape.

2. Use permeable paving surfaces such as wood decks, bricks, and concrete lattice to allow water to soak into the ground.

3. Where possible, direct runoff from impervious surfaces across vegetated areas.

4. Allow "thick" vegetation or "buffer strips" to grow alongside waterways to filter and slow runoff and soak up pollutants.

5. Plant trees, shrubs, and groundcover. They are said to absorb up to fourteen times more rainwater than a grass lawn and they do not require fertilizer.



PERMEABLE PAVEMENTS

Permeable are pavements with surfaces that allow water to pass through voids in the paving material and/or between paving units while providing a stable, load-bearing surface.

- Permeable or porous paving systems defy conventional construction thinking which, for hundreds of years, has focused on getting surface water off and away from the pavement structure as rapidly as possible.
- The surface water is actually directed into the pavement and then stored or released into the environment in a controlled manner.
- Permeable paving is a powerful tool for maintaining and restoring natural hydrological cycles on developed sites by allowing water infiltration rather than concentrating rainwater into runoff.

Differences between Permeable and Impervious surfaces

Collecting water from hardscapes (roofs and pavements) and then channeling it via hard drains increases flow directly into rivers and streams and lakes.

This 'traditional' system accelerates the hydrological cycle

This dramatically reducing the time between a raindrop hitting the ground (or roof) and it entering a watercourse that will eventually lead back to the sea.

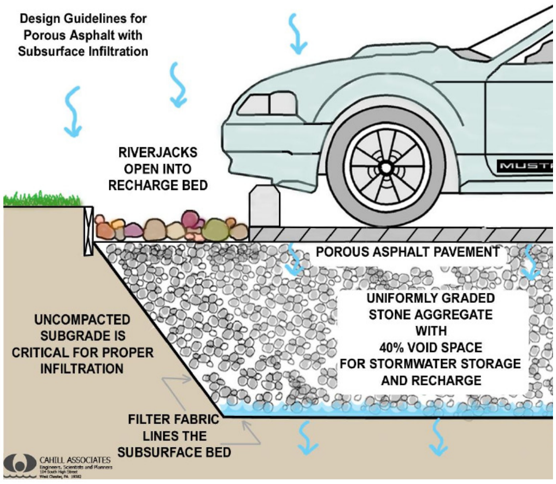
This reduces the storage capacity of the system by artificially diverting water and by-passing the partially-emptied aquifers.

In an undeveloped environment, the raindrop soaks into the ground where it lands.

This means that water then travels through the underlying strata, being naturally filtered during its passage, and eventually joining the body of "groundwater" at the water table.

There's a natural flow regime within the groundwater that results in the aquifers, the water-bearing rock layers, being recharged (topped-up).

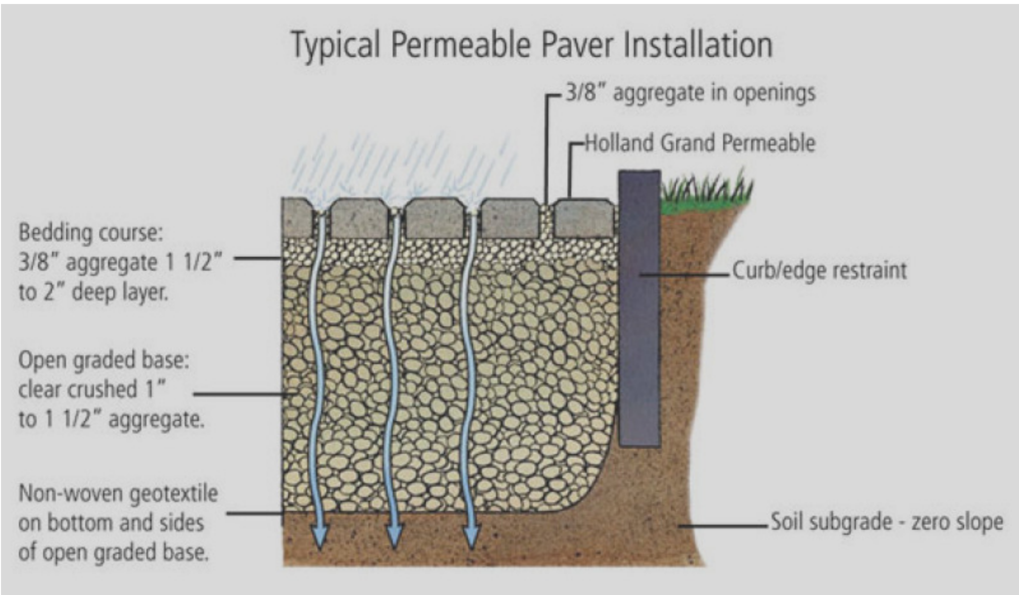
Where to install Permeable Pavements?



- Permeable paving is appropriate for pedestrian-only areas and for very low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, and parking stalls.
- It can be constructed where the underlying soils have a permeability of at least 0.3" per hour.

Where not to install Permeable Pavements?

- Permeable paving is not ideal for high traffic/high speed areas because it has lower load-bearing capacity than conventional pavement.
- Nor should it be used on stormwater "hotspots" with high pollutant loads because stormwater cannot be pretreated prior to infiltration.
- Permeable paving should not receive stormwater from other drainage areas, especially any areas that are not fully stabilized.



SECTION 4

GREEN MATERIALS AND RESOURCES

SECTION 4: GREEN MATERIALS AND RESOURCES

Resources and Materials for the construction of buildings and related infrastructure are usually taken directly or indirectly from nature. Correspondingly, the materials from buildings are often returned to nature. Therefore, any construction has an impact on the environment and the impact unless carefully and sensitively managed is usually negative.

While considering green materials and resources, the following are the main components to take into consideration:

1. Analysis of the environmental impact of building materials
2. Selection of sustainable building materials
3. Reuse of salvaged construction materials

