EVALUATION OF GREEN BUILDING PARAMETERS FOR CONVERTING NON-RATED BUILDING INTO RATED BUILDING

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Abstract_ Global warming has raised global concern on climate change. One of the effective measures to reduce this global warming is to conserve the energy uses globally. Green building or sustainable building is the solution to control the resource consumption, water consumption, energy consumption and increasing indoor air quality for occupant's health within the building. Green buildings are the practices or process which have been done in the field of building construction to reduce the negative environment impact and green house gases as well. This paper has focused on detail study of various parameters and evaluate it for conversion of non-rated i.e conventional building into green building. Which are considered by various green building rating system such as LEED, GRIHA and IGBC from siting to finishing stage of building to achieve the goal of certification in green building. However, the high cost is the main obstacle to develop green building. This paper focused on calculation of life cycle cost and payback period of the non-rated building in order to consider the most credited parameters has given by above rating system.

Keywords: Green Building, Green Building Rating System, Green Building Parameters, Life Cycle Cost.

1.INTRODUCTION :

Today the world has been facing so many problems due to change in shape of climate change, waste accumulation, ozone layer depletion, Global warming etc. The construction sector is consuming 40% of total energy(Yang Geng 2018)[1], natural resource and it helps to increase pollution level globally. In order to reduce the negative impacts on environment, Green building (sustainable building) began to develop, which can give better Indoor environmental Quality (IEQ) for occupants with less use of natural resources[1]. The construction industries has both direct and indirect impacts on climate change and the environment. Construction industries emits the green house gases approximate 23%. In india the urban population has grown at an annual growth rate of 1.15% between 2001 and 2011 from 27.4% to 30.9% (G.S.Vyas, 2018 et.al) [2].

Green building is one of the most important phenomenon across the world. It is the building industries responses to contemporary challenges such as natural resource depletion, pollution ,green house gas (GHG) emissions and human induced global warming. GB advocates going beyond the traditional building codes to improve overall building performance and minimize life cycle environmental impact and cost (I.M. Chethana S. Illankoon 2019 et.all) [3]. Many definitions can be found for green building and the commonly cited defini- tion is from the US Environmental Protection Agency. It indi- cates that green building is the practice of creating structures and using processes that are environmentally responsible and resource- efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruct- tion.(Chong Zang 2019)[4].

The green building has achieved tremendous development and thousand of building has been certified as "green" all over the world (Yang Geng 2018) [1]. For evaluation of green building standard , a number of rating system has been developed to improve the green building developments in many countries such as LEED (United state, since 1998)[5,6], BRE Environmental Assessment Method (BREEM, United Kingdom, since 1990), Compressive Assessment System for built environment Efficiency (CASBEE, Japan, since 2001)[7], Green Star(Australia, since 2003)[8] ,Green Mark Scheme (Singapore, since 2005)[9], IGBC Indian Green Building Council[10], GRIHA(Green Rating for Integrated Habitat Assessment,India)[11],ASGB (China, since 2006)[12].

2. Literature Review :

Implementation of GBRSs to achieve green buildings and compare the performance of Rated building into Non- rated Buildings:

The economic performance of green buildings compared to non- rated building is the main topic among the various dvelopers and investors . The cost benefit analysis of green buildings is widely conducted[13-14] . In Turkey, the payback period of two green buildings has done, certificated as "gold" and "platinum" in LEED –US respectively were assessed[13]. It represented that the construction cost of two buildings can be paid back in 0.41 and 2.56 years. A survey on 17 empirical studies has conducted to compare the cost of green building with non-rated building.[15]. It shows that the cost premiums of more than 90% of the reported green buildings fall ranges from −0.4% to 21%. The initial costs and payback periods of eleven green buildings certi- fied by two GBRSs of India (IGBC and GRIHA) are evaluated and compared with the non-rated buildings [16] . It shows that aver- age increase in initial cost of green buildings is 3.1% for three-star buildings and 9.37% for five-star buildings. The discounted payback period for green buildings is 2.04–7.56 years for three-star build- ings and 2.37–9.14 years for five-star buildings.

