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Green Building Systems in the NCR Region of India

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Abstract:
Green building rating systems (GBRS) result in energy-efficient and environment-friendly buildings. They not only preventpollution and resource wastage during construction ; but also uphold high indoor air quality, energy and water efficiencies throughout the building life-cycle. The economic growth of Indian cities has led to hasty construction activities causing resource challenges, air pollution and congestion. The aim of the paper is to find the greenest building in the National Capital Region (NCR) ,which can be a benchmark building for the new buildings in the region. The paper presents the case study of two greenest buildings in the NCR from the two different GBRS; and also compare their attributes and rating systems. The paper inferscritical energy efficiency, air quality and water efficiency attributes of these benchmark buildings much needed in rapidly growing cities like NCR.

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INTRODUCTION

Air pollution in the National Capital Region (NCR) has gained a lot of attention. Earlier research reports suggest that construction activities within NCR contribute significant PM_{10} (Particulate matter less than 10-micron size) adding to overall pollution load(Guttikunda and Goel, 2013; CPCB, 2016; ARAI & TERI, 2018). Urbanization is expected to reach 71% in the NCR region by the year 2021 and Gurgaon region near the airport has been the highest contributor to this urbanization phenomenon over the last two decades (KPMG, 2017). Gurgaon witnessed unprecedented construction activities over the last two decades ; and became a millennium citystruggling with resource challenges like electricity supply, air quality, drainage, water supply and traffic congestion. Similar resource and environmental challenges are present in other parts of the NCR. Construction activities not just contribute to pollution but also high resource consumption throughout the building lifecycle (Economic Policy Forum, 2014). During the construction and operational phase, buildings are found to consume 40% of natural resources and 40% of global

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energy consumption (Sharma *et al.*, 2011; Sameer and Bringezu, 2019).Theeconomic growth projection for 2030 suggests that two-third of commercial buildings are yet to be built in India (Bureau of Energy Efficiency, 2017). The critical change needed is the adoption of green design and construction practices which are resource-efficient and environmentally friendly throughout the building lifecycle.

Green Building Rating Systems (GBRS) is an integrated development approach which came as an innovation in developed economies in the late 1990s. Green buildings are designed, constructed and operated for resource efficiencies and minimal environmental impact to the buildings, immediate surrounding of the buildings, and the broader regional and global environment (Sayigh, 2013). Green buildings are the result of assessment and verification done by GBRS which is a comprehensive framework designed to develop, assess sustainability and greenness of a building (Lee *et al.*, 2013; Nguyen, Toroghi and Jacobs, 2016). With time, GBRS have undergone progression with new innovation and interventions in green design and construction, building processes, technology and building automation. GBRS has different rating levels based on the level of sustainability or *greenness* the building project has achieved (Verma, Mandal and Bajaj, 2019). This research paper aims to find the greenest building constructed and undergoing operations in the NCR using GBRS and define its critical design elements, systems specification, and technical features as a standard for upcoming buildings in the NCR. The paper also recommends the essential best practices that should be embedded for new as well as existing building stock in the NCR in order to make buildings environment-friendly and efficient.

BACKGROUND

The first GBRS in India was Leadership in Energy and Environmental Design (LEED) rating systems in collaboration with Indian Green Building Council (IGBC) in the year 2001. LEED Rating systems has four levels of certification with the highest certification level as Platinum, followed by Gold, Silver and Certified. In 2003,thefirst LEED-certified green building in India became operational. In the NCR, the first LEED-certified building was ITC Green Centre, Sector-32, Gurgaon, in the year 2004, which was newly constructed on a two-acre plot. Both these first buildings were LEED Platinum certified with high energy and water efficiency achieved due to system design efficiency. LEED rating system as of May 2018 has more than 113 certified buildings in the NCR Region, and there are many other projects that are in the various stages of certification.

