

Implementation of National Building Code Guidelines for Green, Environment and Energy Audits

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Abstract: National Building Code (NBC) of India has a set of rules and guidelines that regulates construction of buildings as well as ecofriendly activities of the campus without harming the environment. In order to achieve the minimum standards of welfare and safety of stakeholders of a campus, the Governing body of Central and State Governments lays down a set of guidelines to offer sustainable environment. By following the guidelines of NBC in line with ISO/IEC 17020:2012 standards, audits such as green, environment and energy were conducted at Nehru Arts and Science College, Coimbatore, Tamil Nadu, India by Nature Science Foundation (NSF), Coimbatore for National Assessment and Accreditation Council (NAAC) accreditation purpose. A team of ISO QMS (9001:2015), EMS (14001:2015) and EnMS (50001:2018) along with Bureau of Energy Efficiency (BEE) certified lead auditors and technical experts from were involved in the process of audits (BEE, 2015). A detailed checklist has been prepared to conduct these three audits in which the essential parameters were recorded. The results showed that all the essential parameters as per the checklist prepared by the team of NSF were found to be highly satisfactory in the College campus coincided with the guidelines of NBC in line with ISO/IEC 17020:2012 standards. This audit outcomes might be more useful to the College to maintain the sustainability which in turn useful to give ecofriendly atmosphere to the students and staff members.

Keywords: Green Audit, Environment Audit, Energy Audit, National Building Code, NAAC Accreditation

1. Introduction

National Building Code (NBC) is not only offering a standard uniform benchmark that constructors and environmentalists must meet, but they also establish safety standards along with ecofriendly atmosphere of a campus for years to come. As extreme weather conditions and fires are growing rapidly in the country, it becomes vital that buildings and structures be built and designed using the current building codes to allow for maximum safety sustainability and resilience to the stakeholders. For instance, new and updated building codes put much emphasis on conservation as energy and the degradable and non-degradable wastes are the most expensive byproduct of older regions. This will not only offer environmental benefits to future generations but will also regulate indoor air pollution and greenhouse gas emissions to protect the health of human beings (Peters and Romi, 2014). Before the introduction of NBC in the construction industry, building commercial and residential properties used a lot of energy which adversely affected the sustainable environment. Thus, enforcing building codes to create low-energy buildings offers a tangible way to decrease the substantial greenhouse gas emissions of the ecosystem which reflected in solving energy issues relating to the use of environmentally compatible construction techniques like planting trees, landscaping, rainwater harvesting and renewable and non-renewable energy sources (Anirudhan *et al.*, 2023).

Green Audit as per the ISO/IEC 17020:2012 standards comprised a set of green, environment, energy, waste management (solid, liquid, municipal sewage, biomedical, plastic and electronic wastes), water, soil, air quality and hygienic audits are playing an important role in Academic

Institutions, Public sectors, R&D Organizations and manufacturing companies to maintain ecofriendly atmosphere to various stakeholders (Pramanik, 2013). The green, environment, energy and waste management audits are very much essential for educational institutions towards the NAAC accreditation to maintain the quality of education, teaching and learning processes. NAAC accreditation encourages to identify the quality of the institute by the students in terms of quality education, research activity, faculty member's strength, infrastructure facility, etc., as well as giving student's confidence level that they are selecting a quality institution.

Due to change in environmental conditions, global warming, human anthropogenic activities and industrial development, the audits such as green, environment, energy and waste management should be undertaken by every educational institution, industrial and public sectors across the globe so that we can uphold the environment sustainability (Wang *et al.*, 2013). The studies on Heat Island Effect (HIE) is very much useful to reduce the heat effect in the globe. The HIE revealed the guidelines of Architect, Designer and Civil contractor for the existing building addresses the choice of material, design methodology, operation and maintenance related options, etc., and also addresses the applicability of National Building Code standards. The HIE denotes the temperature level in the atmosphere. The HIE studies advised that the vehicles should be parked under the tree shade to reduce the HIE and carbon emission to preserve the sustainability. To reduce the HIE, the parking areas should be made up of high albedo materials with light coloured paints to absorb heat. It illustrated further that vegetation and soil health are to be maintained properly with regular watering through irrigation facilities and without discharging any agro

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chemicals (Pramanik, 2013).