It is essential to conduct life cycle assessment and life cycle costing.this toolsare very important for tha developers,Investors,and occupants of buildings to make proper decisions. In Australian,Zoe et al. [17] has analyzed the development of life cycle assessment and life cycle costing of green buildings. The life cycle environmental impact of one green building situated in 400 locations worldwide is investigated by Al-Ghamdi and Bilec [18] . The results show considerable variations between sites in the U.S. and international locations. The indoor air quality (IAQ) of green buildings is also an in- dicator that should be taken into account in green buildings. The credit contribution of IAQ in green building certification is 7.5% on average and ranges from 3% to 11% [19,20] . The green buildings may have higher energy efficiency and sustainability, but the IAQ is not necessarily better, which affects the health and well-being of occupants. The IAQ in green buildings is investigated and compared with conventional buildings [6,21-22] . Majority of available measurements in green buildings shows that the IAQ perceived by occupants is improved.

Comparison between different GBRSs Studies on the comparison of different GBRSs can be classified into two groups:

to compare different GBRSs systematically and to compare the GBRSs on one or several specific aspects.

General comparison *of GBRSs.*

Five GBRSs (CASBEE-Japan, Green Star-Australia, BREEAM- UK, LEED-US and ITACA-Italy) are analyzed and compared in the study [23] to better understand the fundamental aspects related to sustainability assessment. Six new macro-aggregation areas (site, water, energy, comfort and safety, materials and outdoor quality) are defined and the credits of each GBRS are distributed after a normalization procedure. Results show that “Energy “is always the most important except for CASBEE-Japan. Overall,

“Water” has the lowest impact on the final scores, followed by “Materials”and “Outdoor quality”. Seven key credit criteria (Site, Energy, Water, Indoor Environment Quality, Material, Waste and Pollution and Management.) are established in [24] based on eight GBRSs (LEED-US, BREEAM-UK, Green Star-Australia, Green Mark- Singapore, BEAM Plus-Hong Kong, CASBEE-Japan, GBI-Malaysia and IGBC-India). These key credit criteria can be adopted as a baseline to develop new GBRSs and evaluate existing GBRSs. “Energy” has the highest consideration followed by ‘Water” and ‘Indoor Environment Quality’ respectively.

Despite green buildings potentials to achieve sustainable development, widespread adoption of green buildings still faces many obstacles, especially due its high initial construction cost (CC) (Rehm, 2013)[25]. Taemthong and chaissard (2019)[26] has conducted case study of a learning center in Thailand and found that green buildings with higher LEED and certified level had larger construction cost, the cost of green buildings at silver, gold, and platinum level were 0.23%, 1.21%, 6.62% higher than certified level respectively. Kats (2013) [27] has studied 170 buildings and confirmed that the median reduction in energy consumption was 34% compared with conventionally designed buildings. It was found that operation cost of buildings can decrease due to the use of energy efficient technologies and other green features that were invested in to the building particularly in the tropical region. A study on 83 green – retrofitted showed that it could save 40% of energy for 9air conditioning , resulting in about 16% reduction in electricity bills. Literature shows that it is difficult to conduct a life cycle cost(analysis)in the design , construction and operation of building.

3.METHODOLOGY :

1. LEED : The leadership in energy and environmental design (LEED) Green building rating system represents the U.S Green building council's effort to provide a national standard for what constitutes a green building. LEED india programmed has adopted from united states green building council's (IGBC) in India. IGBC has set up the LEED 2011 for India core committee with the objective of LEED rating system for the Indian context. LEED provides Guideline and specification for building construction to achieve its sustainability goals and objectives. LEED is similar to checklist of credits that can be achieved 7 major categories.

- Sustainable sites
- Water Efficiency
- Energy and Atmosphere
- Material and resources
- Indoor Environmental Quality
- Innovations and Design process
- Regional priority.

For making the building green, above criteria are very important as a design guideline for the building to achieve the certification from LEED. LEED evaluates a building for the amount of sustainability objective it achieves and recognizes building at four certification level (certified, silver, Gold, Platinum).