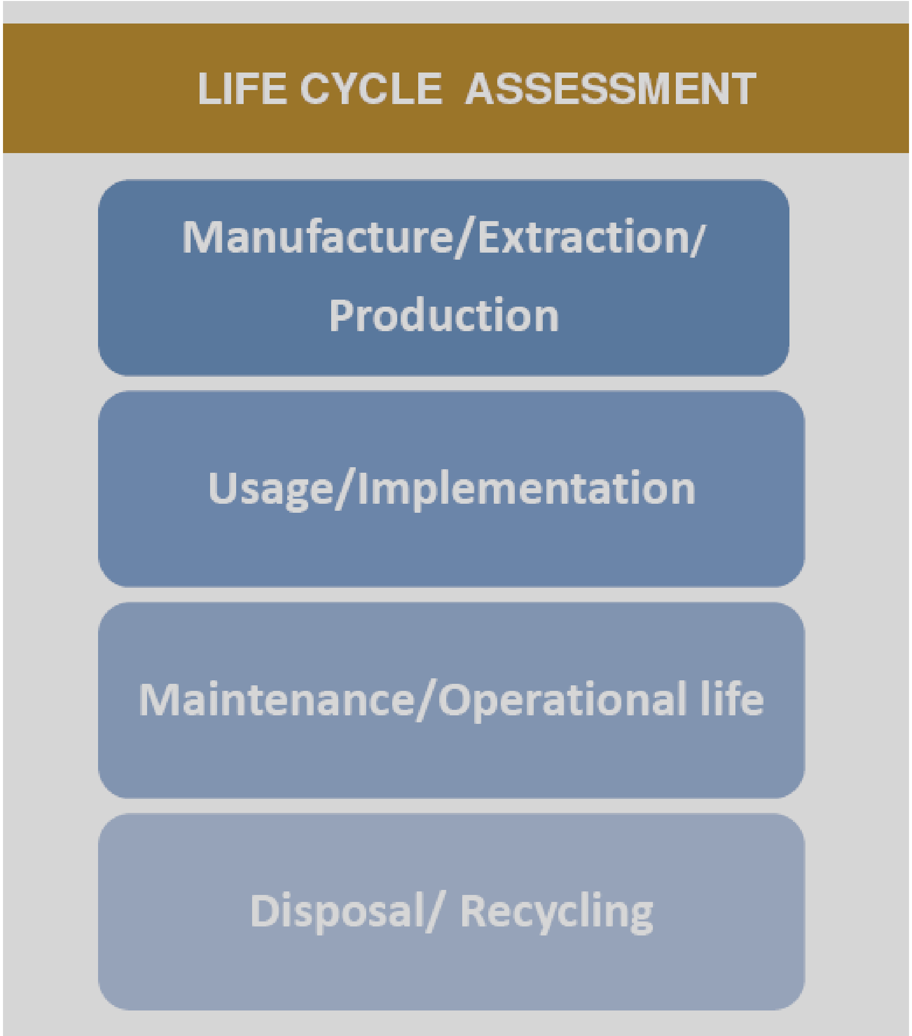
ANALYSIS OF THE ENVIRONMENTAL IMPACT OF BUILDING MATERIALS

Life Cycle Assessment is potentially the most important method for assessing the overall environmental impact of products, processes, or services. It is also sometimes referred to as Life Cycle Analysis or LCA.

Life Cycle Assessment (LCA) is a tool for assessing the environmental impacts of a product, process or service from design to disposal i.e. across its entire lifecycle, a so called cradle to grave approach. The impacts may be beneficial or adverse. These impacts are sometimes referred to as the “environmental footprint” of a product or service.

The LCA for a product is a summation of the impacts of:

1. extraction of the relevant raw materials
2. refinement and conversion to process materials
3. manufacturing and packaging processes
4. transportation and distribution at each stage
5. operation or use during its lifetime
6. at the end of its useful life, final transportation, waste treatment, and disposal.
7. Any recycling or recovery operations built into the life cycle should lead to a proportionate reduction in the adverse environmental impact.


LIFE CYCLE ASSESSMENT
Manufacture/Extraction/
Production
Usage/Implementation
Maintenance/Operational life
Disposal/ Recycling

SELECTION OF SUSTAINABLE BUILDING MATERIALS

The main points of consideration for selection of Materials include the following:

1. Materials and resources should be locally available
2. Low Embodied Energy materials should be considered first.
3. Materials should have minimal air, land, and water pollution footprint
4. Materials should be Biodegradable as far as possible
5. Material resources should be renewable as far as possible
6. materials should increase Energy Efficiency in buildings
7. Materials should have Long life & durability
8. Materials should be Reusable & Recyclable

While selecting materials the main considerations should be for primary materials first as shown below:

1. Primary Materials:
   those found in nature, such as stone, earth, flora (hemp, jute, reed, wool), cotton, and wood.

2. Secondary materials:
   those made from recycled products, such as wood,aluminum, cellulose, and plastics.

3. Tertiary Materials:
   manufactured materials (artificial, synthetic, nonrenewable) having varying degrees of negative impact on the environment and wellbeing of people.

Embodied energy in common materials

Material	Energy MJ per kg	Carbon kg CO2 per kg	Density kg /m^3
Aggregate	0.083	0.0048	2240
Concrete (1:1.5:3)	1.11	0.159	2400
Bricks (common)	3	0.24	1700
Concrete block (Medium density)	0.67	0.073	1450
Aerated block	3.5	0.3	750
Limestone block	0.85		2180
Marble	2	0.116	2500
Cement mortar (1:3)	1.33	0.208	
Steel (general, av. recycled content)	20.1	1.37	7800
Stainless steel	56.7	6.15	7850
Timber (general, excludes sequestration)	10	0.72	480 - 720
Glue laminated timber	12	0.87	
Cellulose insulation (loose fill)	0.94 – 3.3		43
Cork insulation	26.00*		160
Glass fibre insulation (glass wool)	28	1.35	12
Flax insulation	39.5	1.7	30
Rockwool (slab)	16.8	1.05	24
Expanded Polystyrene insulation	88.6	2.55	15 – 30
Polyurethane insulation (rigid foam)	101.5	3.48	30
Wool (recycled) insulation	20.9		25
Straw bale	0.91		100 – 110
Mineral fibre roofing tile	37	2.7	1850
Slate	0.1 – 1.0	0.006 – 0.058	1600
Clay tile	6.5	0.45	1900
Aluminium (general & incl 33% recycled)	155	8.24	2700
Bitumen (general)	51	0.38 - 0.43	
Medium-density fibreboard	11	0.72	680 – 760
Plywood	15	1.07	540 - 700
Plasterboard	6.75	0.38	800
Gypsum plaster	1.8	0.12	1120
Glass	15	0.85	2500
PVC (general)	77.2	2.41	1380
Vinyl flooring	65.64	2.92	1200
Terrazzo tiles	1.4	0.12	1750
Ceramic tiles	12	0.74	2000
Wool carpet	106	5.53	
Wallpaper	36.4	1.93	
Vitrified clay pipe (DN 500)	7.9	0.52	
Iron (general)	25	1.91	7870
Copper (average incl. 37% recycled)	42	2.6	8600
Lead (incl 61% recycled)	25.21	1.57	11340
Ceramic sanitary ware	29	1.51	
Paint - Water-borne	59	2.12	
Paint - Solvent-borne	97	3.13	

