

Case Study of GREEN BOULEVARD, Noida

India's largest LEED Platinum Building in Core & Shell Category

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Even though the Green Building movement is sweeping across a large number of countries in both the developing and developed world, its impact is largely limited to self-use buildings wherein the benefits are availed by the Owners. However, a large number of buildings are constructed by Developers that are either rented or sold to the end users. The Green Building movement is yet to make a big impact in this category of buildings as most Developers aim for the lowest initial investment with disregard for the operating cost, as it is borne by the tenants.

Whereas, there are over 150 LEED Platinum buildings in the world, most of them are under New Construction (LEED NC) category which is applicable to self-use buildings. Out of these, only ten buildings have been rated Platinum under Core & Shell category (LEED CS) which is primarily meant for rented out buildings.

In India too, out of nearly twenty coveted LEED Platinum buildings, only three have achieved the highest Platinum mark in Core & Shell category. The largest building is "Green Boulevard" at Noida which was awarded LEED CS Platinum rating by the US Green Building Council in September 2009.

Green Boulevard at Noida is amongst the most environment friendly Core & Shell projects in India and has the finest

campuses of large IT companies like CSC, Nucleus Software, Patni Computers, HCL etc. as its neighbors. This building has done India proud on the Global map.

Building Description

The building is a multi-tenanted warm shell and offers ready-to-receive fit out option for potential tenants. It is

About the Authors

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.

Ashish Rakheja is a mechanical engineer from REC, Allahabad and an M Tech from IIT, New Delhi. He has been working with Spectral for 16 years and heads a large team of engineers working on various projects all over India. He teaches at the School of Planning and Architecture, Guru Gobind Singh University and Vastu Kala Academy, New Delhi. He is vice chairman, technical committee of IGBC, a certified LEED India trainer and has been involved in the design of 8 green buildings of which 7 were rated LEED-Platinum by USGBC. He is a member of ASHRAE, NFPA and immediate past national president of ISHRAE.



based around the concept of creating a congenial campus-like environment, where every tenant can share common areas, facilities and still retain their privacy. The three towers, of this one million sft. development, are staggered horizontally and vertically, giving each one visibility from the road as well as ensuring harnessing of daylight without shadowing each other.

The stilted public realms on the lower floors consist of an amphitheatre, gymnasium, cafeteria and shops, helping to form an area of common interest. The shaded, stilted landscape areas provide easy visual and physical connections, which creates an interactive environment. All floors above the ground level are rented out to tenants.

Design Strategy Adopted for the Project

The Developer was initially approached with a comprehensive design strategy to ensure minimum first cost and lowest operating cost. Since a major contributor in the annual energy bill is the air conditioning system, special emphasis was laid to reduce the total air conditioning load and also adopt cost effective strategies. It involved close interaction with the architect and other design team members. As a first step, all project designers met on a monthly basis throughout the duration of the project to review the design and sustainability measures. It set the foundation for the green project and the team collectively decided to follow a four pronged strategy:

- Review the “passive” design features which help in reducing annual energy demand by nearly 30% over conventional well designed Indian buildings.
- New “active” design strategies to come up with innovative ideas to cut down internal heat gains.
- Design the HVAC system taking into account the reduction in heat gains achieved through passive and active strategies and shunning the practice of thumb-rule designs.
- Develop a measurement and verification plan to reduce the operating cost by continuous improvement and learning from historical data collected over a period of time.

A comparison was made with ASHRAE Standard 90.1-2004 defined parameters to study the benefit of each strategy.

Passive AC Load Reduction Strategies

Orientation

Since the site is spread over 5 acres, it provided an opportunity for the design team to correctly orient the buildings as per the solar axis. All the three towers are therefore oriented North-South which is the most optimum in the Indian context. North side ensures minimum direct sunlight while the clever horizontal projection features cut-off the high sun from the South side, thereby reducing solar gain impact. The North-South orientation reduced the cooling load and consequently the annual energy consumption by over 1% as compared to ASHRAE 90.1-2004 defined base case.

