Evaluating Energy Efficiency in a Hospital Building with Reference to GRIHA: Case of Trauma Centre at Aligarh, India

Apoorva Dubey[1], Mohammad Arif Kamal[2,*]
[1] Dept. of Architecture, Aligarh Muslim University, Aligarh, India
[2] Architecture Section, Aligarh Muslim University, Aligarh, India
DOI: 10.32629/aes.v3i2.843

Abstract: With the rise in problems mainly ecological as well as energy crises that are intensifying today, the concept of green has become essential concerning sustainable development. The hospital building consumes much more energy and generates more waste, as compared to the other types of buildings. The climate change, contamination of chemicals, and use of unsustainable resources are all making health worse day by day over the world. The health sectors are themselves causing these problems on a broad scale. So, hospitals, health sectors must be green, there must be proper management of resources, waste etc., which means that it must have a minimum negative impact on the environment. The term Green Hospital has evolved as a way of addressing environmental issues, overcoming them and meeting society's need. In India, Green Rating for Integrated Habitat Assessment (GRIHA) is one of the tools that provides green building certification to hospital buildings also. This paper aims at analyzing and investigating a hospital building (Trauma centre), Jawaharlal Nehru Medical College, Aligarh, based on major criteria of the GRIHA variant for existing buildings. This hospital building had been provisionally-rated by GRIHA in the year 2016 as 3 stars. This paper includes the analysis of building based on various calculations and in depth study of how this 3 star rating was provisionally achieved. This paper involves two main calculations, one regarding peak heat gain and the other is EPI.
***Keywords*:** green hospital, Trauma Centre, GRIHA, peak heat gain, EPI, Aligarh, India

1. Introduction

The term Green building is spreading widely and has become one of the most focused area not only in private, public and government sector but also in industry too (Sahamir and Zakaria, 2014). Presently, people are living in a scenario where both the crises, public health as well as the environment have started merging, and it is magnifying the damage of each. As they both together run, the cross-effect of disease as well as ecological declination build on each other, hence becoming increasingly damaging forces. The health care sectors use the greatest amount of energy while doing their daily operations, when the needs are most with respect to heating of water, lighting as well as telecommunications. Studies reveal that around 70 to 80% greenhouse gas emissions are released during this period. The health sectors are the major source of pollution over the world, so there is a need that the design of hospital buildings must include principles of green building (Azar et.al, 2015). There are several rating systems that are working on it like, LEED, BREEM, GRIHA etc., they have provided special requirements for healthcare sector, hospitals etc. The hospitals must provide a good environment because both building's design as well as site affects the healing. This implies that, the planning of hospital and processes of design should include not only the problems surrounding treatments but, must include promoting health and preventing diseases by creating careful as well as safe environment(GCDG, n.d).

2. Research Brief

This research includes the careful analysis along with investigation of the Trauma Centre Jawaharlal Nehru Medical College, Aligarh. This building has been analyzed based on (Green Rating for Integrated Habitat Assessment) GRIHA for existing building. The different criteria of GRIHA have been taken into consideration. There are 9 sections in total under GRIHA variant (GRIHA EB) and under these sections 31 criteria are there. In this paper five major sections have been investigated namely, site planning, energy efficiency, construction management, occupant comfort and wellbeing and water. It also involves some calculations, regarding peak heat gain, SRI and EPI (energy performance index). The minimum points are achieved from site planning section and maximum points are achieved from the energy efficiency section.

3. Research Methodology

In this paper both the research methods have been used, qualitative as well as quantitative. The qualitative data related

has been collected through internet, GRIHA manual and secondary data from relevant published academic literature from journals, articles and research papers, reports etc. The basic concepts and background studies are investigated through literature. The quantitative data has been collected from different sections of JNMC, Aligarh and tis quantitative data has been analyzed using GRIHA manual for existing buildings.

