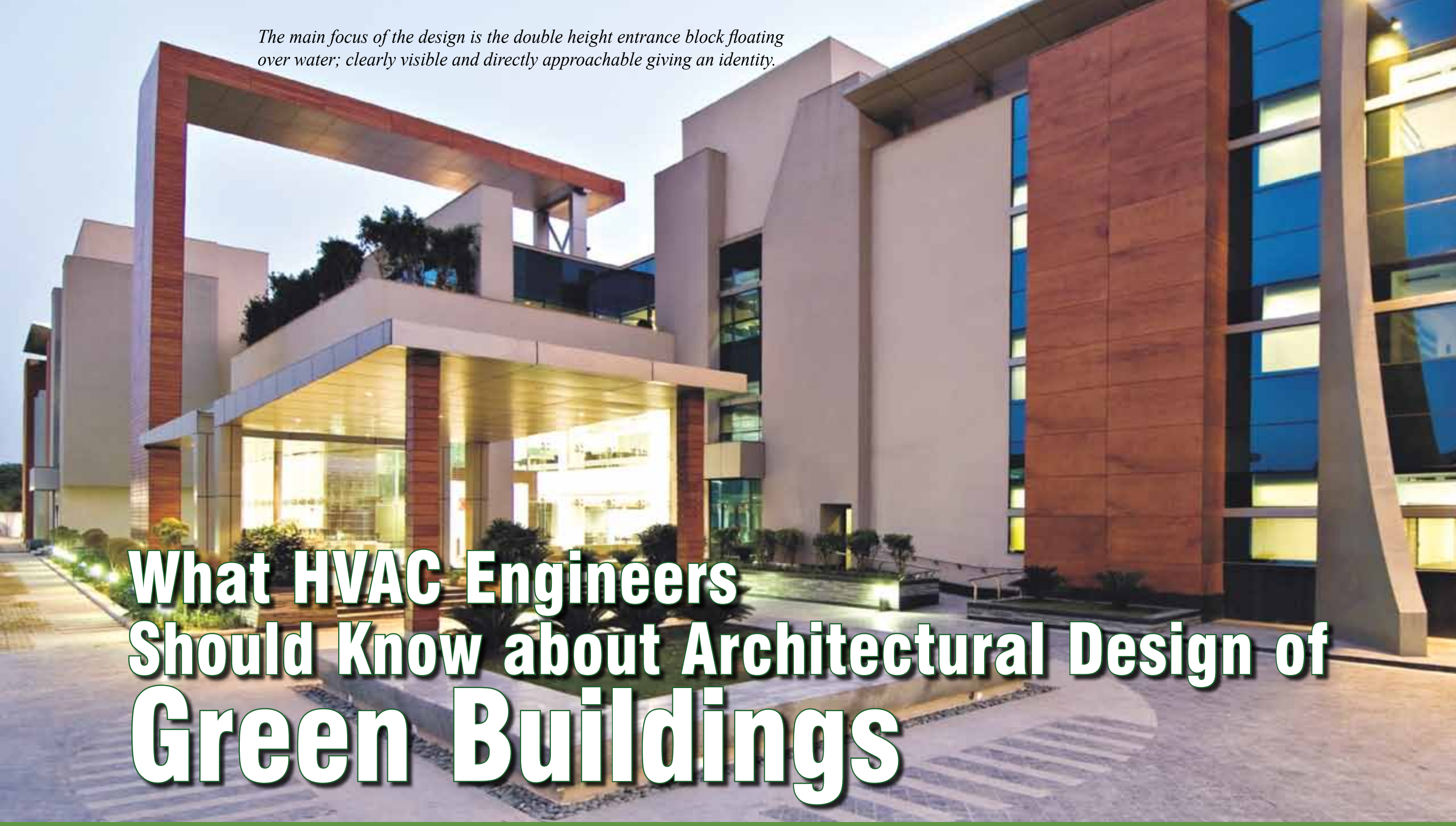

The main focus of the design is the double height entrance block floating over water; clearly visible and directly approachable giving an identity.

What HVAC Engineers Should Know about Architectural Design of Green Buildings

By Sheetal Rakheja
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The thought process that goes into the architectural design of a green building is explained in this article. The building described is the first LEED India Platinum-rated green building at Noida on a 5-acre sprawling campus with 380,000 sq.ft. built-up area for Patni Computers.

Buildings consume vast amounts of our resources like water, energy, materials and threaten the ecological systems that support life, from the ozone layer to the world's forests.