The Energy and Resource Institute (TERI) along with Ministry of New and Renewable Energy came up with a national rating system called Green Rating for Integrated Habitat Assessment (GRIHA) in the year 2007. GRIHA follows a 5-star rating system where the five-star rating is the highest sustainable building level and one star lowest sustainability level that can be achieved. The first building was GRIHA certified in 2009 and ministry made it mandatory for all new government buildings to follow GRIHA 3 star-standard. To incentivize national rating system, the government has provided tax, area and environmental clearance benefits for new buildings adopting GRIHA rating. In the NCR region, the first certified GRIHA building came in 2012; around 8 years later than LEED rated building. The rating is predominant in government and public sector buildings and currently lacks mass presence in NCR Region, unlike LEED.

The third GBRS in India is IGBC Green Rating system ; which was launched in September 2015. IGBC had the license

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to market LEED in India till 2014, and in 2014 LEED Rating systems joined hand with GRIHA. IGBC Rating system was designed for Indian corporate houses, businesses, homes and infrastructure projects and is a new rating system having very few certified buildings currently. The rating system has 4 levels like LEED and follows similar nomenclature inspired by the LEED rating system. The rating system is new and lacks the presence of sizeable certified buildings in the NCR Region currently.

DATA AND METHODS

To find the greenest rated building of the NCR Region we first looked at a database of certified green buildings of LEED and GRIHA in the NCR Region. Since the IGBC rating system hasn't got any sizeable presence as on May 2018, it was dropped from our analysis. GRIHA presence in the NCR region is predominantly confined to government and public sector buildings, and the research couldn't find more than 20 buildings that have already been certified or in the final stages of certification. LEED rating system has a comprehensive database of 113 certified projects in the NCR Region and other buildings which have registered and not yet certified. While deciding on the greenest building and critical technical features the following were the factors looked into

1) Highest rating level achieved
2) Total LEED Score or Percentage score out of the maximum score
3) Version of certification
4) Multiple certifications exist or not
5) Energy efficiency scores
6) New Building or Already existing building
7) Key technical features and attributes of sustainability

For the purpose of our research, we chose only Platinum certified buildings with the highest LEED Score for LEED and 5-star rating building with the highest energy efficiency score for GRIHA certified buildings. The version of certification was considered looks at various upgrades that have happened with time in the LEED and GRIHA rating system. For finding the critical green design attributes and sustainability feature the analysis of LEED and GRIHA scoresheet was undertaken. Based on LEED and GRIHA scoresheet analysis in the given framework the following outputs were derived

1) Key green design attributes
2) Green features and construction practices for which sustainability credit or score received
3) Building materials and construction techniques used during construction, interior work and certification

The key outputs were further validated through discussions with LEED consultants and property managers of the chosen buildings.

FINDINGS AND DISCUSSION

The 113 LEED-certified buildings in NCR Region have 53 Platinum rated buildings with most of them certified under LEED Version v2009. The v2009 version which came out around 2009 and has been one of the admired LEED version in the Indian market. Among the platinum-rated buildings, the top ten building projects which have the maximum percentage score were identified. Interestingly, one of the buildings was listed thrice in the database as it was certified three times in the year 2004, 2012 and 2017 under different versions. The building is ITC Green Centre which is the first building to be certified under GBRS. The building had the second-highest score in sustainability among all the buildings and has been regularly certified ; after an interval of 5-8 years based on the changes in building automation and green certification. The highest scored green building in NCR region was Wipro’s Gurgaon Development

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Centre in Udyog Vihar, Gurgaon certified in the year 2005. Since the certification was 2005 LEED version and many technical improvements have come around in the last fifteen years it couldn't be chosen as benchmark building. ITC Green Centre on the other hand certified under Version v2009, and v2.1 was chosen as the most sustainable building in the NCR Region. Regular recertification shows the commitment of the building to achieve green excellence, sustainability and performance beyond comparison to other buildings. Among GRIHA certified buildings, we found around 20 existing certified buildings in the NCR Region and predominantly government building. Because of the lack of details on GRIHA certification and less GRIHA data availability, the paper couldn't follow the method of selection of greenest building. The greenest building selected among GRIHA buildings was the one declared by the government as a model building ' IndiraParyavaran Bhawan ' which houses the ministry of environment and forest office.