4. Green Hospital

A Green hospital is defined as a Hospital that enhances wellbeing of patients and utilise natural resources effectively and efficiently with minimum negative effect on the environment. The concepts of green hospital as well as green health are changing rapidly (Technical Bulletin, n.d). Hospitals are systems, where changes are not performed easily and also not fast. To design a green hospital it is important to have deep knowledge regarding its strength as well as weakness. The multiple aspects of healthcare centers/ hospitals have negative impact on health of patient, community as well as the environment. Several studies have shown that different type of materials used in hospital have different kind of effect on human health, disease etc. For example, VOC have great negative impact on staff as well as patients. The insufficient ventilation in hospitals leads to poor quality of indoor air as well as pollution (Kumari and Kumar, 2020). People having ill-health must have the greenest surroundings/ buildings of all as within the hospitals the environmental impact on users is much more important than in any other building because it's a place that provide healing along with recovery.

The major objectives of green hospital are to achieve the following:

The reduction in the consumption of energy.

The reduction in cost of the project.

The reduction in waste generation and proper disposal of waste.

The reduction in carbon emissions.(Tabish,2011)

4.1 Benefits of Green hospital

Low and efficient consumption of natural resources.

Reduce recovery time of the patients.

Removes sick building syndrome both for patient as well as staff.

Improves productivity of the staff by providing healthy indoor environment.

Reduces stress among staff.

4.2 Important Green Hospital Elements

4.2.1 Conservation of energy

Hospitals/Healthcare centres are operated 24x7 throughout 365 days in a year. With the advancement of technologies, energy consumption has greatly increased for running these technologies, heating water, operating lights, fans, for different clinical procedures etc., which is leading to greenhouse effect on other hand.so, measure need to be taken, even small measures can bring great change, for example, switch off the lights, technologies when not in used, i.e. cut down energy waste.

4.2.2 Passive Means for the Generation of Energy

The energy that is utilised in the hospital is mostly taken from outside in the form of electricity or fuel so, affecting the operational cost of hospital. AC, lighting, water pumps, different gadgets consumes electricity, also sterilizing instruments require steam, fired boiler are used for generating steam, power generation sets are mostly used in health care centres for generation of electricity. This is leading to reduction in natural resources and having negative impact on the environment. So, renewable resources must be used for generation of electricity in the hospitals.

4.2.3 Management of Waste

Most healthcare centres in India both private as well as public sector have no proper management and safe disposal of waste. The waste generated in hospitals are hazardous, one of the major contributors of pollution. Most hospital in India dispose the hospital waste along road side or discharge into rivers, hence affecting nature, the environment. There should be proper management of waste in all hospitals and healthcare centres. This will reduce pollution.

4.2.4 Water Conservation

The hospitals utilize large quantities of water. The condition of Climatic change, with its impacts like drought, melting of glacier and depletion of aquifer, will lead to scarcity of water. Some measures can help in saving water. Like harvesting rain water, recycling water etc., water from these sources can be used in healthcare facilities for non-drinking purpose.

4.2.5 Environment

Amalgamation of climatic features with features of the site must makes sure that a green building should not be sustainable only but it should make sure that the design of building must incorporate elements of climatic conditions also like hydrology, ecosystem, geology of site etc., and micro-climates (Dhillon and Kaur, 2015).

4.3 Key Areas for designing a Green Hospital

Indoor Lighting
Proper daylight along with views
Improved Air quality
Fresh air Ventilation
Garden as well as landscape
Green building materials
Connectivity with outdoor environment
Regular monitoring of carbon emission (Gultom and Riyanto, n.d)

5. GRIHA

GRIHA stands for Green Rating for Integrated Habitat Assessment is a tool that gives green building certification by measuring the performance of a project with respect to the environment. It is a national tool which is now actively used by different agencies, organizations both private as well as government so as to meet SDG goals. There are different types of GRIHA manual that have been designed for different kinds of projects based on the site area and building type. GRIHA EB is a GRIHA variant for existing buildings whose site area is greater than 2500 sqm. There are 3 criteria in this manual and different set of points are present under each section. GRIHA award green rating in star form based on the criteria defined in each manual of GRIHA. Star rating is from 1 star (minimum rating) to 5 star (maximum rating) on scale of 100 points (Rani et.al, 2017).