Development and construction processes are often destructive to local ecology as they affect the surrounding air and water quality. These activities often encroach on productive agricultural land areas and open spaces. Storm water run-off from developed areas can impact water quality in receiving waters, hinder navigation and recreation and disrupt aquatic life.

It is therefore imperative to be concerned about the planet we inhabit and to preserve it for our future generations. Someone rightly said "We have not inherited this earth from our ancestors but borrowed it from our children".

Sustainable development is easy to achieve with a right approach. Firstly, there is a need to think ... Reassess our excess, as it is important to build for fulfilling our needs and not the greed. Secondly, build in a way to cause least disturbance to the environment and neighbours. For this, one can learn from our ancestors, who used to build their houses based on their practical needs and the constraints of the site and climate. These houses were in harmony with nature by embodying their larger setting through local materials, local techniques, local climate and local culture. In the earlier houses great ingenuity was used to cool homes with cross ventilation, open as well as shuttered verandahs and passages cooled the classic mansions, pergolas hung with vines shaded the sunny side from excessive heat and so on. Even the earlier way of living was sustainable since our elders prohibited us from wasting water/ food and the kabadiwallahs ensured

About the Author

Sheetal Rakheja is a graduate from Sushant School of Art & Architecture with 10 years of design experience in leading architectural groups in Delhi. Designing has always been her key strength from college days. A firm believer in *sustainable architecture*, her experience, strengths and beliefs came in very useful when she became involved, along with Vidur Bharadwaj, in the design of the Wipro Corp. office which was awarded LEED Platinum by USGBC. This building has the distinction of being the largest and greenest in the world. Patni campus at Noida designed by her is the first IGBC Platinum rated green building.

that old clothes/utensils were either recycled or reused. Thirdly, a holistic approach for design and construction of our workplace and home is required in which the design attempts to balance resource efficiency, environmental responsibility, occupant comfort and community sensitivity. Thus, for building green, one needs to carefully use the finite resources of water and energy and construct so as to cause no or minimum environmental damage by selecting materials that are eco-friendly and have low embodied energy. Finally, since the buildings are made for the occupants, their comfort and well being are very important. A careful review of aspects like good daylight into the building and connecting the outdoors with indoors through views, thermal comfort etc needs to be taken. In addition, by selecting the site in close proximity to basic services like shops, clinics, clubs, place of worship for convenience of occupants, enhances community living and reduces long vehicle trips to these places.

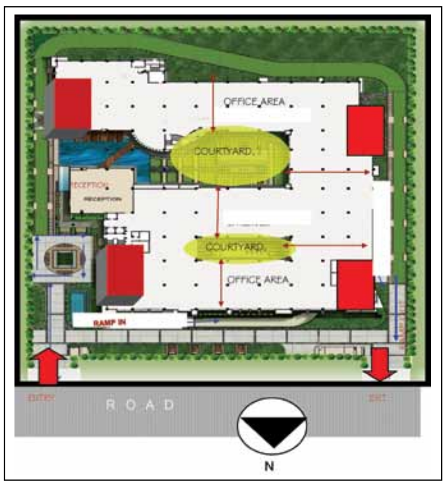
Therefore, to sum up, a Green building is concerned about all of the following aspects: sustainable site planning, water efficiency, materials & resources, energy & atmosphere and Indoor environmental quality.

Case Study of Patni Computers

The campus for Patni Computers at Noida is spread over 5 acres with total constructed area of 3,80,000 sq ft. This campus has been awarded the coveted Platinum rating by Indian Green Building Council (IGBC) and embodies sustainable design practices by careful planning, optimized use of on-site sources, efficient equipment selection, employment of good waste & water management practices, use of eco-friendly & efficient building materials, ideal construction practices and also provides a comfortable & hygienic indoor working condition. Some features which make this Platinum building stand out amongst its contemporaries are highlighted in this article.

Site Selection

Patni campus site was previously a dismantled toy factory. Thus, the site being previously developed, the consequential disturbances of urban development had already occurred and hence further damage to the environment by this development was limited. The site, in addition, has excellent connectivity to city bus routes and has basic services like shopping, banks, medical care facility, entertainment, grocery, place of worship etc within walking distance. This reduces the demand on automobile usage and encourages employees to settle closer to the workplace.



Site plan of Patni campus

To eductae its employees on the benefits of community living, preferred car park spaces for carpool vehicles, charging points for electric vehicles and use of public transport service is encouraged as a corporate policy. In addition, Patni also runs its own CNG driven contract buses, thereby minimizing usage of self-driven vehicles.