Utility of public transportation (buses) reduces carbon emissions greatly and decreases the development of smog within the regions. It determined that the human beings have healthy air to respire effectively. On the other hand, comparing a bus travelling with a car transport for a person, it has been observed that buses are the most effective system by producing lower quantum of emission of carbon when compared to that of car transport. This will be a huge decrease in utility of natural resources per person. The audited organization should be provided with E-vehicles to maintain eco-friendly environment in the campus and to reduce carbon dioxide emissions (Rajalakshmi *et al.*, 2023b). Apart from the e-vehicles, students are to be encouraged to use bicycles in the campus. The organization should have adequate facilities in creating pedestrian path for stakeholders with all the amenities such as accessible public toilets, barrier free environment, dustbins, stone benches, etc. Use of bicycles are being encouraged in the campus to control carbon emission and air pollution (Choy and Karudan, 2016). The objectives of the present study was to implement the NBC guidelines and ISO/IEC 17020:2012 standards for conducting the green, environment and energy audits at Nehru Arts and Science College, Coimbatore, Tamil Nadu, India by the NSF team.

2. Materials and Methods

Green, environment and energy audits were conducted by following the guidelines of National Building Code (NBC), Part 11: Approach to Sustainability as per the NAAC and National Accreditation Board for Certification Bodies (NABCB) advisory circulars and Central / State Government Law, Environmental legislation act and the concept of Swachh Bharath Abhiyan under Clean India Mission (NCP, 2020). The audit checklist was prepared by the lead auditors and technical experts of NSF in line with NBC Part 11 which covered 163 checkpoints (NBC, 2016). During the onsite visit, all the 163 checkpoints were assessed, wherein, the lead auditors' marks applicable and not applicable and write the reason for non-applicability and wherever it was applicable. The auditors were verified the records / practice / documents and physical observation to confirm the same.

There were two parameters such as meeting the requirements and not meeting the requirements. Marking as meeting the requirements for the specific checkpoint revealed that the physical observation and documents were up to the mark. For some checkpoints, the Opportunity for Improvements (OFI) were given by the auditors. The physical observations and documents which were not up to the mark were given as not meeting the requirements. The checkpoints under not meeting the requirements were up to the Management of the Organization to develop further. During the on-site visit, the instruments such as were GPS meter, oxygen, carbon dioxide, lux, sound level and voltage meters were used by the auditing team to check the specific parameters like oxygen, carbon dioxide, light intensity, sound, current flow and etc. in the view of maintaining environment sustainability (Rajalakshmi *et al.*, 2023). All the instruments were calibrated by ISO 17025 accredited labs before and after the audits (ISO, 2021).

GPS meter was subjected to know the latitude and altitude,

location, etc. of the campus in view of understanding the climatic condition and landscape design and management. Oxygen and carbon dioxide meters were used in the audit process to measure the oxygen and carbon dioxide levels in the atmosphere; respectively in the organization. Similarly, light and sound level meters were employed to measure light intensity and noise level; respectively in the organization. Digital Clamp (Voltage) meter was used to check the input and output voltage between two points of an electrical circuit of Alternating Current (AC) and Direct Current (DC) by means of the high resistance of the voltage that impede the flow of current. In order to measure water quality parameters, various instruments pH and TDS meters were used to measure the pH level and total dissolved solids in water samples collected from the campus. Deluxe water and soil analysis kit was used to analyze the salinity, turbidity, alkalinity and dissolved oxygen of water (Rajalakshmi *et al.*, 2021). All the instruments were calibrated before and after use (ISO, 2021).

Personal Protective Equipment (PPE) refers to protective clothing for the eyes, head, ears, hands, respiratory system, body, and feet. The PPE are useful to protect individuals from the risks of injury while minimizing exposure to chemical, biological, and physical hazards. PPE serves as the final line of defense when engineering and administrative controls are insufficient in reducing risks and safeguards all the auditors by supplying PPE during the conduct of audits. PPE used were safety jackets, ear plugs, goggles, face shield, hand gloves and shoes (Gnanamangai *et al.*, 2021).