6. Analysis and Investigation of the Trauma Centre, Jawaharlal Nehru Medical College, Aligarh

Figure 1. Google Map of Trauma Centre,JNMC Site (Source: google earth)

The Trauma centre building is located in Aligarh Muslim University, AMU, Aligarh, Uttar Pradesh. It's a hospital building. The total area of the site is 14532 sq. mtrs. and total Built up area is around 6642 sq. mtrs. It's a three storeyed building (G+2) that was provisionally rated by GRIHA as 3 star in the year 2016.

6.1 Section 1-Site Planning

6.1.1 Criterion 1: Site Selection (Max. Points-1)

The site of the project as per GRIHA manual must be either a brownfield or it must be redevelopment site or there should be at least five basic services available within the site or within 500 meters walking distance from the entrance of the site. The site of JNMC was brownfield site. So, gaining 1 point from here.

6.1.2 Criterion 2: Low-impact Design (Max. Points-4)

There are four strategies that were adopted with respect to 2nd criteria in this building. They are –
The service area and store room are placed on the western side.
The brick walls of the building are 400mm thick to reduce heat gain (solar insolation).
There is proper cross ventilation within the building.
The terracotta jali has been used in this building.

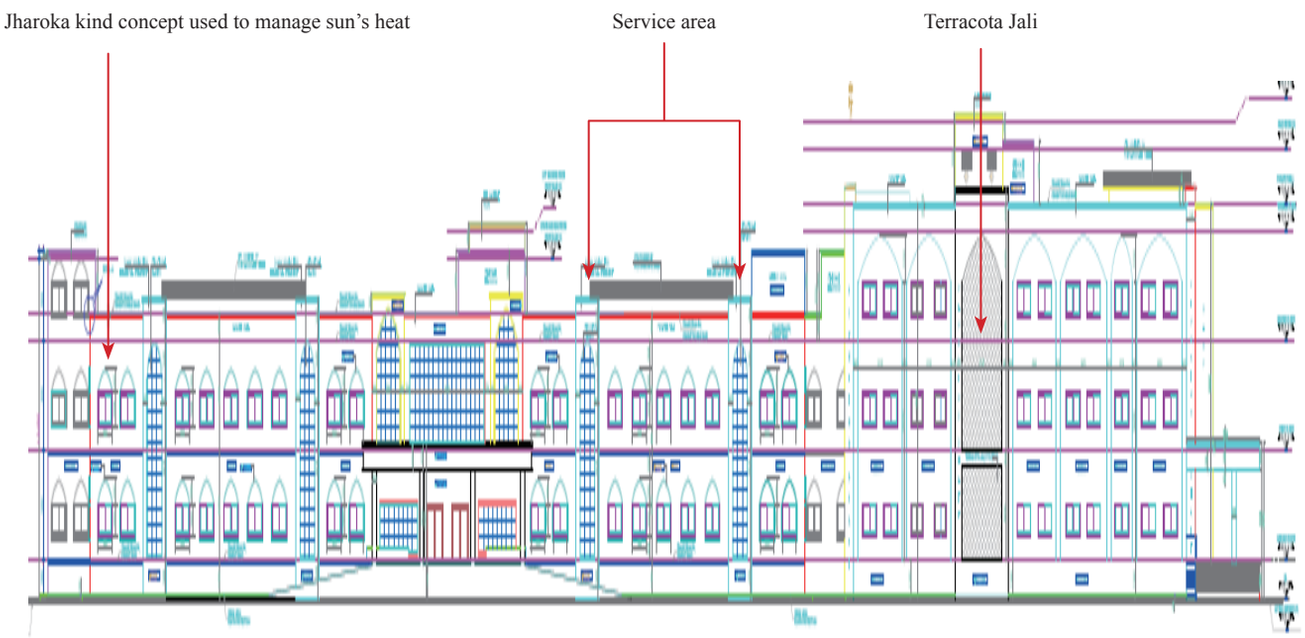

Figure 2. Front elevation of Trauma Centre

Figure 3. View of the Emergency and Trauma Centre

6.1.3 Criterion 3: Design to mitigate UHIE

As per GRIHA the surfaces of the site that are visible to the sky must be soft paved or shaded by trees or covered or shaded by pergolas, etc., if more than 25 percent surface of the site is visible to sky. There is 1 point for this measure. Sim-

ilarly if surfaces of the site that are visible to sky are more than fifty percent and they are covered or shaded or soft paved etc., then 2 points can be gained for this measure.