ITC GREEN CENTRE – DESIGN, CONSTRUCTION AND CERTIFICATION

The building was LEED platinum-certified as new construction building under LEED version 2.1 achieving 77% points. In terms of energy efficiency, the buildings achieved a 53% reduction in energy usage during simulation studies under construction. The building achieved a 94% score in the energy and atmosphere category. Interestingly, the building has only a 60% area, which is air-conditioned, whereas 40% area is non-air-conditioned andposses excellent ventilation systems. The following are the key attributes of this building which made it achieve 53% energy reduction and 40% water saving.

Figure 1 : ITC Green Centre site plan and layout
Source : (Glazette.com, 2011)

DESIGN ATTRIBUTES FOR ENERGY EFFICIENCY

The critical design attributes which were considered for the achievement of desired energy efficiency are given below

1) L-shaped site design and orientation along with atrium connecting the building sides

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(Figure 1) for natural light penetration to the remote corners of the buildings. The natural light penetration indirectly through atrium and windows provides daylight to the remotest corners of the building and saves lighting expenses

2) Excellent site orientation and insulation of windows, walls and

4) low

5) solar heat gain coefficient used with a vacuum between two glass layers.

6) Roof Design is done considering the use of photovoltaics and high albedo roof coating. The roof coating with an emissivity of 0.94 reflects back 90% of the heat that hit the roof surface.

7) Design of octagonal atrium so that direct heat gain is avoided and a column of natural light without heat comes down the L shaped building.

8) Design selection of high-efficiency three screw chillers with the coefficient of performance value 6.1

9) Design provision for Heat recovery wheels and VFD's for fans and pumps

BUILDING MATERIALS AND INTERIOR ATTRIBUTES FOR ENERGY EFFICIENCY

The following were the key attributes during construction which made building score high in Energy efficiency and achieved LEED Platinum certification

1) Use of autoclaved aerated concrete blocks or fly ash bricks with the right thermal insulation as an external wall.
2) Double glazed windows with low U Value - roof for energy conservation and prevention of heat gain. External wall design of 250 mm thickness with 70 mm stone cladding and U-value of 0.687W/m2K

3) Double glazed window facade design with high light-transmitting U Value and a

1.81W/m2K, SC-0.26 and WWR-33%

3) Extruded polystyrene roof insulation of 76 mm thickness with high R-value and structural strength over 120 mm RCC roof
4) Use of energy-efficient T-5 lamps of 36 watts fluorescent and electronic ballast
5) Installation of solar photovoltaics on the roof for hot water in the kitchen and restrooms.
6) Use of daylight sensors for automatic switch-off of the lighting system
7) Interior roller shades for building to prevent heat gain.
8) Use of Energy-star certified highly reflective roof coating with an emissivity of 0.94. This coating reduces the roof temperature significantly and leads to decrease in 15% cooling load for upper floors

ATTRIBUTES FOR AIR QUALITY AND POLLUTION PREVENTION

During the LEED certification, the environmental score of ITC Green Centre was 32 points out of 47 points. One of the critical control measure for pollution prevention during construction was site

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barricading and water sprinkling during the construction. Also, coverage of all building materials, especially dusty materials, was insured along with wheel washing. Other than that few critical attributes inside building for better air quality are given below

1) AHU's installed with CO_2 sensors at various floors and designated smoking rooms with a separate exhaust system.
2) All the carpets, paints, plyboard, polish and sealants had a low volatile organic compound
3) Sensors for increased ventilation which picks up the number of people in the room and pumps in fresh air automatically
4) Elimination of toxic substances and allergens in carpets, plyboard and paints.
5) Shower, change room facilities provided for bicyclist and separate parking area for them
6) Indoor air-quality management program conducted and implemented for the employees and workers
7) Proper coverage of building materials including dusty materials and topsoil was preserved and no erosion reported during construction.