SECTION 5

ENERGY EFFICIENCY IN DESIGN

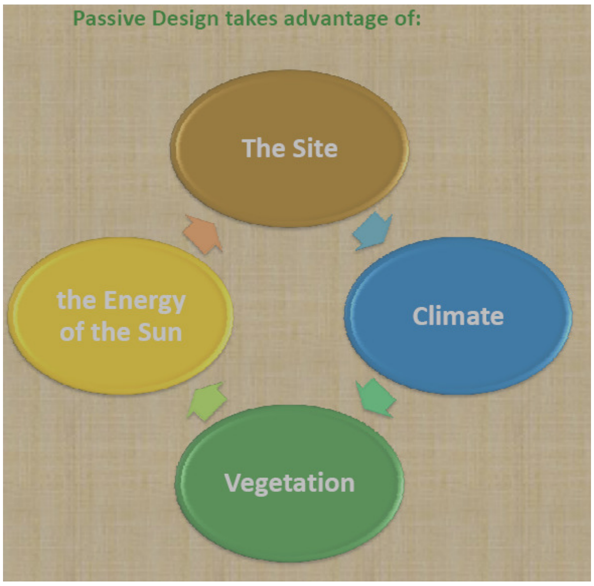
SECTION 5 ENERGY EFFICIENCY IN DESIGN

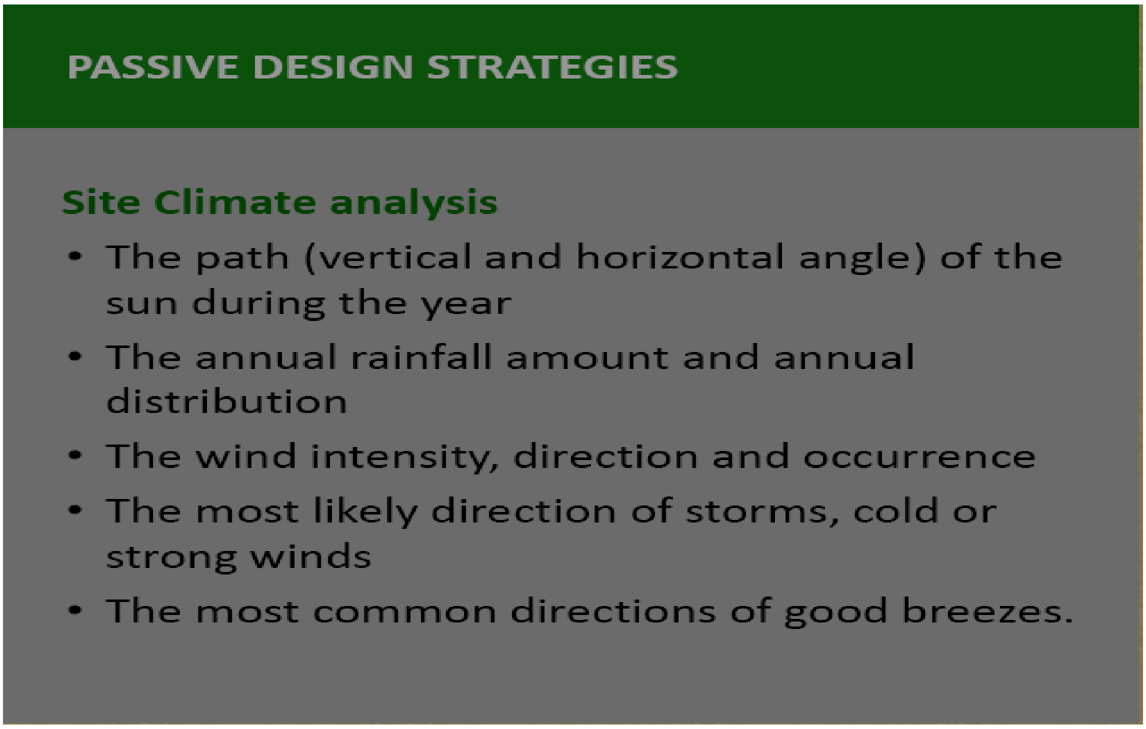
The following actions are means to reduce energy consumption:

- At the beginning of the planning process, a determination must be made to avoid energy-intensive or unnecessary operations.
- The design proposal must incorporate measures to minimize energy use by design and operation.
- Application of the best principles of siting and architectural design to reduce energy demands by passive solar design.
- Feasibility of use primary renewable energy sources such as solar, wind, biogas, and geothermal to satisfy the justifiable energy needs of the resort.
- Installing efficient appliances and taking measures = to minimize the need and use of energy-consuming utilities (air-conditioning, water heaters, high-level artificial lighting).
- Use of energy meters to monitor and illustrate energy consumption to aid in conservation.
- In addition, considerable electrical and thermal energy can be saved through facility design that incorporates daylighting and the other passive energy-conserving strategies appropriate to the local climatic environment.
- In all cases, the need for energy-intensive mechanical air-conditioning of facilities can be effectively eliminated by appropriate use of principles of site planning and building design.
- Natural lighting should be used wherever possible. Lighting design should be based on standards of reduced general lighting with task lighting and highlighting for specific functional considerations.
- Where artificial light is needed, LED or regular and compact fluorescent lighting should be used. Fluorescents use 75% less electricity and the average life is 10 times longer than incandescents, reducing maintenance and transportation costs. The environmental payback is immediate.

USE OF PASSIVE SOLAR DESIGN STRATEGIES FOR BUILDINGS

In passive solar building design, windows, walls, and floors are made to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is called passive solar design or climatic design because, unlike active solar heating systems, it doesn't involve the use of mechanical and electrical device



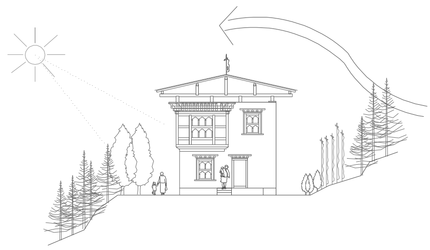


PASSIVE DESIGN STRATEGIES

1. Foot print of Building –Placement on the Site
2. Building and Room Orientation
3. Appropriate Building Form and Thermal Mass
4. Airtight Building Envelope
5. Natural Cross Ventilation
6. Natural Lighting
7. Trees and Vegetation for Shading and protection
8. Use of Colours- light and dark

SITE-ADAPTIVE DESIGN CONSIDERATIONS

The concept of sustainability suggests an approach to the relationship of site components that is somewhat different from conventional site design.



With a sustainable approach, site components defer to the character of the landscape they occupy so that the experience of the landscape will be paramount.

More ecological knowledge is at the core of sustainable design. Instead of human functional needs driving the site design, site components respond to the indigenous spatial character, climate, topography, soils, and vegetation as well as compatibility with the existing cultural context.

For example, all facilities would conform to constraints of existing landforms and tree locations, and the character of existing landscape will be largely maintained.

Natural buffers and openings for privacy are used rather than artificially produced through planting and clearing. Hilly topography and dense vegetation are natural ways of separating site components.

Natural Characteristics

It is important to understand natural systems and the way they interrelate in order to work within these constraints with the least amount of environmental impact. Like nature, design should not be static but always evolving and adapting to interact more intimately with its surroundings. The following natural characteristics are to be considered in the design:

- **Wind**

The major advantage of wind in recreational development is its cooling aspect. The orientation of rooms and outdoor places are to take advantage of this cooling wind movement.

- **Sun**

Where sun is abundant, it is imperative to provide shade for human comfort and safety in activity areas (e.g., pathways patios). The most economical and practical way is to use natural vegetation, slope aspects, or introduced shade structures.

- **Rainfall**

Rainfall should be captured for a variety of uses and this water reused for secondary purposes (e.g., flushing toilets, washing clothes). Wastewater or excess runoff from developed areas should be channeled and discharged in ways that allow for groundwater recharge instead of soil erosion. Minimizing disturbance to soils and vegetation and keeping development away from natural drainage ways protect the environment as well as the structure.

- **Topography**

Protection of native soil and vegetation are critical concerns in high slope areas, and elevated walkways and point footings for structures are appropriate design solutions to this problem.

- **Geology and Soils**

Designing with geologic features such as rock outcrops can enhance the sense of place in the landscape design and brings people in direct contact with the resource of a place. Soil disturbances should be kept to a minimum to avoid erosion of fragile tropical soils and discourage growth of exotic plants. If limited soil disturbance must take place, a continuous cover over disturbed soils with erosion control netting should always be maintained.

- **Vegetation**

Exotic plant materials, while possibly interesting and beautiful, are not amenable to maintaining healthy native ecosystems and are not approved for any landscape design. Use of native plant species are encouraged to encourage biodiversity and to protect the nutrients held in the biomass of native vegetation. Native planting should be incorporated into all new developments on a 2:1 ratio of native plants removed.

Bulldozing all the trees, building, then planting new trees and landscaping is not sustainable practice and must be avoided as far as possible.
Organic Kitchen Gardens may be incorporated within the landscaping design provided that only native food is grown. Incorporation of conventional grass lawns and typical ornamental shrubs shall not be allowed due to their high water and pesticide use, and the pollution generated from mowing.

- **Visual Character**

Natural views and beauty should be used in design whenever possible. Creation of onsite visual intrusions (road cuts, utilities, etc.) should be avoided, and views of offsite intrusions carefully controlled.

Natural appearance must be maintained by using native building material, hiding structures within the vegetation, and working with the topography.

- **Preserve natural drainage systems**

Locate buildings, roadways, and parking areas so that water flowing off the developed site during extreme storm events will not cause environmental damage and result in excessive contamination of the watershed from silt, oils, automobile fluids, and other pollutants. Allow precipitation to naturally recharge groundwater. Use swales and dry retention ponds to maximize infiltration and minimize runoff. Maintain or restore the pre-development stable, natural runoff hydrology of the site throughout the development or redevelopment process. Post construction runoff rate, volume, duration, and temperature should try not to exceed predevelopment rates.

DOORS, WINDOWS, AND OPENINGS

- Size and position doors, windows, and vents in the envelope based on careful consideration of daylighting, heating, and ventilating strategies. The form, size, and location of openings may vary depending on how they affect the building envelope.