Appraisal 1stis being fulfilled in this project, as

25% of 14532 =3633

Site surface visible to sky soft paved=650 sqm

Roof area with SRI coating = 3000sqm

So, 3000+650=3650sqm

Hence, 1 point is gained.

6.1.4 Sustainable site planning:

The natural contours of the site were mostly maintained and a naturally existing water body on the site has been preserved. Excavation and construction started after the monsoon to prevent soil erosion and soil run-off from the site. The top soil was also preserved and was later re-applied for landscaping in this project.

From section 1 the total points earned are six

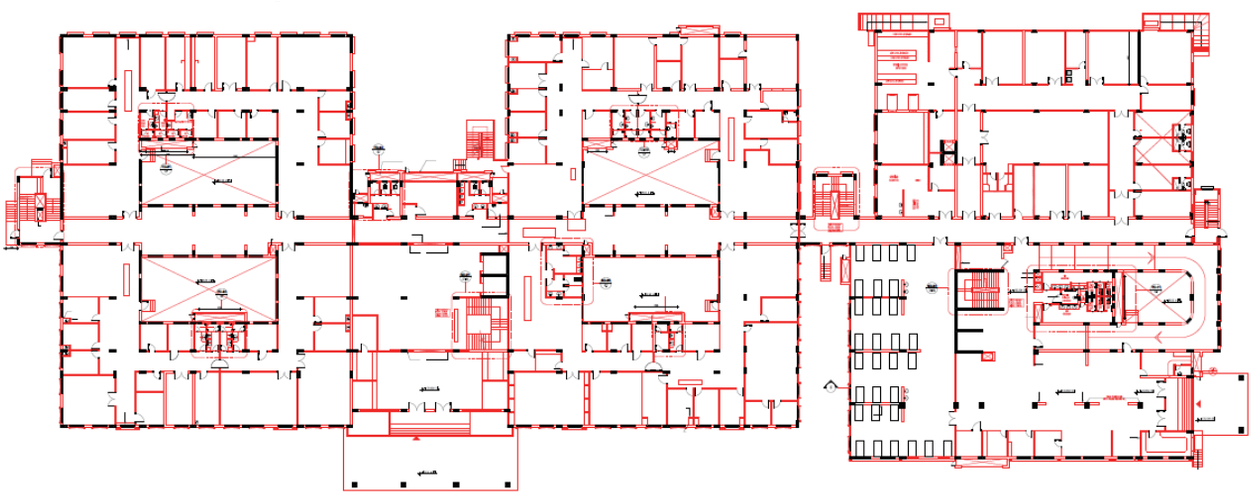

Figure 4. Ground floor plan of Trauma Centre, JNMC, Aligarh

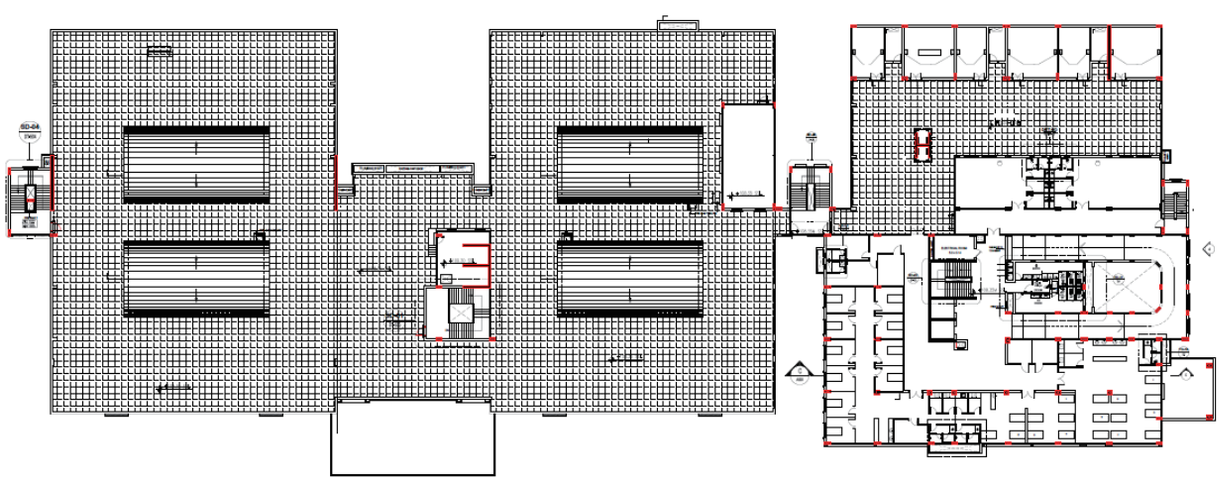

Figure 5. Second floor plan of trauma Centre, JNMC, Aligarh

6.2 Section 2-Construction Management

6.2.1 Criteria7: Construction Management Practices

The staging must be adopted during construction on the project site. Also, various strategies should be incorporated for reducing the movement of the soil outside the construction site. There should be proper management of water during con-

struction on the site and different strategies must be adopted for this. The gunny bags and ponding both were used for curing at the time of construction. Some strategies were adopted for avoiding leaks and wastage of water. The different additives were used for reducing water requirement of water at the time of curing. In total, 9 points were earned from section 2 under its different criteria.

6.3 Section 3-Energy

The Peak heat gained through the building envelope must meet the threshold of GRIHA.
Let H stands for Hour angle

H = 15 X (Time−12)
Time = hour of day from midnight
Zenith angle (Z)

Z = cos−1(sin X sin Y + cos X cos Y cos H)

X = latitude
Y = solar declination angle
H = hour angle

I = S cos Z
I = solar insolation
H = 15 (16 – 12)
= 15×2 = 30

Z = cos−1 (sin27 sin 23.5 + cos27 cos 23.5 cos 30)
= cos−1 (0.4549 × 0.399 + 0.891 × 0.917 × 0.866)
= cos−1 (0.1809+ 0.7075)
= cos (−0.89)
= 0.99 or 1
Area of window = {(1.2×19)+1.72} = 24.5 or 25sqm