Heat Island Effect

A "heat island" develops when hardpaved surfaces like buildings, roads, sidewalks and rooftops replace natural vegetation or green areas. Natural surfaces moderate temperature by evaporation from soils, transpiration from plants and shading, whereas built surfaces made of materials like brick, asphalt, and concrete have low albedos and high heat capacities. Heat island effect raises the localized temperature, impacting local microclimate and adding to global warming as well as adversely affecting human health. The Patni project has tried to eliminate the negative effects of heat island by integrating into its surroundings and separately addressing the adverse effect of roof and non-roof areas.

Heat island effect by roof surface has been reduced by installing a combination of cool roof and vegetated roof. A cool roof (with a white color high albedo paint) has a higher solar reflectance and higher thermal remittance than a normal grey roof. It also helps in warding off heat intake into the building from the roof, thereby reducing cooling loads. Vegetated surface over the roof reduces outdoor air temperature and heat island effect through transpiration from plants, shading and increased reflectivity of the roof. Patni campus has part vegetated roof and the rest is

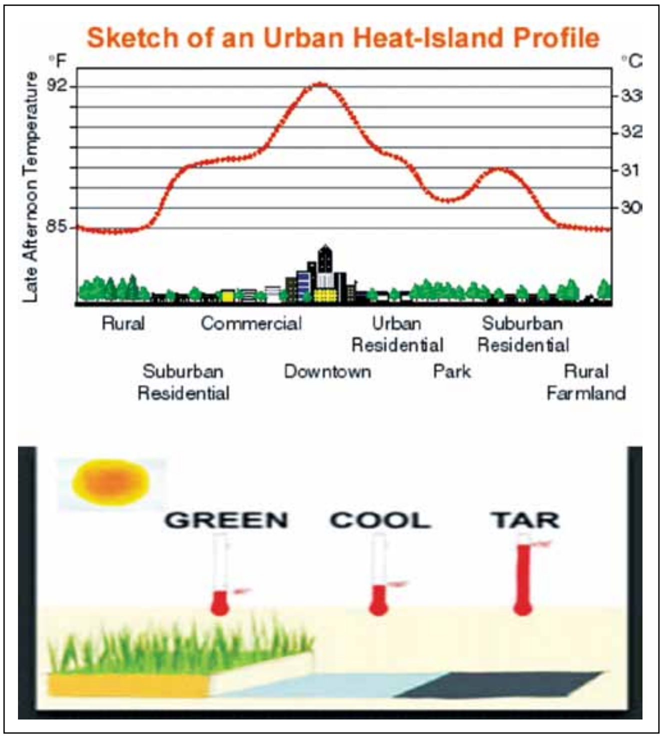


Illustration of "heat island effect"

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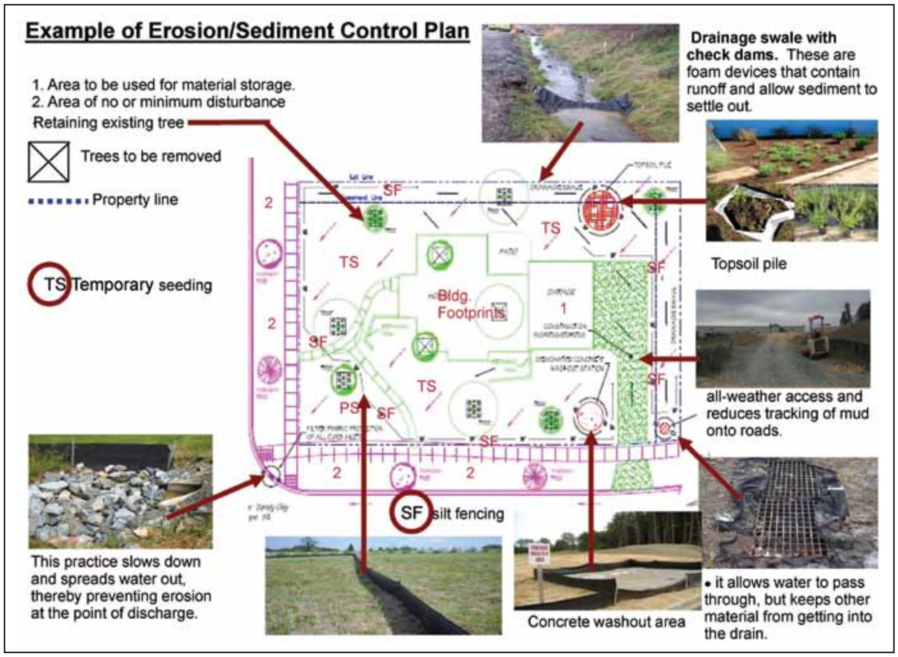
painted using high albedo paint with SRI (Solar Reflective Index) of over 78%.