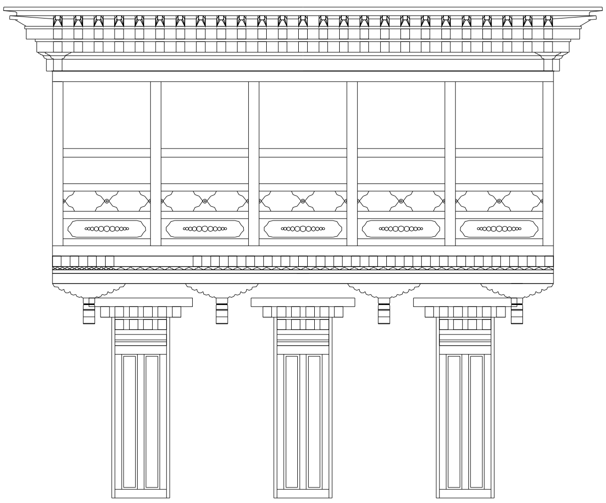
- The negative impact of door openings upon heating or cooling loads can be reduced with airlocks. Members of the design team could coordinate their efforts to integrate optimal design features.

- Shade openings in the envelope during hot weather to reduce the penetration of direct sunlight to the interior of the building. Use design solutions such as overhangs or deciduous plant materials on southern orientations to shade exterior walls during warmer seasons.

- Shade window openings or use light shelves where applicable to minimize thermal discomfort from direct radiation and visual discomfort from glare.

- Select proper glazing for windows.

- Consider more advanced windows that use glazing that alters with changing conditions, such as windows with tinting that increases under direct sunlight and decreases as light levels are reduced.



THERMAL EFFICIENCY

- Determine the building function and amount of equipment that will be used as sensitively as possible. The type of activity and the amount of equipment in a building affect the level of internal heat generated. This is important because the rate at which a building gains or loses heat through it skin is proportional to the difference in air temperature between inside and outside.

- In general, build walls, roofs, and floors of adequate thermal resistance to provide human comfort and energy efficiency.

- Roofs especially are vulnerable to solar gain in summer and heat loss in winter.

- Insulating materials that require chlorofluorocarbons (CFCs) or hydro chlorofluorocarbons (HCFCs) in their production, (ozone-depleting compounds) should not be used.

- Consider environmentally sensitive insulating materials -made from recycled materials such as cellulose or mineral wool, if such items meet the project's performance and budgetary criteria.

- If the framing system is of a highly conductive material, consider the installation of a layer of properly sized insulating sheathing to limit thermal bridging where possible.

- Consider the reflectivity of the building envelope. In regions with significant cooling loads, select exterior finish materials with light colors and high reflectivity. Consider the impact of decisions upon neighboring buildings. A highly reflective envelope may result in a smaller cooling load, but glare from the surface can significantly increase loads on and complaints from adjacent building occupants.

- Consider the prevention of moisture buildup within the envelope. To prevent this, place a vapor-tight sheet of plastic or metal foil, known as a vapor barrier, as near to the warm side of the wall construction as possible. For example, in areas with meaningful heating loads, the vapor barrier should go near the inside of the wall assembly. This placement can lessen or eliminate the problem of water-vapor condensation.

- Consider weather-stripping of all doors and placement of sealing gaskets and latches on all operable windows. Careful detailing, weather stripping, and sealing of the envelope eliminate sources of convective losses.

- Specify construction materials and details that reduce heat transfer. Heat transfer across the building envelope occurs as either conductive, radiant, or convective losses or gains. Building materials conduct heat at different rates. Metals have a high rate of thermal conductance. Masonry has a lower rate of conductance; the rate for wood is lower still.

- Consider the following principles in construction detailing:
  - To reduce thermal transfer from conduction, develop details that eliminate or minimize thermal bridges.
  - To reduce thermal transfer from convection, develop details that minimize opportunities for air infiltration or exfiltration. Plug, caulk, or putty all holes in sills, studs, and joists.
  - Consider sealants with low environmental impact that do not compromise indoor air quality.

- Consider the incorporation of solar controls on the building exterior to reduce heat gain. Radiant gains can have a significant impact on heating and cooling loads. A surface that is highly reflective of solar radiation will gain much less heat than one that is adsorptive. In general, light colors decrease solar gain while dark ones increase it. This may be important in selecting roofing materials; it may also play a role in selecting thermal storage materials in passive solar buildings.
- Overhangs are effective on south-facing facades while a combination of vertical fins and overhangs are required on east and west exposures and, in warmer areas during summer months, on north-facing facades.

- Coordinate building strategy with landscaping decisions. Landscape and other elements such as overhangs are integral to a building's performance.

- Integration of passive solar heating, cooling, and thermal storage features, along with daylighting, into a building can yield considerable energy benefits and added occupant comfort. Incorporation of these items into the building design can lead to substantial reduction in the load requirements for building heating and cooling mechanical systems. The passive solar measures need to be evaluated during the design process.

- Direct gain through south-facing glass is the most common method of passive solar heating. Sunlight is admitted through the glazing into the space to be heated, and typically absorbed by thermal mass materials. Other methods include indirect gain (e.g., using a sunspace or atrium) and thermal storage walls.

- Passive solar cooling strategies include cooling load avoidance, shading, natural ventilation, radiative cooling, evaporative cooling, dehumidification, and ground coupling. Passive design strategies can minimize the need for cooling through proper selection of glazings, window placement, shading techniques, and good landscaping design. However, incorrect daylighting strategies can produce excessive heat gain.

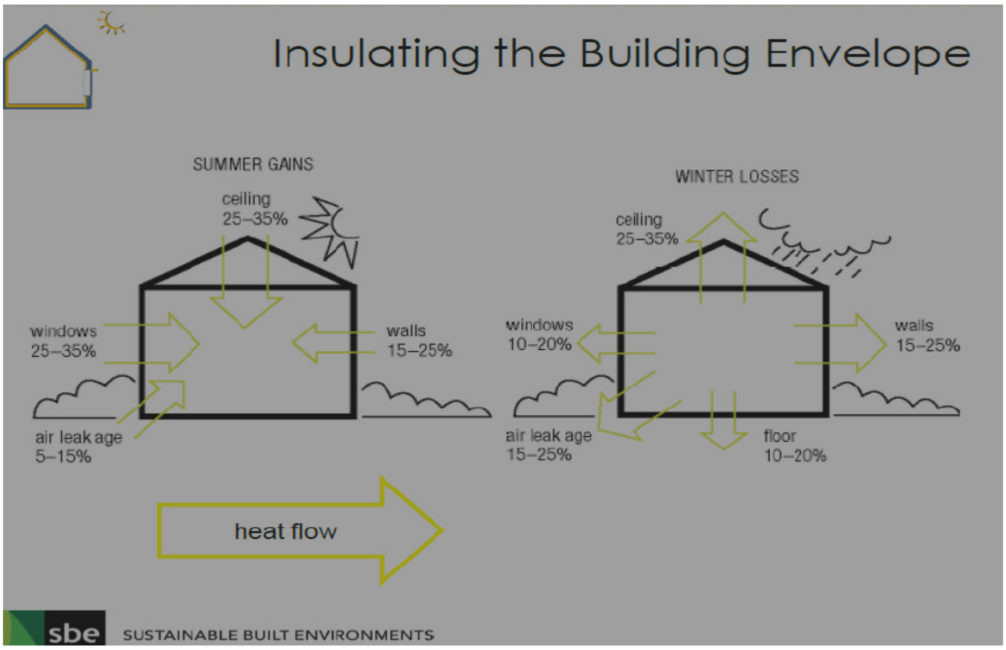
- Minimization of cooling loads should be carefully addressed through proper design for both solar and conventional building design.

- Thermal mass and energy storage are key characteristics of passive solar design. They can provide a mechanism for handling excess warmth, therefore reducing the cooling load, while storing heat that can be slowly released back to the building when needed. The thermal mass can also be cooled during the evening hours by venting the building, reducing the need for cooling in the morning.