3. Results and Discussion

Green audit is playing important role to provide ecofriendly atmosphere to the stakeholders by maintaining the greenish with large number of tree species, herbs, shrubs, lianas, climbers and lawns. The audit outcomes might be useful to reduce the environmental pollution considerably and soil erosion too. Similarly, it is also useful in relation to biodiversity conservation, landscape design with management, maintenance of natural topography with indigenous plant species and irrigation/economic water utilization. For the benefit of stakeholders and to minimize the various levels of pollution, liquid and solid waste management, recycling of sewage / waste waters by primary and secondary treatments and disposal of electronic, plastic and biomedical wastes were suggested and disposed properly to follow the outcome of the audit consistently at 360° view in the organization campus.

A clean and healthy environment of an organization enhances the effective teaching and learning process by imposing green activities and creating the awareness on the importance of environmental education among the student communities and research scholars. According to Rajalakshmi *et al.* (2023), the green audit outcomes are the most effective and need of the hour by adopting the ecological approach to manage environmental complications. Further, they enumerated the importance of green audit consequences at educational institutions in view of maintaining the ecofriendly atmosphere. In accordance with Vinothkumar *et al.*, (2022), green and environment audits are a kind of professional care and a simple indigenized system to monitor the environmental changes in an organization which is necessary

at present. Environmental changes can be regulated in terms of planting a large number of oxygen producing and carbon dioxide assimilating tree species across the campus. Each and every organization should have green, environment and energy policy to promote the green related activities. The policy should be a professional and useful measure to determine how the campus should maintain an eco-friendly atmosphere. Further, it could be used to implement the alleviation measures at win-win situation to overcome the environment related problems for the stakeholders towards green initiatives (Gnanamangai *et al.*, 2022a).

Green audit outcomes

It was observed that the organization had very good facilities like ramp walk, lift, wheel chair, rest rooms, etc., for disabled and different age group people. Monitoring plan of organization development towards the sustainable goals was available for the periodic checking at proper time interval to maintain sustainability. Adequate training and awareness programmes were conducted to the stakeholders for sustainable development at all stages of building life cycle. More than 30% of open space was maintained as vegetation to lower the energy conservation in the campus. Land scape design were planned to maintain the natural capacity of the site. Land scape irrigation were performed as per the microclimatic condition like during humid / winter season less watering through irrigation was observed. Vegetation / vegetative structures were available around the building to reduce energy consumption and maintain indoor climates. Soil health was maintained well without discharging any chemical fertilizers and pesticides. Ecological design / conserving biodiversity such as transplantation, climate and design in accordance with biodiversity, reduced pesticides and other activities were not applicable because no new construction is planned and raised. Terrace garden, vertical garden and green roof system were available to maintain sustainability in a big way. Plant and animal species were monitored by conducting the periodic survey in the organization by the faculty members and research scholars (Saranya *et al.*, 2023). Traffic survey was conducted to measure the number and type of vehicles passing on the existing main roads giving access to the campus. It might be useful to reduce the number of vehicles usage which reflected for the reduction of carbon emission from vehicles to atmosphere.

Facilities for human comforts as per the NBC Part 11 under elements of sustainability, the quality of plumbing services and buildings were maintained properly in line with the standard. Ramp walk and wheel chair facilities were made available in the campus for the benefit of disabled and different age group people. Moreover, the accessible toilet facilities were observed for the comfort of person with disability. As no blind persons were observed in the campus blind reading software, signage were not available. Water management, waste management, operation and maintenance plans were prepared and followed to maintain sustainability as per the standard. Natural topography, green vegetation and monitoring under the original geographical features and natural resources of the site were recorded significantly. It was observed that the college had the natural features like rocks, natural water resources, slopes with landscape, pathways for pedestrians, etc. Further it was documented that

natural vegetation and ground topography in the college campus were found to be excellent. The observation at the campus further indicated that there were more than 40% natural topography and vegetation coincided with the NBC guidelines. Monitoring plan for maintaining the vegetation and sustainability were found to be evident through separate operation and maintenance team & their records for regular watering as per the micro climatic condition through irrigation.