For combating non roof heat islands, the entire parking is planned in the basement. This reduces the asphalt road surfaces and permits more landscape areas with greenery and trees.

Light Pollution

"Light pollution" is becoming a challenging issue in our cities wherein breakaway light from buildings produces glare whenever directed upwards to the sky or directed off the site. It not only adversely affects the ecosystem, nocturnal birds and animals, but also makes driving unsafe and affects astronomical studies.

The interior and external lighting of the Patni project has been designed to cause minimal light pollution. Interior building lighting has been selected such that the majority of direct beam illumination produced by interior luminaires intersects with solid/opaque building surfaces thereby preventing light spill through transparent and translucent surfaces to exterior areas. Exterior lighting design has time scheduled lights to reduce electrical loads, cut-off optics and low wattage lamps to minimize light pollution, shielded luminaires to minimize light trespass on a neighbouring property or building, fully shielded or IESNA (Illuminating Engineering Society of North America) full-cut-off luminaires to eliminate direct light above the horizontal plane and finally good lighting designed in a manner that all the light falls where it is needed and wanted. The building has no up-lighting and glare has been kept to a minimum by ensuring that the main beam angle of all lights that is directed towards any potential observer is not at more than 70 degrees.



Example of "erosion/sediment control plan"

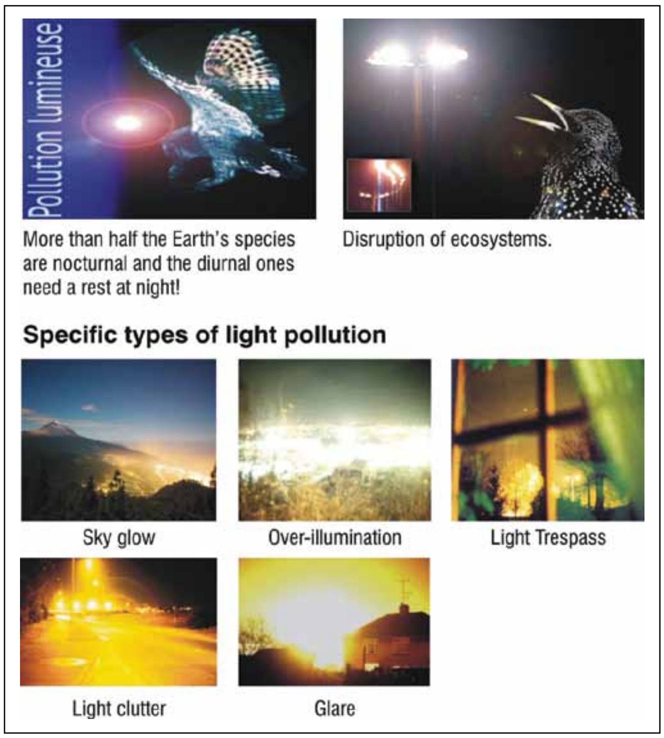


Illustration of "light pollution"

Soil Erosion

This is a natural process but development and construction activity with improper practices adversely affects the local ecology thereby accelerating soil erosion. Erosion rate increases during construction due to the removal of soil cover, alteration of soil characteristics, and changes in site topography. Even a small amount of soil erosion from a site can cause significant environmental damage by the following:

- Blocking of storm water pipes increases.
- Flooding.
- Killing aquatic life and affecting ecosystems.
- Loss of nutrient rich upper layer.
- Silting up streams causing destruction of natural stream channels.
- Reducing water holding capacity of soil.

During the construction process of Patni campus, the existing boundary wall was retained and silt fencing done in all construction areas. A sedimentation tank was made to remove sediments from the surface runoff. Excavation at a slope was carried out to retain earth sliding and then earth slopes were matted with plastic sheets to prevent soil erosion. Transplantation of existing turf and stock piling of top soil was done which was preserved during the period of construction by temporary vegetation on top. At the end of the project, this fertile soil was reused for landscaping.

View of the reception area

Passive Climate-Responsive Architecture

Builidings consume about 40% of the world's energy. Out of this, about 85% gets consumed in operating the buildings and approximately 15% goes in making the buildings, which is called its embodied energy. Energy efficient designs can lower the operating energy required to run the building. However, as the popular adage goes, "Well begun is half done", it is important that the built form is designed in context with the climate and surroundings. Climate responsive architecture takes advantage of free energy in the form of heat and light. This is known more commonly as vernacular architecture, or "forms which grow out of the practical needs of the inhabitants of a place and the constraints of the site and climate". The goal is to modulate the conditions such that they are always within or as close as possible to the comfort zone. Modulations introduced by the landscape, built form, building envelope, materials and other control measures bring the conditions within the comfort range throughout the diurnal variation.