BUILDING ENVELOPE DESIGN FOR SUSTAINABILITY

- The building envelope, or “skin,” consists of structural materials and finishes that enclose space, separating inside from outside. This includes walls, windows, doors, roofs, and floor surfaces.
- The envelope must balance requirements for ventilation and daylight while providing thermal and moisture protection appropriate to the climatic conditions of the site. Envelope design is a major factor in determining the amount of energy a building will use in its operation.
- In keeping with the whole building approach, the entire design team should integrate design of the envelope with other design elements including material selection; daylighting and other passive solar design strategies; heating, ventilating, and air-conditioning (HVAC) and electrical strategies; and project performance goals.
- One of the most important factors affecting envelope design is climate. Hot/dry, hot/moist, temperate, or cold climates will suggest different design strategies –this should be presented in the proposal. Specific designs and materials can take advantage of or provide solutions for the given climate.
- A second important factor in envelope design is what occurs inside the building. If the activity and equipment inside the building generate a significant amount of heat, the thermal loads may be primarily internal (from people and equipment) rather than external (from the sun). This affects the rate at which a building gains or loses heat.
- Building volume and siting also have significant impacts upon the efficiency and requirements of the building envelope. Careful study is required to arrive at a building footprint and orientation that work with the building envelope to maximize energy benefit.
- Openings are located in the envelope to provide physical access to a building, create views to the outside, admit daylight and/or solar energy for heating, and supply natural ventilation. Show sensitive use of form, size, and location of the openings vary depending upon the role they play in the building envelope. Sensitive design of window glazing can be used to affect heating and cooling requirements and occupant comfort by controlling the type and amount of light that passes through windows. This could be presented in the proposal.
- Decisions about construction details also play a crucial role in design of the building envelope. Building materials conduct heat at different rates. Components of the envelope such as foundation walls, sills, studs, joists, and connectors, among others,

can create paths for the transfer of thermal energy, known as thermal bridges that conduct heat across the wall assembly. Wise detailing decisions, including choice and placement of insulation material, are essential to assure thermal efficiency and this must be included within the design proposal.



PASSIVE SOLAR HEATING

- Consider Analyzing building thermal-load patterns.
  An important concept of passive solar design is to match the time when the sun can provide daylighting and heat to a building with those when the building needs heat. This will determine which passive solar design strategies are most effective. The design strategies require computer analysis by an architect or engineer and could be incorporated.

- Design the building’s floor plan to optimize passive solar heating.
  Orient the solar collection surfaces, for example appropriate glazing in windows and doors, within 15 degrees of true south, if possible. Because of the solar path, the optimum orientation for passive solar buildings is due south. South-facing surfaces do not have to be all along the same wall. For example, larger windows can project south sun deep into the back of the building. Both the efficiency of the system and the ability to control shading and summer overheating decline dramatically as the surface shifts away from due south.

- Identify appropriate locations for exposure to beam sunlight where applicable
  Overheating and glare can occur whenever sunlight penetrates directly into a building and must be addressed through proper design. A “direct-gain” space can overheat in full sunlight and is many times brighter than normal indoor l ighting, causing intense glare.

- Consider locating thermal mass so that it will be illuminated by low winter sun angles. Building design should incorporate a sufficient amount of correctly located thermal mass to effectively contribute to the heating requirements and provide cooling benefits in the summer.

PASSIVE SOLAR COOLING

- Design buildings for cooling in summer
  Minimization of cooling loads should be carefully addressed for both solar building and conventional energy- efficient building design. Design strategies that minimize the need for mechanical cooling systems include proper window placement and daylighting design, selection of appropriate glazing for windows and skylights, proper shading of glass when heat gains are not desired, use of light-colored materials for the building envelope and roof, careful siting and orientation decisions, and good landscaping design.

- Consider one or more shading strategies where applicable.
  Fixed shading devices, which are designed into a building, will shade windows throughout the solar cycle. They are most effective on the south-facing windows. The depth and position of fixed shading devices must be carefully engineered to allow the sun to penetrate only during predetermined times of the year. In the winter, overhangs allow the low winter sun to enter south- facing windows. In the summer, the overhangs block the higher sun.

- Plant trees and/or bushes to shade the windows at the right time of day and season. Deciduous vegetation is often an attractive and inexpensive form of shading, because it follows the local seasons, not the solar calendar.

- In the warm south, where more shading is needed, trees leaf out earlier, while in the cold north, where solar heat is beneficial late into spring, trees wait until the weather warms up before they leaf out. Trees can be strategically planted on east and west sides to block the rising and setting sun.

- Bushes can be positioned to block undesirable low sun angles from the east or west, and deciduous vines trained to grow over trellises make easily controlled shading systems.

- Evergreen trees trimmed so that their canopies allow low winter sun underneath but block the high summer sun can be very effective.

- Properly placed vegetation can also guide air flows toward buildings for natural ventilation and can block cold winter winds. Vegetation and groundcover also contribute to evaporative cooling around a building.

- Vegetation used for shading should be properly located so as not to interfere with solar gain to buildings in winter. Deciduous trees can reduce winter solar gain by 20 percent or more and should not be placed in the solar access zone.

- Also it should be noted that plants and trees require maintenance, pruning, watering and feeding. As they grow they change their shading pattern, and they can be damaged or killed, leaving the building exposed.

Consider other cooling strategies.

- Design the building to take advantage of natural ventilation. Natural ventilation uses the passive stack effect and pressure differentials to bring fresh, cooling air through a building without mechanical systems. This process cools the occupants and provides comfort even in humid climates. Buildings using this design will incorporate operable windows or other means of outdoor air intakes.

- Other features include fresh air inlets located near floor level, use of ceiling fans, and the use of atriums and stairwell towers to enhance the stack effect.

- Consider radiative cooling in appropriate climates. Radiative cooling, also known as nocturnal radiative cooling, uses design strategies that allow stored heat to be released to the outside. This strategy is particularly effective in climates and during seasons of the year when the daytime-nighttime temperature differences are meaningful.

- Night flushing of buildings uses radiative cooling principles. Building thermal storage serves as a heat sink during the day, but releases the heat at night, while being cooled with night air.

- Consider ground coupled cooling. Ground coupling is achieved by conductive contact of the building with the earth. The most common strategy is to cool air by channeling it through an underground tunnel. Another strategy provides cool air by installing a tube in the ground and dripping water into the tube. This reduces the ground temperature through evaporation.

- Consider evaporative cooling strategies. This cooling method works when water, evaporating into the atmosphere, extracts heat from the air. Evaporative cooling is most appropriate in dry climates.

THERMAL STORAGE:

- Determine if excess heat should be stored or vented.

- Thermal mass in a passive solar building is intended to meet two needs. It should be designed to quickly absorb solar heat for use over the diurnal cycle and to avoid overheating. It should provide slow release of the stored heat when the sun is no longer shining.

- Depending upon the local climate and the use of the building, the delayed release of heat may be timed to occur a few hours later or slowly over days. Careful selection of the thermal storage medium, its location in the building, and its quantity are important design and cost decisions.

Choose one or more thermal storage strategies:

- There are two basic thermal storage strategies using thermal mass. “Direct” thermal storage materials, such as concrete masonry or tiles, are placed directly in the sunlight so that intense solar energy enters them quickly. “Diffuse” thermal storage materials are placed throughout the building. They can absorb heat by radiation, the reflectance of sunlight as it bounces around a room and via air heated elsewhere in the building (e.g., sunspaces and atria). Several storage strategies are presented below.

