Evaluating Energy Efficiency in Traditional Architecture with Reference to Criterion 8 of GRIHA

Apoorva Dubey¹, Mohammad Arif Kamal²,*

¹Department of Architecture, Aligarh Muslim University, Aligarh, India
²Architecture Section, Aligarh Muslim University, Aligarh, India
*Corresponding author: architarif@gmail.com

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Abstract Energy efficiency has become one of the key focuses for several national policies related to energy, climate change. Currently, major attention is being given to the issues related to energy conservation as the world is more concern about the effects of global climate change that is arising because of carbon emission, greenhouse effects etc., also concerns about achieving SDG goals. Recently, the pandemic Covid-19 taught all of us how playing with nature, utilizing natural resources more than that are available, can adversely affect not only life of people but can also risk their health and wealth. Until and unless such issues are seriously looked after and resolved such types of outbreaks may occur again. Also, energy efficiency has become the top most issue that professionals deals with on daily basis. The concept of green building play key role in overcoming these kinds of challenges. Focusing on energy efficiency can itself save many natural resources. A green building rating system is already there on national level that is GRIHA (Green Rating for Integrated Habitat Assessment), which includes certain criteria that involves simple and easy calculations, measures etc., which will help in reducing energy efficiency in a building. It identifies the benchmark parameters with regulations that suit local climatic conditions. It came into force in 2007. There are different variants of GRIHA for different kind of projects and volumes of GRIHA are revised after every three years. This paper depicts the analysis of a building by using criterion 8 i.e. energy efficiency that comes under energy section of GRIHA volume 2015. There are three criteria under energy section of this variant but this paper focus on only one criteria i.e. energy efficiency.

Keywords: energy efficiency, traditional, architecture, GRIHA, Aligarh, India


1. Introduction

Today the world is moving at a fast pace towards achieving the initiatives of sustainability development goals. These goals are designed in such a way that they will definitely result in green building concept [1]. The green building concept has gradually developed in a surprising way to achieve the goals of sustainable development [2]. Green buildings are designed in such a way to have minimum negative impact on climatic challenges and conserve natural resources [3]. Green buildings tend to save environment. The movement internationally started for green building in the year 1990 after Earth Summit. In 2001, the initiatives for the concept of green building started in India with the introduction of green rating certified system i.e., LEED India. Later in 2005, GRIHA was developed and introduced as a rating system. It came into force in 2007 [4]. There are different variants of GRIHA based on the types of project. To reflect the current market scenario and to develop different latest benchmarks to improve the market, GRIHA rating system undergo revisions after every 3 years after holding discussion with different stakeholders, experienced professionals of on-going GRIHA projects as well as taking feedback from the market. It helps the Council of GRIHA to develop a better green building rating system which is updated with time. In GRIHA manual there are different sections, each section consist of different criterion and each criterion consist of different kind of points. The section of Energy is of great importance under each variant of GRIHA. Hence, consist of maximum points. It is so, because this section can itself helps in reducing the dependency on natural resources, hence resources can be conserved.

This paper presents work on the analysis of a traditional building i.e., Foreign Language Department at Aligarh Muslim University (AMU), Aligarh, India on the basis of energy section under GRIHA volume 2015. Under energy section the criterion number 8 i.e. Energy efficiency has been analyzed in detail in this paper. This criterion contains maximum points 13. The two main calculations that are involved in this criterion are regarding LPD (lighting power density) and EPI (energy performance index). Both are analyzed in detail in the paper.
2. Research Methodology

In this paper both qualitative as well as quantitative research methods have been used. The qualitative data related to literature has been gathered through internet, GRIHA manual and secondary data from relevant published academic literature from journals articles and research papers. The basic concepts and background studies are investigated through literature. The quantitative data has been collected from Foreign Language Department, Aligarh Muslim University, Aligarh, India as well as from different sections of AMU. The analysis of quantitative data has been done by analyzing GRIHA manual i.e. volume 2015, also by attending GRIHA 3 days training program that helped in understanding the details related to different aspects of criterion 8, Energy efficiency including calculations.