ATTRIBUTES FOR WATER EFFICIENCY

Water consumption during construction and operation needs monitoring and efficient utilization. During construction, water is used for curing purpose, and there is a need for alternatives. Also, significant consumption of water happens during building lifecycle, and the following are the key features which reduce water consumption in ITC Green Centre. These features led to a reduction in water consumption by more than 40% of a conventional building.

1) Treatment of grey water using sewage treatment plant where water is recycled for irrigation and landscaping purposes.
2) Installation of rainwater collection pits at the suitable locations
3) Interlocking tiles with zero surface runoff was installed on the landscape.
4) Use of waterless urinals and low flow fixtures
5) Use of native plants which consume less water and high-efficiency drip irrigation system.
6) Enhancement of indoor plumbing fixtures in 2012 for already installed fixtures during construction
7) Cooling tower water efficiency management plan implemented

INDIRA PARYAVARAN BHAWAN - GREEN DESIGN, CONSTRUCTION AND CERTIFICATION

Indira Paryavaran Bhawan (IPB) building was designed as the most energy-efficient building and is a net-zero building. The building has a mix of passive and active design strategies for achieving 70% less energy consumption compared to a conventional building. The building was constructed in 2013 with GRIHA, 5star certification located on Jor Bagh Road, New Delhi. Only 38% area of the building is air-conditioned, and the rest is the non-airconditioned area, including the basement area.

GRIHA emphasises vernacular ventilation system and less use of airconditioning as compared to LEED. The energy and water savings achieved by this building are higher than ITC Green Centre, but since both rating system has different benchmarks, both green buildings were not compared.

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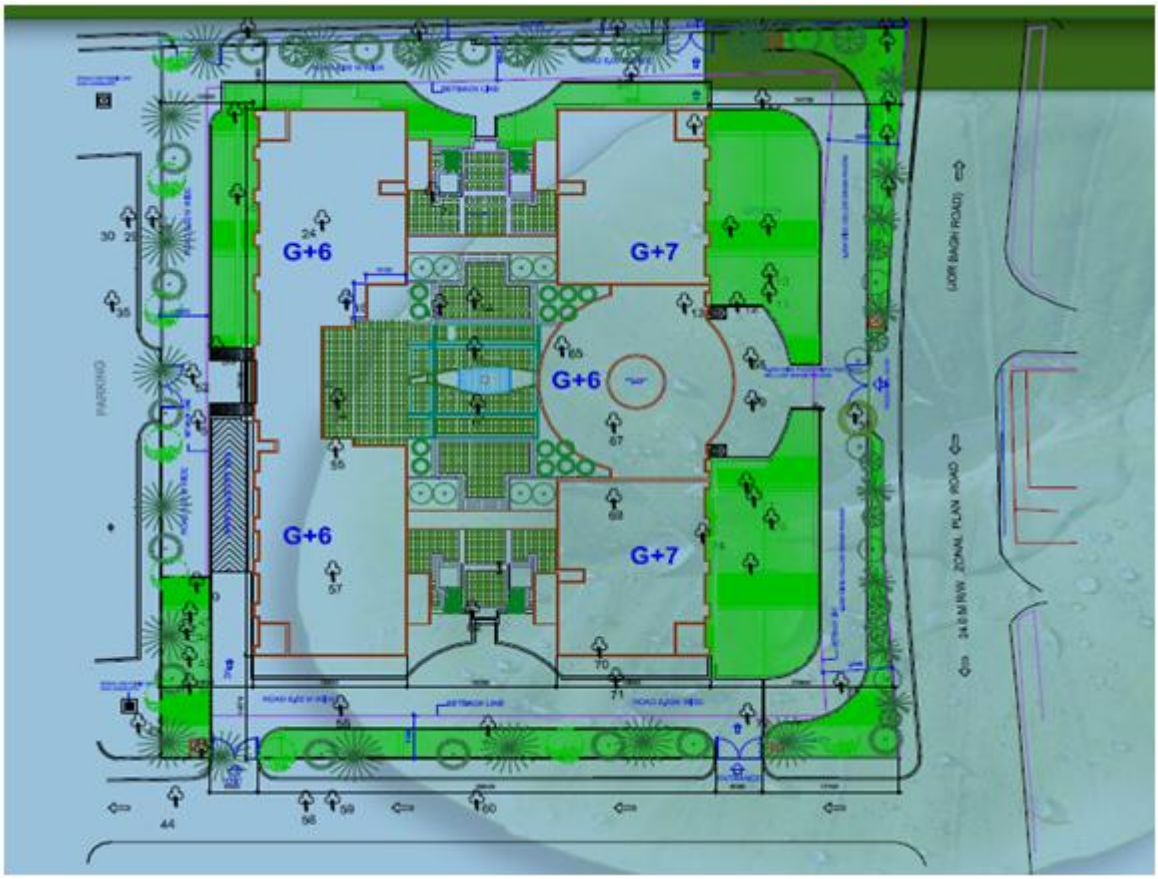