- Consider tile, stone, or masonry floors for heat storage where possible. Flooring using these materials, exposed to direct sunlight, is probably the most common form of thermal storage selected for passive solar buildings.
- Masonry materials have high thermal capacity; their natural dark color aids in the absorption of sunlight. They also provide an attractive and durable floor surface, are widely available, and readily accepted by contractors and building occupants. Masonry’s effectiveness can be inhibited if occupants place furniture and carpets over the floors. To address this, use masonry floors only in the areas where direct heat gain and storage is required.

- Consider a Trombe wall—a south-facing masonry wall covered with glass spaced a few inches away. Sunlight passes through the glass and is absorbed and stored by the wall. The glass and airspace keep the heat from radiating back to the outside.

Heat is transferred by conduction as the masonry surface warms up, and is slowly delivered to the building some hours later.

- Trombe walls can provide carefully controlled solar heat to a space without the use of windows and direct sunlight, thus avoiding potential problems from glare and overheating, if thermal storage is inadequate. The masonry wall is part of the building's structural system, effectively lowering costs. The inside, or discharge, surface of the Trombe wall can be painted white to enhance lighting efficiency within the space. However, the outside large dark walls sheathed in glass must be carefully designed for both proper performance and aesthetics.

- Consider water-storage containers for thermal mass. Water has a very high thermal capacity, about twice that of common masonry materials. Water also has the advantage that convection currents distribute heat more evenly throughout the medium. Creative solutions that could be considered are enclosing water containers in seating boxes under south windows or using water as an indoor feature such as a large tropical aquarium, pond, or pool.

INTEGRATION OF NATURAL DAY LIGHTING INTO THE DESIGN

Daylighting is the practice of bringing natural light into a building interior and distributing it in a way that provides more desirable and better-quality illumination than artificial light sources. This reduces the need for electrical light sources, thus cutting down on electricity use and its associated costs and pollution. Studies substantiate that daylighting creates healthier and more stimulating work environments than artificial lighting systems and can increase productivity up to 15 percent.

Daylighting significantly reduces energy consumption and operating costs. Greater use of daylighting can also provide advantages for the environment by reducing power demand and the related pollution and waste byproducts from power production. Daylighting requires the correct placement of openings, or *apertures,* in the building envelope to allow light penetration while providing adequate distribution and diffusion of the light.

Design Process for Daylighting

- Establish daylighting performance objectives and requirements.
  The designer should establish required illumination levels to meet the needs of the building occupants and the tasks they perform. These levels have been reduced significantly over the past decades because it is now generally accepted that illumination can be reduced in situations where the quality of light is high and background surface reflectance is optimal.

- Analyze lighting performance needs using the following procedures:
  - Perform a solar-path analysis for the latitude at the site;
  - Perform preliminary aperture-optimization studies (optimal window-to-floor ratio, optimal skylight-to-floor ratio);
  - Determine the design illumination levels for various program functions based on international and local assessments.

- Establish basic daylighting parameters as part of the building design.
  - Establish the location, shape, and orientation of the building on the site based on daylighting performance objectives as part of an integrated passive solar heating and cooling strategy.
  - Establish fenestration design objectives based on optimization studies.
  - Establish energy-efficient artificial illumination systems based on design illumination levels and energy-efficiency targets.

- Consider a preliminary life-cycle cost-benefit analysis of daylighting systems as an integrated part of the total building system. Consider qualitative benefits such as increased productivity and reduced absenteeism, as well as the direct costs of design systems when assessing costs and benefits.
- Specify details for lighting systems and products.
- Specify glazing materials based on climate, fenestration position, and solar orientation, maintaining the highest possible luminous efficacy and daylight factor.
- Based on a solar-path analysis, determine the type and location of, and control methods for, shading systems that minimize or eliminate direct sun in work areas and moderate excessive brightness.
- Specify control systems, including photo-sensors, control zones and occupancy sensors, based on control strategies where applicable.
- Incorporate flexible, ongoing capabilities for monitoring lighting conditions, including lighting-energy consumption and lighting operation hours by zone.
- Determine the method for reviewing and analyzing field-monitoring data and performing associated responsibilities where possible.
- Confirm that specified practices and materials are installed properly during construction

OUTDOOR LIGHTING

- When lighting an outdoor space, keep in mind that light pollution can be a problem.

- Good examples of light pollution and its negative effects are high school football fields, retail centers and parking lots.

- In this type of diffuse lighting where lamps light a large surface area, light pollution occurs when the excess light spills over onto nearby houses, lighting the streets and backyards and generally creating a nuisance for the surrounding neighbors.

MATERIALS/FINISHES FOR EFFECTIVE LIGHTING

Materials and finishes can have huge impact on lighting in your space. The materials used within a facility need to be considered when designing a lighting plan.

The following are a few points that should guide materials and finishes for effective lighting:

- Painting a room a dark color can make it look smaller. That dark color can also absorb more light, forcing your eyes to adjust to lower light levels.

- Rooms painted a light color help a person perceive the space as larger and aid in lighting.

- In addition, keeping reflective surfaces to a minimum can also help. Unexpected glare from floors and windows can affect the lighting of the space.

- Another useful technique is to light the walls in your space. At lower wattages, lighting the walls can increase the perception of brightness.

USING RENEWABLE ENERGY SOURCES IN BUILDINGS

References and information for this consideration can be found with the Department of Renewable Energy of the Ministry of Economic Affairs, which is the lead agency for these considerations of active renewable energy sources in buildings.

- Renewable energy resources, such as sun, wind, and biogas conversion should be considered.

- Solar applications range from heating of hot water to electric power production with photovoltaic cells.

- Wind-powered generators can provide electricity and pumping applications in some areas.

- The Biogas conversion process is sustainable as it reduces gas or electricity costs and eliminates the release of wastewater effluent into water resources.

- The availability, potential, and feasibility of primary renewable energy resources must be analyzed early in the planning process as part of a comprehensive energy plan.

SECTION 6

CONSERVATION OF WATER IN BUILDINGS

SECTION 6: CONSERVATION OF WATER IN BUILDINGS

Green design principles respect water resources with diligence whatever the natural distribution. The Guiding principle for water conservation is to use best practice and cost effective measures to avoid and then minimize energy and water use.

The main Goals of Water Design and Management Measures include the following:

1. Sustainability:
   To ensure availability for future generations, the withdrawal of fresh water from an ecosystem should not exceed its natural replacement rate.

2. Energy conservation:
   Water pumping, delivery and waste water treatment facilities consume a significant amount of energy. In some regions of the world over 15% of total electricity consumption is devoted to water management.

3. Habitat conservation:
   Minimizing human water use helps to preserve fresh water habitats for local wildlife , as well as reducing the need to build new dams and other water diversion infrastructures.

4. Reduction of water waste and consumption per capita.

There are 6 key Phases in Water Design and Management Measures.

These include:

1. Water Source
2. Water Storage
3. Water Treatment
4. Water Distribution
5. Water Use
6. Water Recycling

WATER CONSERVATION MEASURES

Some Water Conservation Measures include:

1) Provide details of water supply and use, including measures that will first avoid and then minimize water use.
2) This should include, use of energy and water efficient appliances, fittings and timers.
3) Use waterless toilets (composting toilets where feasible.
4) Provide bulk potable water (in designated drinking water tanks) to minimise the need for bottled water.
5) Using water of lower quality such as reclaimed wastewater effluent, gray water, or runoff from ground surfaces for toilet flushing or irrigation of vegetative landscape or food crops. These uses do not require the level of water quality as that needed for internal consumption, bathing, or washing.
6) Flush toilets are the largest inside user of water. To conserve water, the maximum permissible water use per flushing cycle is 1.6 gallons. Double flush units also save water
7) Efficient shower fixtures should be rated for a maximum flow rate of 2.5 gpm at 80 psi. Instead of a hot water shower, tempered water using a solar thermal collector may be a good median
8) Commercial appliances used in kitchen and laundry areas should also be water-savings models.
9) Garbage disposals should not be used as they are water consumptive and exert a huge load on the wastewater treatment facilities.