3. Green Rating for Integrated Habitat Assessment (GRIHA)

Green Rating for Integrated Habitat Assessment (GRIHA) is the rating tool which measures environmental performance of buildings in India. Earlier it was founded in 2005 by TERI which was earlier known as Tata Energy Research Institute, but in 1984 it moved to Delhi from Mumbai and named as, The Energy and Resource Institute. Later in 2007, Ministry of new and renewable energy adopted GRIHA as a national green building rating tool[5,6]. But before knowing more and in detail about GRIHA, it is important to know how it all started.

Figure 1. Formation of green building and GRIHA in India

In 1960s and 1970s a movement, political movement was started firstly in Australia as well as New Zealand named as green movement for addressing the key issues related to environmental preoccupation and protection. This movement very quickly passed over to Europe. In first half of 70s and second half of 80s green movement began to grow in different parts of Europe. A group of Swiss green was the first green party with some institutional success. In 1980s green emerged in Germany, Netherlands, Belgium etc. Later a green alternative European link was formed in 1984. Further in 1980s United Nation appointed a commission that was named ‘Brundtland Commission’ for studying as well as reporting the different problems related to the sustainable development as well as environment so as to address the global problems related to the environment and climate change [7]. In 1987 a report was submitted and it was named as ‘Our Common Future’. The commission forms common goals so as to save planet. This commission further gave definition of sustainability that was accepted by the UN as well as world community. After that in 1992, the report of the commission made UN to conduct earth summit in Brazil at Rio de Janeiro where ‘Agenda 21’ was formed as a plan of action to hold environmental problem at global level. The main focus of Agenda 21 was to control carbon emissions (CO2 emission). In 1990s after earth summit, the movement for sustainable green building started internationally [8,9]. As a result of the movement, in 1993 USGBC (US green building Council) was established for promoting sustainable construction. After that USGBC formed LEED for evaluating green performance of building in terms of green building and awarding rating. In India green movement started in 1972, and in 2001 LEED India was formed and later in 2005, GRIHA was established by TERI and it was adopted as a national rating system by MNRE IN 2007. Since then GRIHA is in work force and have attain a remark in India. GRIHA also plays very important role in achieving Sustainability Development goals.

GRIHA is a rating System for green building that provides maximum rating of 5 star. GRIHA is an evaluation tool which provides rating in terms of green building in the three stage process. This process involves document’s submission through online mode, followed by the site visit and last but not the least is building’s evaluation by the team of experts and professionals of different fields. Green Rating for Integrated Habitat Assessment combines all suitable Indian codes as well as standards. It performs as a tool to make easier implementation of the same. The major motive of GRIHA is minimizing resource consumption, generation of waste as well as overall the environmental impact of building/campus by comparing to the certain nationally accepted standards. It gives emphasis to passive design techniques for improving visual as well as thermal comfort. It is a system which is both guiding as well performance oriented, where certain set of points are earned by fulfilling the minimum criteria under each set of section. It means that, if some project is focusing to meet the criteria of GRIHA, then it have to qualify for the points [10]. GRIHA majorly focus on some sections, they are site planning, Energy, water, comfort & wellbeing, socio-economic, solid waste management, performance metering and monitoring etc. Each variant of GRIHA consist of certain set of sections, each section consist of number of criteria. Each section consists of some points that are divided among various criteria which come under that particular section. The points related to particular criteria are firstly provisionally awarded then they are converted to final points through detailed monitoring, validation as well as submission of documents for supporting the award of points. On one hand there are some set of points that are mandatory that needs to be fulfilled while on the other hand there are other set of points that are optional, it’s not mandatory to achieve them.
3.1. Different Variants of GRIHA

A) For Existing Building
- GRIHA EB, built-up area > 2500 SQM
- GRIHA for Existing Day Schools

B) For New Building
- SVA GRIHA (Simple versatile affordable housing), 100 SQM < BUILTUP AREA > 2500 SQM.
- GRIHA, built-up area > 2500 SQM
- GRIHA LD, site area > 50 Ha
- GRIHA for Affordable Housing

3.2. Stages in Documentation and Rating

There are two stages that are involved they are Pre-documentation and Post-documentation. In stage of Pre-documentation a team from Association for Development and Research of Sustainable Habitats with the Design Team that is integrated by client decide the points that need to be targeted by the project. Then in post documentation stage, all the documents that are necessary are submitted to achieve the targeted points. After the documents are uploaded, then evaluation is done by third party that consists of a team of professionals in different fields as well as experts, they award the provisional ratings [11].