I = 1000 cos1
= 1000/25=40 w/sqm

6.3.1 Criterion 8: Energy efficiency

Energy performance index (EPI) is the total energy consumed in a building over a year divided by total built up area in kWh/sq m/year. The total energy consumed through different sources within the building is as follows:

Energy consumed by Lights = 1698kw
Energy consumed by Fans = 350 × 65 =19500kw
Similarly, Energy consumed by AC = 2250.79kw
Energy consumed by Generator = 450kw = 450×3 (3generators) = 1350kw
By Transformer = 450kw =450×3(3 transformers)= 1350kw
By Equipments = 3000kw
The total energy consumed per year in kwh=1,095,132.96kwh
Epi=1,095,132.96/6642=164.88kwh/sqm/year
Which is lesser than 225, so getting 10 points.

6.3.2 Criterion 9: Renewable energy utilization

The different technologies were installed on the site for generation of renewable energy. 36 kilo Watt Peak solar panels have been installed for fulfilling energy requirement of the building. A water System for solar hot water of the capacity of two thousand litres has been installed on the site.

6.4 Section 4-Occupant Comfort and Well-Being

6.4.1 Use of low energy materials:

The Flyash bricks as well as stone masonry both are used in the construction of this building. For false ceiling Gypsum

board along with particle boards have been used. For flooring kota stone, cement tiles, vitrified tiles etc., have been used.

6.4.2 Reducing energy consumption (compared to GRIHA benchmarks) while maintaining occupant comfort:

This building has been designed efficiently. The Double glazed windows have been installed in the building with an Solar Heat Gain Coefficient of around 0.23. Also, for maximizing the daylight penetration into common areas various cut-outs have been there.

6.5 Section 5-Water

6.5.1 Reducing consumption of water:

There is a reduction of about 66% in the water consumption by building as compared to the GRIHA base case just by installation of low flow fixtures. Also, the building has achieved around 43.55% reduction in water requirement for landscape over GRIHA's base case (Rani et.al, 2017).