Figure 2 : Indira ParyavaranBawan building ground floor plan
Source : (CPWD, 2015)

DESIGN ATTRIBUTES FOR ENERGY EFFICIENCY

The following are the design strategies used so that building has enhanced energy efficiency and achieves the net-zero target (CPWD, 2015)

1) The facade design for receiving 70% natural daylight and less heat ; with passive shading devices on the East, West and Southside to take care of Summer heat gain
2) Shaded green open courtyard in between the buildings and centre of the plot and an eco-park for air circulation and to reduce the ambient temperature.
3) The orientation of the building with a large opening on North and South face reducing solar ingress
4) Natural ventilation using building punctures to aid cross ventilation due to stack effect.
5) Cooling of air through geothermal exchangers under the ground.
6) Landscaping design with inner courtyard fenestration for natural cooling.
7) Design of integrated photovoltaics on the roof which can act as a shading device for the summer sun
8) Design of projections into the central space for shading
9) Electrical load and energy load designed for drastically low value compared to a conventional building.

BUILDING MATERIALS AND INTERIOR ATTRIBUTES FOR ENERGY EFFICIENCY

Along with design elements, the following are other active strategies used for energy efficiency including interior elements

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1) Use of Aerated Autoclaved cement (AAC) block during construction with better thermal insulation
2) Use of portlandpuzzolona cement with 30% fly ash and thermal insulation
3) Use of high-efficiency reflective glass for windows
4) Light shelves of high VLT and low U value for bringing in diffused sunlight for natural lighting
5) Efficient and certified electrical equipment as per ECBC 2007 requirements
6) Double skin air handling units with variable frequency drives (VFD)
7) T-5 lamps and energy-efficient LED fixtures
8) High-efficiency solar panels for making it a net-zero building.