Walls

The wall assembly impacts the cooling load due to conductive heat gains. Careful inputs on wall assembly selection helped to achieve 1.5% operational savings over ASHARE Standard 90.1-2004 defined base building. Wall composition adopted for the project is as follows:

- 230 mm thick brick wall and plaster on both sides.
- 25 mm thick extruded polystyrene insulation.
- 50 mm air gap.

‘U’ value of the the assembly is 0.095 Btu/hr-sqft⁰F which is better than ASHRAE defined ‘U’ value of 0.124 Btu/hr sqft⁰F. It may be noted that this value was most cost effective for the Developer.

Window

The window to wall ratio (WWR) has been kept by the Architect as only 30%. This ensured lower heat gain through exterior glazing without compromising on day-lighting. The location of windows was optimized using computer modeling tools. Double insulated high performance glass has been employed to balance-daylight, views and first cost to the Developer. Annual energy savings of over 2% were achieved over ASHRAE 90.1-2004 defined base building.

continued on page 76

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continued from page 73

'U' value of the selected glass is 0.28 Btu/hr sft⁰F which is far superior to conventional practice of using single glazing with thermal conductivity of 1.13 Btu/hr sft⁰F i.e. nearly 75% improvement.

Roof

A layer of 75 mm thick extruded polystyrene insulation laid over-deck helped in minimizing the heat gain through the roof. In addition, the final finish of the roof was specified as white glazed tiles to achieve the cool-roof effect by reflecting direct sunlight at source.

Roof insulation (to achieve R of 18) thus resulted in lowering the cooling load and consequently 0.5% annual energy savings over ASHRAE 90.1-2004 defined base building (R of 15).

Shading Devices & Day-lighting

The Architect's team played a major role in planning the exterior shading systems over glazing on all facades to cut-off heat and harness glare free light. A computer simulation of the devices was done to size and design the appropriate shading system.

The building is designed around two carved landscaped courtyards with water bodies, plants and sculptures as visual nodes. The building's facade opens out for greater transparency and ambience towards the courtyard which provides indirect sun light with little impact on the cooling load.

The building depth has been optimized so that more than 75% of the regularly occupied interior spaces get natural light. Strict guidelines were laid for tenants to discourage them from providing cabins on the outer periphery which may block ingress of natural light and thereby necessitate use of artificial lights.

Day lighting coupled with shading devices contributed in reducing the internal heat gains through lighting and thereby the cooling load of the building. The two strategies together helped in reducing annual energy demand by 2.5% over ASHRAE Standard 90.1 2004 defined base building.

Heat Island Effect (Macroclimate)

It is a common practice in modern buildings to hard pave surroundings of the buildings. It has been proven with research that reflective sunlight from paved surfaces can contribute to enhanced heat gains in the building and impact upto 2% energy bill. Recognizing this, the project team planned water bodies in the two courtyards to create a micro-climate to reduce ambient temperature thereby lowering the heat gain.

The external periphery of the building is provided with landscaped areas. More than 40% of the ground area has been kept green to increase the porosity of the site (for rain water harvesting) and simultaneously minimize the heat island effect.

The above passive measures thus helped in giving the project a good head start on HVAC design.

Active Internal Heat Gain Reduction Strategies

Lighting Power Density (LPD)

It has been an age old practice for air conditioning designers to compute the cooling load considering a heat gain of 2 W/sft from internal lighting. ASHRAE Standard 90.1-2004 defines allowable maximum Lighting Power Density (LPD) as 1.1 W/sft. However, in consultation with the Developer, it was decided to limit the allowable LPD to 0.8 W/sft by educating end users on the benefits of using energy efficient lighting fixtures without compromising on internal lighting levels.

Reduction in internal LPD helped the project to achieve nearly 5% annual energy saving over ASHRAE Standard 90.1-2004 defined base building due to reduction in cooling load.

Daylighting Controls

In all the common areas (which are finished by the Developer) like reception, atrium, lift lobbies etc, two-step control lighting has been designed which operates based on daylight sensors. The artificial lights are either 100% 'ON' or 50% 'ON' or completely 'OFF' based on demand. These daylight controls help in reducing the lighting load and subsequently the cooling load of the building thereby helping to achieve approximately 2% saving in annual electricity consumption over ASHRAE Standard 90.1-2004 defined base building. For all tenanted areas, similar guidelines are laid down to encourage use of daylighting controls.