Landscape design and soil erosion control are the important features for any natural disasters to regulate the strong vegetation. Observations revealed that the audited site had very good landscape design management without disturbing the natural vegetation by following the contour ploughing method in which it was being done at right angles to the slope wherever possible and ridges and furrows were properly maintained. Microclimatic conditions are considered, during winter season irrigation and watering to plants are controlled as per the water management plan and its action. External landscapes were designed based on the shading pattern of the building in the college campus and implemented effectively (Rajalakshmi *et al.*, 2023b). Green vegetation were excellent around the buildings to reduce the heat emission and also terrace and vertical gardens to lower the energy consumption. To maintain certain biomass critical for human health and also to reduce the bio-retention through water flow rates, different types of gardens like ornamental, herbal, zodiac and desert gardens were implemented in the campus.

Environment audit outcomes

It revealed that the construction was proposed based on the applicable climatic zone and geological conditions at Coimbatore District of Tamil Nadu state, India. The human comforts were implemented effectively and observed like ramp walk and fire safety precautions. Fire extinguishers were available in all the buildings to consider the safety of all the stakeholders and being maintained properly as per the annual maintenance contract (AMC) policy. Public transport facilities were available in the campus to control air pollution. E-vehicle were implemented and operated for internal mobility to reduce the carbon emission. Bicycle for internal mobility was implemented and used inside the campus. The pedestrian pathways were maintained with adequate shading facilities by planting more number of tree species. No offsite and subsidized parking were encouraged in the campus. Both liquid and solid waste were segregated properly before the disposal. Biodegradable wastes were collected and used in the vermicomposting as a recycling practice. Several training and awareness programmes on fire safety measures records were made available to maintain sustainability. It was observed that the mock drills were conducted among the students and staff members for disaster management plan and emergency preparedness were available as the safety of the stakeholders.

Water is one of the major source of living. Per capita water consumption in the building was calculated as per the water management plan (litres / person/ day). To reduce the demand of water consumption rain water harvesting unit was implemented and practiced. Proper monitoring plan was made evident to reduce the water consumption in the leakage areas. The rain water harvesting system was maintained well without using any chemical, the

wastewaters were collected and re-used for irrigation purpose. Paver block to increase the percolation of rain water to ground were implemented and practiced successfully. Retaining wall was built near the drainage and vegetation had been planted to avoid the surface soil run off. Use of potable and non-potable waters were identified and differentiated to conserve water.

Environmental safety measures are playing important role in the ecosystem of educational institutions' buildings. As far as students, research scholars, staff members and other stakeholders like parents and alumni are concerned, it requires vigilance and awareness on the importance of environmental safety measures. The Management of educational institutions should extend by issuing guidance and the best safety tools to all the stakeholders. The organization should have the details of nearby police force, escort services and call boxes for easy access by the staff members. In addition, the first aid box, fire extinguishers, fire alarms and security systems should be made available towards the safety measures. The audit results indicated that the college had very good safety measures as per the NBC guidelines. In addition, in all the places, 'Exit', 'Entry' and other sign boards kept across the place to give safety to the stakeholders.

Carbon footprint means measuring/recording the greenhouse gases (GHG) emissions of an organization within its defined boundary. Observations on carbon dioxide and oxygen levels monitored in different parts of the campus are presented while observation on carbon footprint due to electricity usage per year at the organization along with other fossil fuel utility were documented. Building materials were selected as per the Guidelines to Architect, Designer and Civil contractors. Low carbon emitting cements, bricks and other building materials were used for the construction and recycled glass materials were used for windows. Existing building service life plan was prepared and made available as per the NBC guidelines. Environment Impact Assessment (EIA) plan was also being followed by the campus to save the stakeholders. Management of water and waste are the two important parameters which plays a vital role to maintain sustainability (Rajalakshmi *et al.*, 2023b). It was observed that different coloured dustbins were used in the organization to segregate the wastes at the source of generation. These activities reflected the involvement of the organization to achieve the environment sustainability goals (Sreekala *et al.*, 2023).