Water feature and plantation brings down ambient temp

The courtyard at Patni Campus

Patni campus site falls under the composite climate of Delhi. The basic architectural design is inspired by the traditional inward looking "Indian Haveli Plan". The design concept is that of a simple straight line low key architecture in context with the surroundings, site and climate.

The term "Courtyard" is an environmental space that combines the principles of physics, perception and cultural psychology. It produces an aesthetic language in which nature is reinstated as a beneficient force in architecture. The most important characteristic of the courtyard building form is that the inner building envelope is used for light and ventilation instead of the outer envelope. The buildings in Patni campus are designed around two beautifully landscaped courtyards with water bodies, plants, sculpture as visual nodes that enhances and binds the spaces. The building envelope opens out with greater transparency towards the courtyard. Water features in these courtyards lower down the ambient temperature and the area thus performs multi functions of being a light well, a microclimatic generator and a landscape element.

The basic design of PATNI is inspired by the traditional inward looking 'INDIAN' haveli plan.

Elevation is inspired from a typical Indian haveli jharokha.

Climate responsive architecture

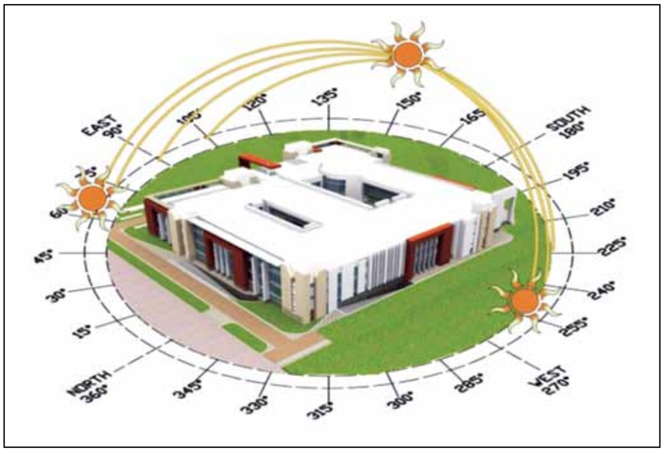
Building Envelope

The building envelope consists of elements such as walls, windows, doors, roofs, and floor surfaces etc., that enclose space, separating inside from outside.

Within Patni campus, the longer sides of the building have been oriented north-south. North surface receives minimum direct sunlight and south faces high sun which is cut off by horizontal projections. Computer simulation model has been prepared and studied to finalise the glazing size, glass selection and shading devices' type and sizes.

Elevations of the building are inspired from a typical "Indian Haveli Jharokha". The building depth is optimized to capture natural daylight for more than 75% of occupied interiors and to maximize outdoor views. All exterior shading systems have been designed, to cut off heat while achieving maximum penetration of glare-free light with the help of reflective light shelves and light colored false ceiling design which tapers near the glazing to let in more light. The daylight design helps in reducing electrical loads.

The building envelope is designed to reduce unwanted heat gain. All external walls are built with 200 mm thick "Autoclaved Aereated Concrete" (AAC) blockwork on outside, and 100 mm thick brickwork on inside with 25 mm thick extruded polystyrene insulation in between the outer and inner walls. The roof has a combination of high albedo paint as a reflective barrier and 75 mm thick extruded polystyrene overdeck insulation to resist heat ingress.



Sun path diagram for Patni campus

Two different types of Double Glazing Units (DGU) have been employed on the building façade. Visible glass area upto 2.1 m (7 feet) height is with lower light transmission and low shading coefficient (high heat cut-off) to prevent glare on computer screens of the users. All the higher glass surfaces (above 2.1 m height) have DGU with superior light transmission to maximize the daylighting effect into the building.

Water Bodies in Landscaping Areas

In composite climates, water bodies can be used both for evaporative cooling as well as for minimizing heat gain. Water bodies absorb much heat during the day and re-radiate it at night. When the water body is in a shadow (for instance a pond in a courtyard), the incoming solar radiation is reduced, with a further reduction in water temperature.

In the Patni campus, one side of the building (next to reception) faces the wind direction and other side opens into the court which is stilted. A water body is strategically designed in the stilted area so that the wind while passing through this opening touches the water, gets cooled and enters the court. This helps in creating a microclimate which reduces air conditioning loads.