3.3. GRIHA Volume 2015

Table 1. Point wise distribution of Green Rating

<table>
<thead>
<tr>
<th>GRIHA Volume 2015 Rating Threshold</th>
<th>Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-40</td>
<td>1 star</td>
</tr>
<tr>
<td>41-55</td>
<td>2 star</td>
</tr>
<tr>
<td>56-70</td>
<td>3 star</td>
</tr>
<tr>
<td>71-85</td>
<td>4 star</td>
</tr>
<tr>
<td>86 and more</td>
<td>5 star</td>
</tr>
</tbody>
</table>

It is one of the variant of GRIHA. GRIHA volume 2015 consists of different sections and each section consists of different set of criteria. In total there are 31 criteria that are divided under nine different sections. This variant provides rating on a scale of maximum 100 points and minimum points that can be achieved for getting green building certification are 25. The section from where maximum points can be achieved is energy, i.e. 20. This section consists of three criteria namely, Energy efficiency, renewable energy utilization and zero ODP materials. The energy efficiency criterion no 8 consists of maximum 13 points, whereas criteria no 9 Renewable energy utilization consist of maximum 7 points and for zero ODP (ozone depletion potential material) there are zero points for this criterion.

3.4. GRIHA Criteria No. 8: Energy Efficiency (Maximum Points-13)

The intent of this criterion is to make sure that the projects are energy efficient. There are total five appraisals under this criterion out of which two appraisals are mandatory. The mandatory appraisals are, firstly to make sure all the projects must meet the compulsory requirements of energy conservation building code (ECBC) and fans must BEE star rated and secondly to make sure that the EPI of the project is below GRIHA’S base-case. The other appraisals- peak heat gain by building envelop must meet GRIHA’S threshold for this 2 points will be awarded, also all the outdoor lighting fixtures must meet GRIHA’S requirement of luminous efficacy for this 1 point will be awarded etc. After the appraisals there are some set of compliance under this criterion, these compliances include submission of mandatory documents for claiming the points to be achieved. Actually they are the proofs against achieving the points [12].

4. Energy Efficiency in Department of Foreign Language, Aligarh Muslim University, India

The Department of Foreign Language was constructed many years ago. It is a department which provides courses (BA, MA) in different foreign languages including Chinese, French, German, Russian, Spanish etc. It has 100 student intake in BA and 50 student intake in MA course at present. Earlier it had only one block i.e. old block but now new block has been added adjacent to the old block. The old block is single story with total height of 6.8meters. This block consist of total five classrooms, where four classrooms are general classroom and one is smart classroom, two teachers rooms, 4 toilets, reception, foyer and office are there. There are height variations in front and rare elevation of the old building block. The site area of this block is around 5504sqm. The old block is designed in such a way that indoor thermal as well as visual conditions remain comfortable even in peak winters and peak summers. Also, there is lot of landscaped green space around the building.

4.1. Calculation of Lighting Power Density (LPD)

LPD stands for Lighting Power Density. It is the lighting power divided by the lighted floor area. It’s a measure of energy usage over time. It is generally expressed in watt per square feet or watt per square meter. LPD technically represents the load of lighting equipment in an area.
Figure 3. Ground Floor Plan of the Dept. of Foreign Language at AMU

Figure 4. Elevation of the Dept. of Foreign Language at AMU
Numerically LPD can be written as,
LPD = Total lighting power in watt / Total lighted floor Area
Total Lighting Power (in watt) = 240 + 72 + 18 + 9 = 339 w
Total Area = 252.72sqm
LPD = 339/252.72 = 1.32 w/ sq. mtrs.