Demand Control Ventilation

The design ventilation rate is 30% additional over ASHRAE Standard 62.1-2004 in accordance with LEED guidelines. Outdoor air in each AHU room is brought in through a centralised, roof mounted, treated fresh air unit which injects air into each AHU room through a VAV box which in turn is controlled by CO₂ sensor thereby achieving the concept of 'outdoor air on demand' which helped in reducing operating cost and cooling load.

Energy Recovery (Pre Cooling)

Heat Recovery Units provide a way of recovering waste energy in hot climates like Noida. Dehumidified cold exhaust air from toilets, pantry and atrium is collected in each service core which enters one side of the rotating Heat Wheel, thereby, chilling the wheel and drying the desiccant coating. This cool and dry part of the wheel then rotates into the outdoor air stream where it absorbs heat and humidity from the incoming ventilation air before it is

continued on page 78

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continued from page 76

cooled to room temperature in the AHU room.

The Energy Recovery Wheel helped to reduce the ventilation cooling load by 70%, thereby reducing the operating energy and the size of the air conditioning equipment and helped Green Boulevard to achieve 8% annual energy saving over ASHRAE Standard 90.1-2004 defined base building.

Air-side Economizer (Free Cooling)

Noida falls under Composite climate zone as per National Building Code (NBC) of India. Thus, for nearly 4 months in the year (Nov–Feb), the outdoor climate conditions are generally lower than indoor temperatures. However, due to high internal heat gains (and high glazing surfaces), most buildings continue to run in the cooling mode round the year. With optimized envelope design, it was decided to provide a means of running the building on 100% outdoor air in case of fair weather conditions when the enthalpy of the outside air is less than the enthalpy of the re-circulated air.

This helped the project to achieve 3% energy saving over ASHRAE Standard 90.1-2004 defined base building.

In order to prevent loss of usable rented space, the exhaust fans were carefully located in dead corner spaces. This feature also enhanced the fire safety aspect of the building by providing means to extract smoke in case of emergency.

Designing the HVAC System

After careful planning of passive and active design strategies, an attempt was made not to get carried away with conventional thumb-rule design practices.

Outdoor Design Conditions

ISHRAE weather data file WeDCo was referred for creating year round cooling load profile using Carrier Hourly Analysis Program (HAP) to size the equipment. A specific check was also carried out on the cooling load based on the peak weather data available for New Delhi (Metro city closest to the site)

| S. No. | Areas Monitored | Monitoring Methodology |
|--------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Lighting & raw power loads | Lighting power and raw power consumption at each floor is obtained through dedicated energy meters. This helps in keeping a tab on the internal heat gains. |
| 2 | Variable motor loads | VFD's have been provided for each AHU, chilled water pump and large fans. All the VFD's have provision of software integration with BMS. Through the integration data on many variables like speed, power, current drawn etc. is collected. |
| 3 | Chiller & primary pumps monitoring | Digital ammeters have been provided at each incomer feeder of chillers and all primary pumps for current measurement while networkable energy meter is provided at incomer feeder of chiller panel to gather the energy consumption data. |
| 4 | Chiller efficiency at variable loads (kW / TR) | kW can be measured using portable "Load Manager. The cooling load can be calculated with the information on chilled water flow rate and supply/return chilled water temperatures recorded by BMS. Thus kW/TR at different loads is calculated and compared with manufacturers data. |
| 5 | Total building energy consumption | Energy meters at the main incomer from two transformers as well as from DG sets have been provided, from which energy monitoring data is obtained. |
| 6 | Indoor water risers | Permanent water consumption meters have been provided for monitoring the water consumption for domestic use and irrigation. |
| 7 | Indoor air quality | Temperature, humidity and CO ₂ sensors have been provided in all AHU rooms. |
| 8 | Total water consumption | Total water usage is analyzed as there are meters to measure the water consumption at specific locations. There are individual meters to measure the total incoming water supply. Water meter is also installed at the discharge end of Sewage Treatment plant (STP) to determine the total water out. |