Energy audit outcomes

Energy audit observations were documented in which the availability physical facilities were verified during onsite audit. It indicated that adequate awareness programmes on energy audit were organized and conducted to the stakeholders for the proper handling and maintenance of the appliances with respect to the energy audit. Standard Operating Procedure (SOP) and user manual were adequately available for the operation and maintenance of utilities like DG, AC, UPS and lifts. In addition, adequate external and vertical shading were provided to conserve energy (Mishra and Patel, 2016). Natural ventilation through windows and shading was available adequately to reduce the energy consumption. It was observed that large foliage trees were planted inside the campus to reduce noise pollution. Low

emitting lights are fixed as per the LPD mentioned in the NBC for safety and comfort. External and internal signage lights were differentiated to conserve energy. 'Danger' and 'warning boards' were available near transformer, generator and UPS along with over deck and under deck insulation of roofs were available. Solar water heaters and panels were available to maintain the sustainability. Building Integrated Photovoltaic system like power storage system, backup power supplies, wiring and safety disconnects were available. Adequate HVAC and day lighting facilities were observed. Outside air was introduced through windows for ventilation in the conditioned spaces. The metering system were appropriately monitored through maintenance of log books and sub meters. Five star rated appliances (lift, AC, Air cooler, Refrigerator, etc.) were procured to conserve energy. All the fluorescent (tube) lights were replaced with LED lights to conserve energy. Awareness posters like 'Turn off when not in use', 'Save Energy', etc., were displayed for conserving energy. All the artificial lighting system were monitored and controlled through partial availability of sensors. Lifts and moving walk path were adequately available in the campus. These energy audit parameters are found to be significant in terms of energy savings opportunities and energy conservation methods of an organization (Gnanamangai *et al.*, 2022b).

External shading facilities were made based on the sun path to reduce the energy consumption. Day light integration was implemented in the buildings by placing adequate number of windows. Electrical lighting facilities during day time increased the energy consumption, it was observed that sufficient day lighting facilities were available through windows which in turn reduce the energy consumption bill of the organization. The energy audit results showed that artificial lighting facilities were regularly monitored and maintained. In some areas sensor lights were implemented to save energy consumption coincided with the energy assessment and savings opportunities (Asnani and Bhawana, 2015).

To save energy in the buildings there should be a proper plan for HVAC system. In the organization it was observed that adequate natural ventilation was implemented and practices. In some places exhaust fans were used for ventilation especially in the canteen and laboratories. Solar panels were implemented at the roof top to reduce the heat and to save energy. Air conditioning were provided at specific areas. Energy conservation plays vital role in maintaining the sustainability (Gnanamangai *et al.*, 2022b). It was observed that the organization had replaced all the tube lights with CFL and LED lamps, had proper metering and sub-metering facilities, availability of BEE star rated appliances in Air cooler, lift, AC, UPS, generator, compressors and converters. Energy consumption and cost profile were presented in the Table 1. Other than electrical energy from grid, energy generated using fossil fuels for the year were presented in the Table 2.

Light intensity or light output is used to measure whether a particular light source provides enough light for an application needed. There is a well-established light level recommendation for a wide range of applications in lighting industry and also for the type of space (Singh *et al.*, 2012).

Light intensity was measured in terms of lumens per square foot (foot-candles) or lumens per square meter (lux). A light meter (lux meter) was used to measure the amount of light in a space/on a particular work surface. The light meter consists of a sensor that measures the light falling on it and provides the user with a measurable illuminance reading. Light meters are an especially useful tool for measuring light for safety or over-illumination. The light intensity measurements showed the intensity of light was found to be different in various places due to building construction, number of shade trees and population density of students and staff members in the campus (Table 3). Noise level observed in the different location resulted in normal range. Voltage measurement in AC & DC at different places in the campus was measured using the clamp (voltage) meter to reduce the energy consumption. The results were presented in the Table 4. It showed that the energy consumption was varied in varying levels at different locations of the campus. These parameters are very much essential for green auditing of an organization (Shahirabanu *et al.*, 2023).

4. Conclusion

The audited organization is a well-established academic institution in the world and there is significant scope for conserving green, environment and energy conservation strategies which in turn make the campus as self-sustained in coming years. The organization has taken enormous efforts to maintain green campus in a sustainable manner. A large number of activities related to green campus for the benefit of rural and tribal community people without disturbing the natural environment.