Electro-Mechanical System Design

The building has a state-of-the-art MEP design consisting of high COP water chilling machines, high efficiency motors and blowers, variable frequency drives on all the motors to increase part load efficiency, modulating fresh air dampers linked to CO_2 sensors for adding fresh air on demand etc. Pre-cooling of outdoor ventilation air through heat recovery wheels further helps in energy conservation. The peak air-conditioning load is approximately 700 TR.

The lighting design employs occupancy sensors for normally unoccupied areas like corporate lounges, AHU rooms and stores. Perimeter lighting is linked to daylight sensors which cut-off artificial lighting during daytime and gradually build it up as dusk approaches. All internal lighting is provided with high efficiency dimmable electronic ballasts. Lighting Power Density (LPD) of 0.65 W/ sft was achieved in all occupied floors and 0.18 W/sft in the basement car park.

Active and passive features together help in saving 35.8% energy over ASHRAE Standard 90.1-2004 defined base building as per building simulation results. The commissioning agency was involved not only in fundamental and additional commissioning of the building systems, but also in developing a Measurement & Verification (M&V) program.

Materials

Building materials choice is important in sustainable design because of the extensive process of extraction, transformation and transportation steps required to get the finished product at site. These activities pollute surrounding air and water, destroy habitats and deplete natural resources. "A sustainable building material is environment friendly, healthy for occupants, readily available, is made from renewable raw materials, and uses only renewable energy in its extraction, production, transport and can be reclaimed and recycled"

The concept of embodied energy is the scalar total of energy input required to produce a product and energy used in its transportation. Hence, by using regional materials, with higher recycled content, the embodied energy and environmental impact of a product can be reduced.

One of the most effective strategies for minimizing the environmental impacts of the construction process is to reuse existing buildings. Rehabilitation of an existing building shell and non-shell components, reduces solid waste volumes and diverts these waste volumes from landfills. It also reduces environmental impacts associated with the production and delivery of new building products. Reuse of an existing building minimizes habitat disturbance and typically requires less infrastructure such as utilities and roads.

For new construction also, it is always best to use old materials as much as possible and refurbish them. Not only does it reduce the demand on virgin materials but also diverts waste from going to landfill. Second best alternative is to use recycled materials which have a high percentage of recycled content. Concrete, a widely used material is composed of cement, sand and gravel. A certain percentage of cement can easily be replaced by flyash (about 30%) in concrete, thereby reducing concrete's embodied energy. Flyash is a by-product of coal industries. For the Patni project, gravel was replaced by broken crushed bricks and waste

Another view of the building

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crushed concrete which was generated at site.

Metals on the other hand have the highest embodied energy but the good part is that this materials can take recycling upto 90%. There is no limit to the amount of times aluminium can be recycled. In Patni project, reinforcement steel and structural steel with up to 85% recycled content has been successfully used.

Regional wood is low in embodied energy, as not much processing is required. It's always better to use wood from sustainably managed forests where trees are grown for harvesting purposes and do not disturb the ecology. A better alternative is to use wood products like MDF, LDF (Medium Density Fibreboard & Low Density Fibreboard) which are made from wood wastes, and agriculture waste which have again been used successfully at the Patni project. Examples of some materials used in the project are as follows:

- 90% of the total value of materials is "sourced locally" like AAC blocks, bricks, flooring stone and Dholpur stone for the façade.
- 15% of the total value of materials can be categorized under "rapidly renewable" such as use of bamboo wallpaper on feature walls, bamboo flooring in cafeteria, MDF for partition and feature walls etc.
- 25% of the total value of materials falls under the category of "resource reuse" such as staircase railing from another demolished site and use of broken tiles in balconies.
- 30% of the total value of materials has a "recycled content" in them such as extruded polystyrene insulation (40% recycled content), AAC blocks (35% flyash recycled content), aluminium sections (40% recycled content), glass (15% recycled content), gypsum (40% recycled content) and vitrified floor tiles (10% recycled content).

Construction Waste Management

"Recycling 1 ton of paper saves 17 trees, 2 barrels of oil (enough to run the average car for 1,260 miles), 4,100 kilowatts of energy (enough power for the average home for 6 months), 3.2 cubic yards of landfill space, and 60 pounds of air pollution".

Recycling of construction and demolition debris reduces demand for virgin resources, and, in turn, reduces the environmental impacts associated with resource extraction, processing and, in many cases, transportation. Landfills contaminate groundwater and encroach upon valuable green space. Through effective construction waste management, it is possible to extend the lifetime of existing landfills, avoiding the need for expansion or new landfill sites.