Table 1 Shows how various aspects of the functioning of the HVAC system are monitored

Indoor Design Conditions

Breaking free of the traditional practice of 22° C internal temperature (and also keeping in view the demand from potential tenants), the following was specified for the project:

Cafeteria and Common Areas

- Dry Bulb Temperature 25 ± 1°C
- Relative Humidity Less than 60%
- Dust Filtration Low Efficiency

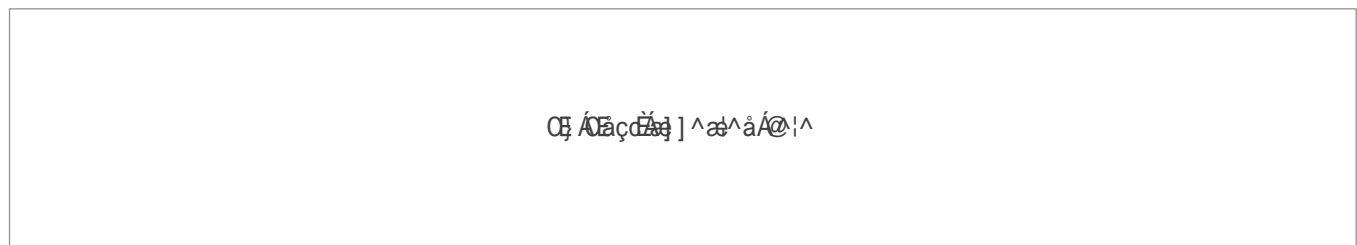
General Offices

- Dry Bulb Temperature 23 ± 1°C
- Relative Humidity Less than 60%
- Dust Filtration Medium Efficiency

Air Conditioning Load Computation

Based on output from the Heat Load Calculation program, the total air conditioning demand load worked out to 1600 TR, for which 4x550 TR water cooled centrifugal chilling machines were selected including a standby. Thus, for a built-up area of nearly 650,000 sft above ground, the project was able to achieve

continued on page 80



continued from page 78

an astounding 400 sft/TR, thereby breaking the conventional barrier.

Chilled Water Pumps

Primary variable flow chilled water pumps coupled with a bypass line and variable speed drive on primary pumps are provided to achieve variable water flow in the chilled water circuits. Chilled water flow in load circuits and chiller is varied. By measuring the pressure differential between chilled water supply and return header, the speed of primary variable flow chilled water pump is automatically varied, thus conserving pump brake horse power.

Cooling Tower

The cooling towers are as per minimum efficiency standard specified in ASHRAE standard 90.1-2004. Selected cooling towers are certified for test procedure as per CTI ATC-105 and CTI STD-201 and provided with variable frequency drives.

Motor

All motors for the air conditioning system are energy efficient EFF-1 type, suitable for 415 ± 10% volts incoming power supply.

Air Handling Unit

All air handling units are variable volume type, double skin (for noise control) construction, comprising of centrifugal fans coupled to a variable frequency drive, cooling coil section, stainless steel double sloping drain pan (for zero water retention) and filter section. These are floor-standing type with ducted arrangement for supply air. All AHUs have provision to modulate RPM of supply air fan on the basis of return air temperature. These air handling units are capable of executing a full air-side economizer cycle. In addition, since the fresh air quantity for the space was large, hence CO₂ level monitoring was carried out for all occupied spaces and fresh air damper modulated to ensure that difference between indoor and outdoor CO₂ levels is maintained at less than 530 ppm. All fans have efficiency greater than 75% with sound level not exceeding 60 dB(A) at a distance of 1 m from the unit in both supply and return air streams. On supply air stream, pre-filters (MERV 8) and bag filters (MERV-13) are provided for superior dust-free environment.