WATER-SAVING TECHNOLOGY FOR THE HOME

Water-saving technology for the home includes:

1) Low-flow shower heads sometimes called energy-efficient shower heads as they also use less energy,

2) Low-flush toilets and composting toilets.

3) Dual flush toilets includes two buttons or handles to flush different levels of water. Dual flush toilets use up to 67% less water than conventional toilets.

4) Rain water can be used for flushing toilets.

5) Tap Aerators, which break water flow into fine droplets to maintain "wetting effectiveness" while using less water. An additional benefit is that they reduce splashing while washing hands and dishes.

6) Wastewater reuse or recycling systems, allowing:
   - Reuse of graywater for flushing toilets or watering gardens
   - Recycling of wastewater through purification at a water treatment plant.

7) Rainwater harvesting

8) High-efficiency clothes washers

9) Weather-based irrigation controllers

10) Garden hose nozzles that shut off water when it is not being used, instead of letting a hose run.

11) Automatic taps is a water conservation tap that eliminates water waste at the tap

12) Water can also be conserved by landscaping with native plants

PROTECTION OF WATER SOURCE

1) Extreme efforts should be made to protect existing and potential groundwater sources from contamination.
2) Use of groundwater is probably the least energy-intensive because renewable energy sources (wind, photovoltaic) can be used to pump the water to a hillside storage reservoir for distribution by gravity. This type of system has so many advantages from both an environmental and economical perspective that the source can be developed up to several miles from the final use point.
3) Fresh surface water can be used when groundwater is not available from streams, rivers, and lakes.
4) In those areas where there is a lack of water, rain catchment becomes an option as a stand-alone supply of water or a supplement to a limited ground or surface supply. Rainfall catchment from the roofs of structures is a recognized option for water supply, provided the necessary treatment processes are used prior to distribution. Care should be used in selecting a roofing material. Rainwater collected from ground surfaces can be used for secondary uses such as toilet flushing and irrigation of food crops.

WATER TREATMENT

1) The type(s) of treatment required will depend on the source of water and the quality of source water and must follow the law of the land including water assessment tests.
2) Treatment of groundwater is to be accomplished by simple measures that do not contaminate the natural environment.
3) The recommended filtration processes would be slow sand filtration or cartridge filtration. Only the water used for drinking, washing, and cooking would need to be completely treated. Dual distribution systems are required - one for drinking water and one for lesser quality uses such as toilet flushing.
4) The slow sand filter is an old technology that has recently reemerged. No chemical additions or additional power are required and operations and maintenance requirements are low. However, a certain land area is required for the filter basin.

WATER STORAGE

1) Water storage methods should not adversely affect the natural environment.
2) Water storage must be designed to ensure the special aspects of the aesthetics of the natural environment are not disturbed.
3) Gravity storage of any water product (raw, finished, reclaimed) should be used wherever possible. Gravity storage enables wind and photovoltaic pumping systems to be effective. Because these pumping systems work at relatively low pumping rates, the gravity storage tank acts as an accumulator to store water for heavy demand periods or for days when the wind does not blow or the sun does not shine. Photovoltaic pumping systems can also be used.
4) Another means of transferring raw water from a source to a storage tank at a higher elevation without electrical or hydrocarbon input is the hydraulic ram. The hydraulic ram is a self-acting impulse pump that uses the momentum of a slight fall of water to force a part of the water to a higher elevation. A hydraulic ram is noisy, but the noise can be successfully mitigated with the use of sound-attenuating materials in an enclosure. The hydraulic ram is well suited for areas where electrical power is not available and where an excess supply of water is available.
5) As a gravity storage tank will be located in an elevated location, visual quality will be important. Multiple smaller tanks may be easier to screen than one large tank. Multiple tanks also provide greater flexibility in operation. Tank materials should be noncorrosive and sectioned for minimal transportation requirements to the tank site.

WATER DISTRIBUTION

1) Most distribution systems are either buried or placed at grade. At-grade distribution systems affect the site and vegetation minimally during construction. Burying has the advantage of protecting against accidental breakage, but leaks are more difficult to locate on a buried distribution system. Leak detection and repair is imperative when dealing with such a precious resource as water.
2) Dual distribution systems are very effective in that different qualities of water can be delivered to different use points. Pipe contents should be color coded so that cross-connection problems can be prevented.
3) No distribution methods should cause large scale destruction to the natural environment.
4) Water distribution methods should not disturb the natural aesthetics or quality of the site

SECTION 7:

INDOOR ENVIRONMENTAL QUALITY

SECTION 7: INDOOR ENVIRONMENTAL QUALITY

For healthy indoor air quality the following should be considered:

1. Natural Cross Ventilation Design Strategies should be incorporated to ensure fresh air quality with minimal reliance on mechanical operations for air quality.

2. Analysis of Indoor Air Pollution could be considered with subsequent use of effective pollution defences and filters

3. The Design of HVAC Systems should be effective to promote improved air quality

4. Choosing Zero- Or Low-Emission Finish Materials for the building

5. Use of Low VOC Materials, Paints & Adhesives

Examples of

CHEMICALS SOURCES IN BUILDING MATERIALS TO AVOID:

Some toxic chemicals to avoid are the following:

1. ***Benzene***
   found in synthetic fibers and plastics: highly toxic to red blood cells

2. ***Acetone***
   found in masonry, caulking, wall coverings, strippers, adhesives, polyurethane, stains, and sealers: flammable and strong odor

3. ***Toluene***
   found in adhesives, paint remover, paint: flammable and may cause lung damage

4. ***Dichloromethane***
   found in solvent in paint remover and adhesive paint aerosols: may cause cancer, heart attacks; a known water pollutant

5. ***Ethylene glycol***
   found in solvent in latex paint: may cause damage to blood and bone morrow

- ***DEHP***
  found in plasticizer used in wall covering and floor covering to keep vinyl flexible: known carcinogen

- ***Dioxin***
  found in PVC products: very toxic; low levels cause cancer; disrupts endocrine functioning

- ***Formaldehyde***
  found in plywood, particleboard, adhesives, fabric finishes, and carpet padding: known carcinogen; may cause allergic reactions or asthma attacks

- ***4-PC,***
  A natural result of binding latex to carpet: it may cause allergic reactions

SECTION 8:

GREEN CONSTRUCTION MANAGEMENT

SECTION 8: GREEN CONSTRUCTION MANAGEMENT

The key objective for sustainable construction is to
leave the landscape visually
and environmentally
in the condition closest to
how it was before the construction.

A planned green design is a great step towards sustainability in buildings Bhutan. However, it will mean absolutely nothing if the construction is then not as it was intended to achieve green buildings. Green construction management is achieved through the 4 essential elements:

1. Consideration of the Qualifications of the Construction team
2. Environmentally Sensitive Construction practices
3. Protection of site during construction
4. Conservation of resources during construction processes
5. Effective Construction Waste Management

QUALIFICATIONS OF THE CONSTRUCTION TEAM

A great deal of pressure is currently placed on design teams to achieve low carbon and green buildings. For construction companies to turn plans into reality and meet the design objectives, it is vital that the site team has the correct knowledge and skills.

Having these skills ensures quality in project delivery and helps to minimize the environmental impacts of the construction process and the building in use, as well as meeting the intentions of the building designers.

In order to ensure that the green design details and specifications are effectively carried out on site during the construction it is imperative that the construction team understands the concepts of green design and construction. Therefore it is important to ensure that the different levels of the construction team right from the management level to the day workers level have an understanding of green design principles and objectives of the project.

The Project should be lead by a professional who has the relevant training and experience of green building design and also construction management depending on the level of complexities of the design and specifications.

The project management should further ensure that the team for the construction are instructed or informed right from the beginning on the specifications of the project so that implementation does not take place in an ad-hoc manner that compromises green design and green construction principles.