At Patni, approximately 75% construction waste was reused and 85% diverted from landfill site. Some of the achievements are as follows:

- Scrap steel was straightened and re-used in Guard Room slabs.
- Part of the scrap steel was sent to other ongoing project sites for reuse and recycling.
- Concrete debris, broken tiles, AAC blocks were used for internal & external development.
- Broken bricks were reused as brick bat coba for terrace waterproofing.
- Stone waste was used as finishing material for landscape feature walls.
- Gypsum false ceiling tiles were sent to a nearby manufacturing unit for recycling.

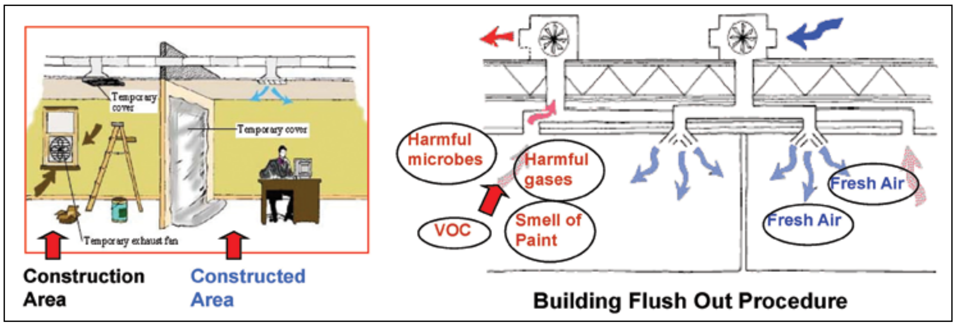
Other effective strategies for construction waste management which were employed are as follows:

1. Factors that contribute to waste such as over-packaging, improper storage, ordering errors, poor planning, breakage, mishandling, and contamination of construction materials were minimised.
2. Construction waste management plan was developed that identified proposed deconstruction and salvage opportunities, on-site reprocessing and reuse opportunities, recommended recycling activities, licensed haulers and processors of recyclables, and potential markets for salvaged materials.
3. On the construction site, an area was designated specifically for construction and demolition waste recycling.
4. Training of site workers was done on the proper recycling protocol and labelling recyclable containers effectively.

Stone waste as finishing material for planters

Broken bricks reused for brickbat coba

Pictures of construction waste management



Indoor environmental quality

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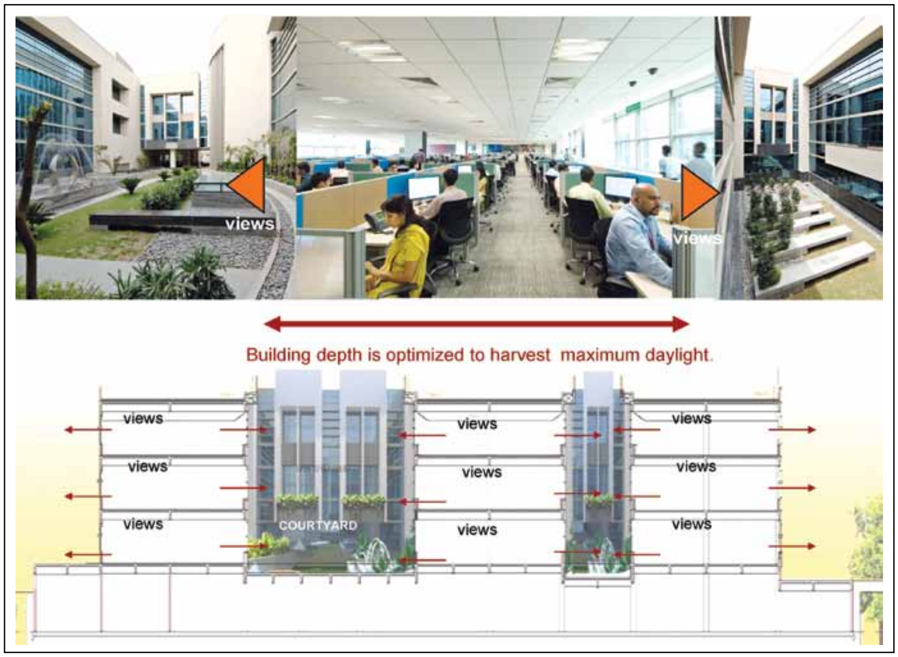
Indoor Environmental Quality

Most people spend an average of 90% of their time indoors, where levels of pollutants may be two to five times (and occasionally more than 100 times higher) than outdoor levels. Many of these pollutants can cause adverse health effects like asthma, allergies, thus contributing to millions of days absent from school and work. This emphasizes the need for optimal indoor environmental quality (IEQ) strategies. Case studies suggest that IEQ improvements can increase worker productivity by as much as 16%. IEQ strategies include issues related to indoor air quality (IAQ) such as increased ratios of filtered outside air, ventilation effectiveness, moisture management and control of contaminants. Other IEQ issues to consider include; day lighting and lighting quality, thermal comfort, acoustics, occupant control of building systems, and access to views. All of these issues have the potential to enhance the indoor environment and optimize interior spaces for building occupants.