Pre-Cooling

Outdoor air for air handling units was supplied through

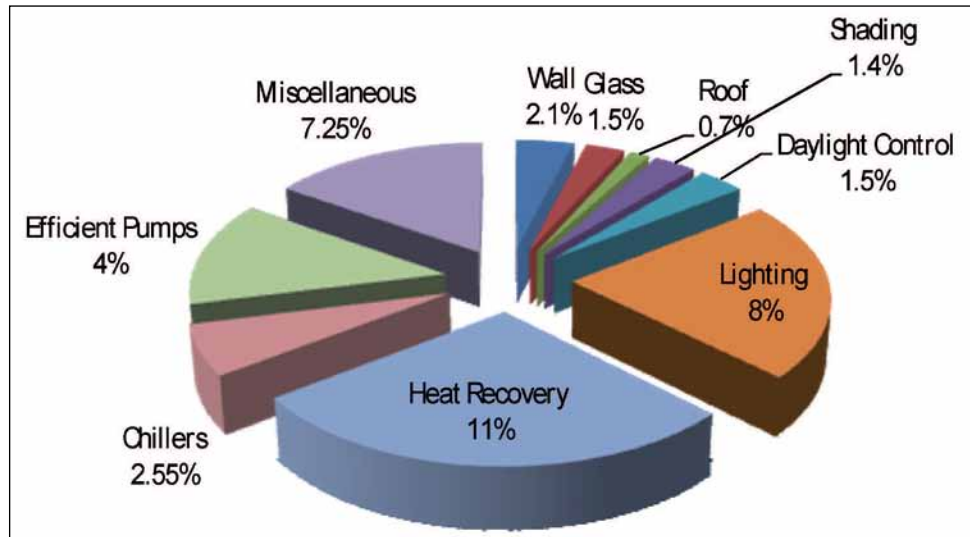


Diagram 1: Breakdown of Energy Conservation Measures

a centralized Treated Fresh Air unit located on the terrace. The outdoor air was pre-cooled by recovering energy from the building exhaust thereby reducing the air conditioning load. Outdoor air for each individual air handling unit is added through a VAV box which is modulated based on the difference of outdoor/indoor CO₂ levels. All Heat Recovery Wheels have an efficiency greater than 70%. The VAVs are set to supply air at not less than the quantity exhausted from the toilet.

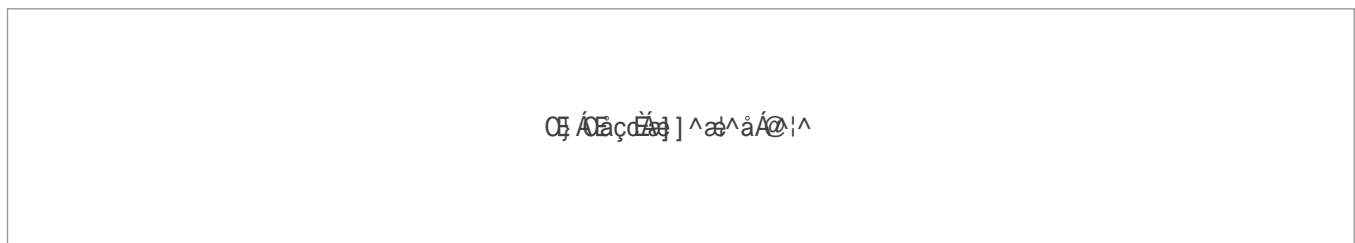
Measurement & Verification

Green Boulevard is a quantum leap compared to buildings based on the conventional design practices. This project sets up stringent standards for its contemporaries to follow and provides them with a direction to further improve on those standards. A strong monitoring process has been put into place to lower the energy consumption of the development every subsequent year.

Data from the energy meters is continuously logged on to the BMS system. This data is compared to the baseline data to determine the savings. A daily and weekly comparison of the consumption is carried out and the monthly consumption of the whole building, as well as, the individual consumption of HVAC, lighting and other related areas are compared by an independent third party commissioning authority with the monthly baseline consumption figures provided in the Energy Modeling report.