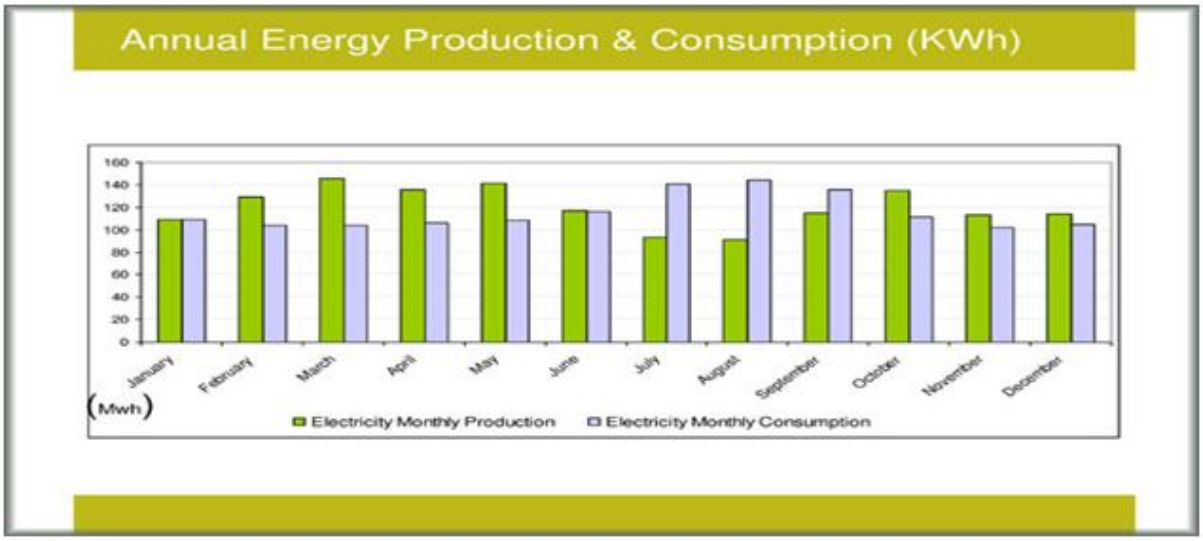

Figure : Indira ParyavaranBawan yearly energy production and consumption
Source :(https://nzeb.in 2018)

The solar panels have the capacity to generate 14 lakhs kWh of electricity, and as per below table only in months of July, August and September, the peak demand is higher than generation capacity. The key features of solar installation are
Solar Capacity – 930KW
Total Area – 6000 m^2
Panel area – 4640 m^2
No. Of panels – 2844
Source :(https://nzeb.in 2018)

ATTRIBUTES FOR WATER EFFICIENCY AND SUSTAINABLE ENVIRONMENT

The following are the other critical attributes bringing in water efficiency and sustainable environment in and around the project

1) STP with FAB/MBBR technology for zero wastewater discharge
2) Wastewater recycling for the cooling towers
3) Low flow fixtures for the reduction in water consumption of the building
4) Usage of native plants and trees along with judicious usage of drip and sprinkler irrigation system
5) Rainwater harvesting and aquifer charging
6) Green biodiversity and south side sun spaces during winters
7) Grass paver blocks pavements and calcium silicate tiles
8) Natural stone for flooring and cladding

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9) Bamboo jute composite for frames and doors

GRIHA and LEED rating system comparison

The GRIHA rating system has fewer credits or scores for indoor air quality and more for water efficiency as compared to the LEED rating system. Water has been significant importance in GRIHA rating and it the third-highest scored category whereas, in LEED rating system, it is a minor category (Agarwal, Himanshu; Singh, Hari Kumar; Vashishtha, 2017). One can achieve more than 60% water efficiency in the GRIHA rating system whereas LEED has credits only for 40% water efficiency savings or more. GRIHA encourages buildings to use natural ventilation systems and have less air conditioning load. This is good for the external environment, whereas LEED rating systems give a lot of credit to internal thermal comfort inside the building. LEED rating system stands out in its importance to indoor air quality and energy efficiency. In terms of costs of certification LEED rating system is expensive and accessible as compared to GRIHA. GRIHA gives credits or scores for strategies or outcome, whereas LEED gives points or credits based on performance measurement. Overall GRIHA has its suitability for Indian climatic conditions as compared to the LEED rating system but lacks the integrated performance enhancement and measurement that LEED buildings can achieve. Also, the LEED brand name is well-established worldwide as compared to GRIHA, which lacks brand initiatives. The sourcing of green building materials is well established in the LEED rating system ; whereas in the GRIHA rating system, green building material sourcing needs a better description.

CONCLUSION

Both LEED rating systems and GRIHA rating provide a strong foundation for making buildings energy-efficient. Both buildings are useful benchmarks for new and upcoming buildings in the NCR Region. The GRIHA rating system gives more credits to water efficiency and more suited for Indian climate conditions but lacks the performance measurement approach and Indoor air quality focus which is excellent in LEED rating system. Water savings needs a better presence in the LEED rating system, as water imbalance in India needs sustainable solutions. Overall we need new buildings to follow these standards with mandatory GBRS compliance to make a significant difference in construction pollution and resource efficiencies which cities need desperately. This will lead to decreased PM_{10} concentration in the air and make our cities and communities healthier.

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