Indoor environmental quality

Tightly sealed building envelopes with no scope of outside fresh air and recirculation of indoor air with high levels of CO_2, pollutants like microbes, micro-organisms and VOC's (Volatile Organic Compounds) in materials lead to poor indoor air quality.

A large number of building products contain compounds that have a negative impact on indoor air quality and the earth's atmosphere. The most prominent of these volatile organic compounds contribute to smog generation and air pollution outdoors while having an adverse effect on the well-being of building occupants indoors. Materials commonly associated with high-VOC content include; adhesives, paints and coatings, carpet systems, composite wood, and agrifiber products.

For the Patni project, proper selection of materials having low VOC content was done. Zero VOC paints were used. Water based solvents were preferred for waterproofing and polishing, as they have much lower VOC content than oil based solvents. Care was taken while selecting composite wood products, as they can have harmful urea formaldehyde resins.

Indoor Environmental Quality (IEQ) strategies employed during construction for the Patni Campus project are as follows:

- Proper protection and storage of materials/equipment was done to protect them from moisture and dust like window frames, light fixtures etc.
- Protected electrical panels from moisture by covering them with plastic sheets.
- Moisture absorbing glass Insulation was kept sealed and stored separately in a dry room.
- Air conditioning duct openings were kept in covered condition till construction was over to prevent dust ingress.

After construction, Indoor Environmental Quality (IEQ) enhancing strategies included the following:

- "Construction indoor air quality management plan" was employed to effectively get rid of the particulate matter and volatile organic compounds by a building flush-out procedure. This was done after construction ended and prior to occupancy, where for a minimum of two weeks the building was flushed-out using Minimum Efficiency Reporting Value (MERV) 8 commissioning filters on every air handling unit with 100% outside air.
- All exterior entrances have been designed with permanent entryway systems (e.g. grilles and grates) to catch and hold dirt particles and to prevent contamination of the building interior from dust entering through shoes and clothing of occupants/visitors entering the building.
- Exterior stone, brick, or concrete surfaces are designed to drain away from building entrances.
- The landscape design at building entrances has a low maintenance vegetation.
- Occupant activities associated with chemical use (like housekeeping equipments) are physically isolated. All of these areas have sinks and drains plumbed for appropriate disposal of liquid waste and separate exhausts vented to the outside that are operated under negative pressure.
- Copy and printing rooms are designed with structural deck-to-deck partitions and dedicated exhaust systems.

To enhance indoor environment for occupants, almost all building occupants have a connection with the outdoor beautiful landscapes. Most of the areas are designed to capture glare free natural daylight.

The building thus vouches for a comfortable thermal

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environment with adequate fresh air, ventilation that supports productivity and well-being of occupants.

Water

Patni campus can be termed as a "zero discharge" building, wherein not a drop of water is wasted. The entire rain water is collected and taken to harvesting tanks or soaked into the ground. Sewage is 100% treated and the recycled water is used for cooling tower makeup, gardening and flushing. Solar water heating, drip irrigation, native and low water consuming plants are some other strategies adopted for efficient water management.

Going a Few Steps Further..

There were interactive sessions for all the team members involved in the project during the entire design and construction process for inputs, transparency and to ensure that strict ethical principles and practices were followed. A high standard of social responsibility was monitored by the project management team.

The design team (including architects, landscape consultants, service consultants and energy consultants) looked into all the aspects of buildings and system planning, design, construction and operation. The impact of each design decision on the environment was critically evaluated, leading to viable design solutions to minimize negative impacts, and enhance the positive impacts on the environment

It's a quantum leap in comparison to the conventional procedures which accomplish lesser criteria. This project sets up stringent standards and gives direction to further improve on those standards. Strong monitoring is being done to bring energy consumption down every subsequent year. To verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended, a commissioning authority was engaged.

Patni computers is yet another attempt to showcase to the world the benefits of *Going Green.* ❖