The measurement and verification methodology for each of the systems is described in Table 1.

continued on page 82



continued from page 80

| COMPARISON OF GREEN BOULEVARD (GREEN BUILDING) & NON-GREEN BUILDING | | | | | | | | | | | | |
|---------------------------------------------------------------------|----------------|----------|-----------------|----------|--------------|----------|--------------|----------|------------|----------|-------------|----------|
| PERIOD | January - 2009 | | February - 2009 | | March - 2009 | | April - 2009 | | May - 2009 | | June - 2009 | |
| FACILITY | NON-GREEN | GREEN | NON-GREEN | GREEN | NON-GREEN | GREEN | NON-GREEN | GREEN | NON-GREEN | GREEN | NON-GREEN | GREEN |
| CONSUMPTION - EB | 1113200.00 | 312959 | 1032160.00 | 327112 | 1199540.00 | 366799 | 1283520.00 | 423759 | 1334360.00 | 466445 | 1479180.00 | 537130 |
| Area Occupied (sqft) | 708566.4 | 298294 | 708566.4 | 298294 | 708566.4 | 298294 | 708566.4 | 298294 | 708566.4 | 298294 | 708566.4 | 305230 |
| Consumption / SF | 1.57105954 | 1.049163 | 1.45668776 | 1.096609 | 1.692911208 | 1.229656 | 1.81143221 | 1.420609 | 1.88318272 | 1.563709 | 2.08756723 | 1.759755 |

Note: The above data is excluding DG Power. The above data includes Common area consumption. The data of Green Boulevard will take a huge positive change once occupied in total

Table 2: Comparison of electric power consumed for six months

Other Environmental Friendly Measures

Diagram 1 Summarises the savings obtained by various energy conservation measures which result in an energy saving of 40% compared to a standard design Indian building. Other environmental friendly measures are:

Erosion and sedimentation control

Erosion typically results from foot traffic killing the vegetation, steep slopes where storm water sheet flow exceeds vegetation holding power, runoff that exceeds vegetation holding power, or vehicle traffic on unpaved areas. These issues were identified and eliminated which has minimized soil loss and nourished receiving water quality. The top soil was protected and further used for landscaping by stockpiling.

Zero Discharge Building

The waste water generated is treated on site by a Sewage Treatment Plant (STP) and the treated water is used to meet water requirements for irrigation, flushing and cooling tower makeup, thereby avoiding any pressure on precious municipal/ground water reserves.

Rain Water Harvesting

The rain water (from terrace and surface runoff) is collected and recharged through rain water harvesting pits.

Night Pollution Reduction

Down lighters are used for exterior lighting which are provided with low LPD to prevent glowing of the sky. Minimized light trespass from the building and site, reduce skyglow to increase night sky access, improve night time visibility through glare reduction and reduce development impact on nocturnal environments.

Regional Materials

Over 75% of building materials such as concrete, brick, glass, tiles, stone, MDF, steel etc have been procured from suppliers within a radius of 500 miles, thus reducing the energy associated with the transportation of materials.

Recycled Content

More than 90% of the materials used in the building have

recycled content (post-industrial and post-consumer)

Rapidly Renewable Materials

Rapidly renewable materials such as bamboo, straw board, MDF have been used in the interior of the building.

Construction Waste Management

- Scrap steel straightened & re-used in Guard Room slabs.
- Scrap steel sent to other sites for reuse and recycling.
- Cement bags donated to workers at site.
- Broken bricks reused for brick bat coba.
- Broken tiles, AAC blocks used for internal and external development.
- Stone waste used as finishing material for landscape feature walls.
- Gypsum false ceiling tiles sent to manufacturing unit for recycling.

Low Volatile Organic Compound Products

All paints, adhesives, sealants, carpets and composite wood used in the building contain low VOC to prevent the occupants from chemicals-related diseases and provide good IAQ.

Ozone Depletion Prevention:

All the refrigerants used in the HVAC & R system are CFC free.

Going a Few Steps Further..

Though the Developer adopted a green approach, however, the integrated design process paid rich dividends when the project achieved Platinum rating with an impact of less than 5% on the overall budget. This can be attributed to the fact that significant savings were achieved due to a reduction in the total air conditioning load as well as peak energy demand thereby reducing the rating of equipment. Coupled to this, strict waste management at site ensured reuse of resources.

The benefits of green development were visible to all when the building attracted multinational tenants even during the recession period last year. Table 2 shows a comparison of actual power consumption for six months between a green and non-green building.

Green Boulevard is yet another attempt to showcase to the world the benefits of Going Green. ♦