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Table 1: Electrical energy consumption and cost profile of Nehru Arts and Science College, Coimbatore, Tamil Nadu, India

| S. No | Months | Rating / Capacity units in kWh | Cost in Rs. |
|-------|-----------|--------------------------------|-------------|
| 1. | January | 36074 | 4,04,455 |
| 2. | February | 62164 | 5,80,55 |
| 3. | March | 79934 | 7,68,789 |
| 4. | April | 94785 | 8,62,123 |
| 5. | May | 101193 | 9,05,532 |
| 6. | June | 104322 | 8,63,456 |
| 7. | July | 86275 | 7,42,657 |
| 8. | August | 65861 | 6,70,412 |
| 9. | September | 76745 | 9,13,987 |
| 10. | October | 67362 | 9,19,942 |
| 11. | November | 94587 | 11,35,984 |
| 12. | December | 92962 | 13,24,643 |

Table 2: Annual Energy Consumption of Fuels of Nehru Arts and Science College, Coimbatore, Tamil Nadu, India

| S. No | Month | Diesel consumption (Liters) | Petrol consumption (Liters) | LPG consumption (kg) |
|-------|-----------|-----------------------------|-----------------------------|----------------------|
| 1. | January | 563 | 1255 | 38147 |
| 2. | February | 354 | 1247 | 34265 |
| 3. | March | 620 | 2545 | 62212 |
| 4. | April | 1254 | 3415 | 86075 |
| 5. | May | 1786 | 3168 | 92534 |
| 6. | June | 2546 | 5622 | 98957 |
| 7. | July | 1324 | 3644 | 93741 |
| 8. | August | 1443 | 4122 | 96855 |
| 9. | September | 2245 | 5355 | 102820 |
| 10. | October | 2145 | 4133 | 77574 |
| 11. | November | 2495 | 5725 | 74888 |
| 12. | December | 2127 | 4462 | 84847 |

Table 3: Light intensity and sound level measured at various locations of Nehru Arts and Science College, Coimbatore, Tamil Nadu, India

| S. No | Type of Spaces | Illuminances (LUX) | Noise level (Limits in dB (A) Leq) |
|-------|------------------|--------------------|------------------------------------|
| 1. | Class room | 265.5 | 60.5 |
| 2. | Auditorium | 335.7 | 62.7 |
| 3. | Seminar hall | 322.3 | 62.7 |
| 4. | Library | 272.0 | 55.5 |
| 5. | Laboratory | 233.3 | 58.0 |
| 6. | Canteen | 127.3 | 65.5 |
| 7. | Open area | 173.0 | 70.5 |
| 8. | Car Parking area | 235.5 | 72.5 |
| | SE± | 27.73 | 5.56 |
| | CD | 54.75 | 10.25 |

Source: BIS, 2015

Table 4: Voltage measured at various locations of Nehru Arts and Science College, Coimbatore, Tamil Nadu, India

| S. No | Name of the Place | AC & DC Voltage Measurement [Volt (v)] |
|-------|-------------------|--|
| 1. | Class Room (AC) | 231.7 |
| 2. | Auditorium (AC) | 233.5 |
| 3. | Seminar Hall (AC) | 233.3 |
| 4. | Library (AC) | 225.3 |
| 5. | Laboratory (AC) | 230.0 |
| 6. | Canteen (AC) | 227.3 |
| 7. | Power Room (AC) | 231.3 |
| 8. | Battery (DC) | 262.5 |
| 9. | Solar Panel (DC) | 255.7 |
| | SD± | 31.94 |
| | CD | 55.69 |

Source: BEE, 2015



Figure 1: Instruments used for the conduct of various audits at Nehru Arts and Science College, Coimbatore, Tamil Nadu, India

A. Oxygen Meter, B. Carbon dioxide Meter, C. Light (LUX) Meter, D. Sound Level Meter, E. pH Meter, F. TDS Meter, G. GPS Meter and H. Digital Clamp (Voltage) Meter



Figure 2: Personal Protective Equipment used for the conduct of various audits at Nehru Arts and Science College, Coimbatore, Tamil Nadu, India

A. Safety Jackets, B. Goggles and Face Shield, C. Helmet, D. Hand gloves, E. Safety Boots and F. Ear Plugs