4.2. Calculation of Energy Performance Index (EPI)

EPI stands for Energy performance index. It is defined as total energy consumed in a building over a year divided
by total built-up area. It is calculated in kWh/sqm/year. It’s considered to be one of the simple as well as most relevant in terms of indicator for identifying whether a building is energy efficient. Numerically it can be written as,

\[
EPI = \frac{(\text{Total Internal Load} + \text{HVAC load})}{\text{Built-up area}}
\]

Total CFL load = 0.153 kW,
Total load of fans = 0.7 kW,
Total load of tube lights = 0.075 kW

Office load = 1379.5 kWh/yr
HVAC = 10976 kWh/yr
Total load = 13923.484
epi = 3 kWh/sqm/yr
It is much lesser than GRIHA base-case

5. Conclusions

The sector related to energy worldwide faces many acute difficulties each day. There are various well known energy efficiency measures as well as innovative technologies that are widely spread but the major problem lies in identifying more effective and reliable one with respect to long term [13]. With n. number of proposed measures, the policy makers are compensating in terms of various factors including environmental, social, energy and financial as well, so as to attain best possible solution that will help in ensuring energy efficiency in building. Incorporation of energy efficiency (EE) results in energy saving in buildings. EE means doing more work with same quantity of energy unit. EE acts as parameter that helps in achieving low level energy usage. The energy efficiency concept can be defined as the less energy usage to provide the same amount of outcome in longer term. It utilizes less inputs for more energy saving. It can also be explained as ratio of energy output to energy input. EE is one of the important criteria that helps in making building green, save on resources etc., and achieving green building certification. Greater the energy demand more will be usage of natural resources, the negative effect on environment as well as the quality of life [14,15].

Lighting is one of the important aspects that help in minimizing overall energy consumption, hence achieving energy efficiency. LPD calculation for any project helps in identifying usage of energy over time. It helps in identifying what kind of lights, in terms of their wattage, their star rating in terms of BEE rating (Bureau of energy efficiency) can be used with respect to floor area to be lighted that will help in lowering energy usage. It means using passive and innovative means can help in achieving low LPD [16]. The other aspect that helps in achieving energy efficiency is EPI. It is defined as the ratio of annual energy consumption to built-up area. There are two methods for calculating EPI, first one is prescriptive method and other one is whole building performance method. Here in this research second method of EPI calculation has been used. There are certain sets of standard values for EPI with respect to Indian climatic conditions that are provided in GRIHA manual 2015 and they need to be fulfilled for achieving rating. The old building of department of foreign language is made of 18” thick walls, used local available materials, sufficient window openings, proper ventilation and daylight, comfortable thermal condition as well have been provided in the building, also in elevation there are height variations, high ceilings these helps in reducing heat load, reducing the need for more windows, lights, fans and ac as well, hence reducing lighting loads. Which on the other hand fulfilling criterion no 8 of GRIHA volume 2015. This building is energy efficient since it was constructed. Though this building was built many years ago, the city in which this building is located have composite climate but still, it is energy-efficient in all the seasons of weather. As it incorporated passive design techniques. Energy efficiency can be achieved by simply using locally available materials, ancient design techniques, simple creativity etc., so it is not necessary to depend on costly technologies and measures for making energy efficient building. The resources can be saved just by incorporating simple design measures as well as techniques only and small effort can bring big change.

Table 2. Depicting data of foreign Language Department in terms of room sizes, number of lights and their wattage

<table>
<thead>
<tr>
<th>Space Size (Sq. Mtrs)</th>
<th>No. of Lights and Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2 CFL - 9W each</td>
</tr>
<tr>
<td>50</td>
<td>2 CFL - 9W each, 2 Tube lights - 15W each</td>
</tr>
<tr>
<td>20</td>
<td>2 CFL - 9W each, 2 Tube lights - 15W each</td>
</tr>
<tr>
<td>27.5</td>
<td>2 CFL - 9W each, 2 Tube lights - 15W each</td>
</tr>
<tr>
<td>20</td>
<td>2 CFL - 9W each, 2 Tubelights - 15W each</td>
</tr>
<tr>
<td>6.76</td>
<td>2 CFL - 9W each</td>
</tr>
<tr>
<td>15</td>
<td>2 CFL - 9W each</td>
</tr>
<tr>
<td>4.5</td>
<td>2 CFL - 9W each</td>
</tr>
<tr>
<td>12.76</td>
<td>2 CFL - 9W each</td>
</tr>
<tr>
<td>15</td>
<td>2 CFL - 9W each</td>
</tr>
<tr>
<td>33.6 each</td>
<td>1 CFL - 9W in each corridor</td>
</tr>
</tbody>
</table>

References