Table 1. Depicting total points achieved under each section

S. No.	Sections	Points Achieved
1.	Section 1- Site Planning	6
2.	Section 2-Construction Management	9
3.	Section 3-Energy Efficiency	20
4.	Section 4- Occupant Comfort and Well-Being	6
5.	Section 5-Water	16
	Total Points Earned	57
	out of 100 points, 57 points achieved,so it is a 3 star rating	

7. Conclusion

Hospitals are highly energy resourced consumers. On one hand, they are providing good care to the patients, and on the other hand, they are negatively affecting the environment. The poor management of resources, unsafe disposal of hospital waste, great dependency on fuel etc., are the factors that are leading to carbon emissions hence, creating damage to the environment in the hospital and healthcare buildings. Apart from this, nowadays hospitals have started incorporating the measures and strategies related to green design to improve the hospital's environment for healing patients and also to save the Earth. Healthcare centres face certain problems while incorporating green design measures and one of the key issues is find a way to identify the appropriate measures along with strategies and their effectiveness. Hence, green health care and hospitals have become a necessity in the present scenario (Chias and Abad, 2017). The rating systems of the green buildings follow a systematic way for evaluation and implementation of measures related to green. They provide appropriate strategies, measures and considerations in the form of a certain set of criteria under some set of sections. It's a practice that provides professionals, consumers, and regulators a standard and a means for assessment and evaluation of the building's environmental performance and provides ways to reduce the negative impact of the structure on the environment, hence saving on resources, climate and environment. It was found from the analysis that taking a few measures of green rating systems into consideration can help in making buildings green. One of them is Solar Insolation, which plays important role in calculating peak heat gained, solar insolation is directly proportional to peak heat gained, so for getting a lesser amount of peak gained by the building to have comfortable condition inside the building, lesser must be the solar insolation and vice-versa, likewise, the role of solar reflective index and EPI. So, if a building is certified by a green rating system, the people surrounding it will get motivated and they will start taking measures related to green building as, its human intrinsic nature that until and unless he has not been given an appraisal he won't work. And GRIHA is a tool that provides easy measures, appropriate strategies to make a structure green along with certification. Just by following GRIHA, by following small basic measures and green building guidelines a structure can be made green.

References

[1] Sahamir S & Zakaria R. (2014). Green assessment criteria for public hospital building Development in Malaysia. 4th

International Conference on Sustainable Future for Human Security, 106–115.
[2] Azar F E, Farzianpour F, Foroushani A R, et .al. (2015). Evaluation of green hospital dimensions in teaching and private hospitals covered by tehran university of medical sciences. Journal of Service Science and Management, 2015, 8, 259-266. http://www.scirp.org/journal/jssmhttp://dx.doi.org/10.4236/jssm.2015.82029.
[3] The green checklist and discussion guide, n.d. section III, 1-35.
[4] Technical bulletin green hospitals, n.d. Indian green building council, CII-sohrabji godrej green business centre,1-4.
[5] Kumari S & Kumar R. (2020).Green hospital- A necessity and not option. Journal of management research and analysis, doi: 10.18231/j.jmra.2020.010. https://www.researchgate.net/publication/342958633.
[6] Tabish S.A. (2011). Future trends in green hospitals. Research gate, 1-12. https://www.researchgate.net/publication/303365580.
[7] Dhillon V.S, Kaur D. (2015). Green hospital and climate change: their interrelationship and the way forward. Journal of Clinical and Diagnostic Research, Vol-9(12): LE01-LE05.
[8] Gultom M and Riyanto S, n.d. Green human resource management: strategies to enhance green behaviour of hospital. 1-11.
[9] Rani S, Choudhary Y, Mahal N.K, et.al.(2017). Transforming existing buildings to sustainable buildings. GRIHA for existing buildings abridged manual, version 1, 14-19.
[10] Chias P and Abad T. (2017). Green hospitals, green healthcare. International Journal of Energy Production & Management, Vol. 2, No. 2, 196–205.