ENVIRONMENTALLY SENSITIVE CONSTRUCTION PRACTICES

The construction methods employed should ensure that each step of the building process is focused on eliminating unnecessary site disruption (e.g., excessive grading, blasting, clearing) and resource degradation (e.g., stream siltation, groundwater contamination, air-quality loss). For the project to be successful in sustainability there should thus be no residual signs of site cutting, construction, and environmental damage. The main task for sustainability during the construction process consists of:

a) Constructing the building so it will perform as intended and
b) Protecting the environment as much as possible throughout the process.

The following are necessary for sustainable site development:

1) Development of detailed construction documents with accurate and clears specifications.
2) Development of systems for informing and training contractors and sub-contractors about unfamiliar materials and construction methods.
3) Development of detailed construction schedule with specification of activities, material staging and sequences of work on site.
4) Details of systems to be used during construction to ensure development is in accordance with approved sustainable plans,
5) Use of construction equipment that meets best-practice emission standards.
6) Professional supervision on the site as per the specifications and design. The construction on site has to be supervised by professional engineers, architects, and relevant consultants of a minimum of 3 years of practical experience in construction

supervision.

7) Contractors and subcontractors must be trained and experienced in sustainable construction or supervised by professionals trained and experienced in sustainable construction.

8) All undisturbed soil and vegetation located outside specifically designated construction limits should be fenced or otherwise protected (e.g., drop cloths, tree barriers).

9) Where disturbance occurs, the site should be restored as soon as possible.

10) All topsoil from construction area should be collected for use in site restoration.

11) Preplanning of the construction process to identify alternative methods that minimize resource degradation.

12) Flexibility in revising construction plans should be allowed to change materials and construction methods based on actual site impacts.

13) Resource indicators are to be developed to allow for monitoring to ensure that resources are not being adversely affected.

14) Development and adoption of an erosion & sediment control plan for the project site during construction to keep sediment on site

15) Disruptions of wildlife travel or nesting patterns are to be avoided by sensitive siting of development.

PROTECTION OF SITE DURING CONSTRUCTION

The site development and construction should minimize site disturbance zones by the following:

1. A plan that protects as much of the site as possible, including vegetation, land contours, and drainages should be considered by the project team.
2. The plan should indicate areas of the site to be used, including staging areas, storage areas (for materials and excavated materials), and the building site.
3. Consider any site clearing that may be necessary to meet fire risk reduction.
4. Elements to protect should be clearly marked in the site plan. If necessary provide pictures and images.
5. Avoid damaging existing vegetation, especially to mature stands of trees. Damage to trees, both above and below ground, can occur during construction activities.

The following guidelines help preserve existing trees:

6. Install fences around trees to protect them from construction activities.
7. Avoid trenching and digging near roots. (Roots can grow at distances one to three times the height of the tree.)
8. If trenching cannot be avoided, then place the trench directly under the tree, as this damages the fewest roots and does not unbalance the tree. (If major roots from one side of a tree are severed, the tree could fall or blow over.)
9. Avoid compacting soils containing tree roots to prevent decreasing the soil oxygen level, which inhibits root growth.
10. Avoid placing additional soil on the ground or changing the surface grade over the tree root systems, as that can smother the roots.
11. Carefully choose which trees to remove, since removal of tall neighboring trees can expose other remaining sun-and wind-sensitive trees to the elements and cause damage such as sunscald to trunks and branches. Where necessary, consider relocating and planting trees, shrubs, and other flora that could be restored as landscaping on this project or another project.
12. Be sure to select plants that are able to tolerate transplanting; and become familiar with the best method for trans-planting and care of the species chosen.
13. Locate all construction trailers and parking areas for construction equipment and employees where they will cause the least damage to the site and vegetation.
14. Specify areas in which to receive materials. All materials entering the site should have a designated site storage destination prior to their arrival. Often, materials entering the

site are “dropped” haphazardly at any point that looks open. The more materials are moved, the greater the possibility for damage to the materials and the site and the potential for wasted funds.

15. Identify access paths for construction vehicles and general public access. If possible, these paths should correspond to areas that will eventually be paved or covered with other hard surfaces for the project.
16. Consider laying down preliminary paving in areas that will be permanently paved later. This will reduce dust and erosion from construction activities and traffic.
17. Use best management practices for storm water and silt management. Consider creating storm water management practices, such as piping systems, retention ponds, or tanks, which can be carried over after the building is complete.
18. During construction, the areas available for builder’s access are to be tightly defined.
19. A daily clean-up of the building site at the end of the day is to be strictly enforced to minimize impact on the environment.

CONSERVATION OF RESOURCES DURING CONSTRUCTION PROCESSES

Construction of a building uses a lot of energy, water, and other resources, beyond those that end up in the building itself. By paying attention to these resource flows, contractors can adopt procedures that are more efficient and less polluting.

Some basic but effective examples include:

1. Monitoring og energy and water use for construction.

2. Providing incentives or place the utility and water bills in the contractor’s name to encourage conservation.

3. Use of lighting during construction only in active areas of the site. This saves energy and protects the night sky from light pollution.

4. Turning all lights off when work is at a halt.

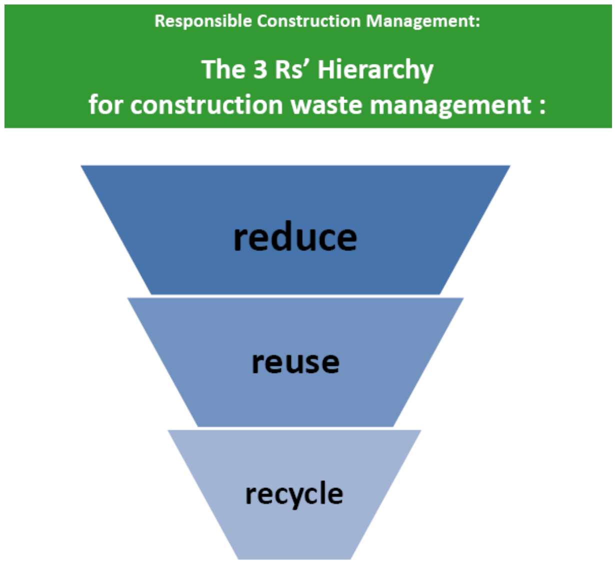
5. Operating security lighting on motion sensors

SECTION 9:

MANAGEMENT OF WASTE FROM CONSTRUCTION

SECTION 9: MANAGEMENT OF WASTE FROM CONSTRUCTION

Construction activities always generate significant quantities of solid waste. The primary intent of sustainable construction waste management practices is to conserve resources by minimizing the amount of material disposed of in landfills or thrown in the parks.



CONSTRUCTION SITE WASTE MANAGEMENT STRATEGIES

It is important for a Construction Waste Management Plan to be in place before even starting any construction on site. The Construction waste plan will be in line with the regulations put in place by NEC or other relevant authorities including City Offices.

A Construction Waste management Plan should include the following:

1. Waste handling requirements should be included right from the start in all project documents. This makes it clear from the beginning that waste prevention and recycling is expected from all crew members and subcontractors of the construction team.

2. An analysis of project waste could be made right from the start of the project. This will facilitate the construction waste management plan and strategies.

3. Identification of what materials will be recycled and handled for recycling should be carried out by the construction project team.

4. Disposal methods should be identified and the construction team informed about the different disposal methods.

5. The recycling and trash bins should also be near each other so that trash is not thrown into the recycling bins.

6. Bins for toxic waste should be in a supervised or locked area.

7. Leadership in Construction Waste Management should be identified and placed in the project.

8. Once space for recycling and disposal activities has been designated, the plans must be strongly communicated to the construction crew and any subcontractors. Everyone will need to know how materials should be separated, where materials should go, and how often the materials will be collected and delivered to appropriate facilities. This is very essential as most construction crew members in Bhutan are not familiar with waste management.