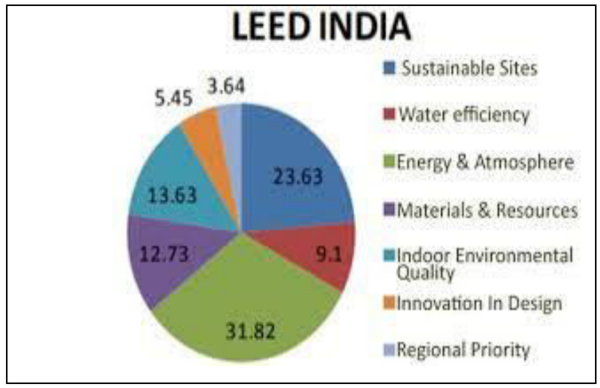

Fig.No.1

Under these categories credits are listed which are assigned with points that can be achieved by fulfilling the requirements of respective credits in a project. The total number of points achieved, irrespective of category, is thus counted as the final measure of degree of sustainability for projects. Depending on the count different, levels of certification are provided as follows:

Table- 1

POINTS ACHIEVED IN LEED V4 :

Certified	40-49
Silver	50-59
Gold	60-69
Platinum	80-110

IGBC Rating System :

Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) formed in the

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year 2001.The council is committee-based and consensus-focused. The council also closely works with several state governments, central government, World Green Building Council, bilateral multi-lateral agencies in promoting green building concepts in the country. The purpose of this rating system is to ensure that an existing or upcoming project should incorporate the finest green building practices that would ensure sustained savings and enhanced operation and processes. The vision of the council is, “To enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025.”

The IGBC defined an important development in the growth of green buildings with different credit systems to address individual aspects of different kind of the buildings and construction which include IGBC for New Buildings, Existing Buildings, Homes, Residential societies, Interior, Health care, Schools, Factory Buildings, Data Centre, Campus, Village, Township, Cities, Landscape, Affordable housing, Health and Well-being. All the IGBC rating system are voluntary, consensus based, market-driven building programme.

The main structure of IGBC rating system is divided in seven categories as listed below:

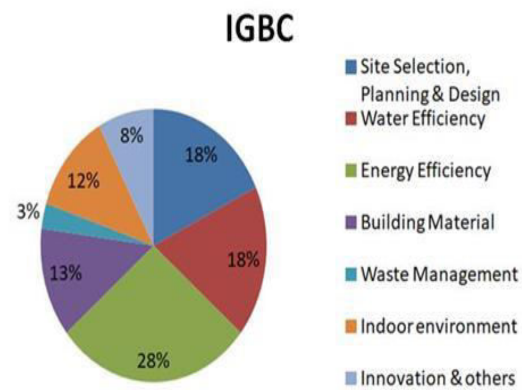

Fig.No.2

Under these categories credits are listed which are assigned with points that can be achieved by fulfilling the requirements of respective credits in a project. The total number of points achieved, irrespective of category, is thus counted as the final measure of degree of sustainability for projects. Depending on the count different, levels of certification are provided as follows:

Table- 2

IGBC POINTS CATEGORY

Certified	50-59
Silver	60-69
Gold	70-79
Platinum	80-89
Super platinum	90-100

GRIHA Rating System :

Green Rating for Integrated Habitat Assessment (GRIHA) is the national rating system of India. It has been envisioned by TERI (The Energy and Resources Institute) and built in cooperation with the Ministry of New and Renewable Energy, Government of India as of November 1 2007, GRIHA is a five star rating system for green buildings which emphasizes on the passive solar techniques for optimizing indoor visual and thermal comfort. GRIHA was developed as an indigenous building rating system, particularly to address and assess non-air conditioned or partially air conditioned buildings. It has been developed to rate commercial, institutional and residential buildings in India emphasizing national environmental concerns, regional climatic conditions, and indigenous solutions. In order to address energy efficiency, GRIHA encourages optimization of building design to reduce conventional energy demand and further optimize energy performance of the building within specified comfort limit. GRIHA integrates all relevant Indian codes and standards for buildings and act as a tool to facilitate implementation of the same.

Fig.No.3

Table-3

GRIHA CATEGORY POINTS

One star	50-60 points
Two star	61-70points
Three star	71-80points
Four star	81-90points
Five star	91-100 points and above

A COMPARATIVE ANALYSIS OF GREEN BUILDING RATING SYSTEMS

The primary three most prevailing rating systems were considered under study by using the thematic approach of the categorized criteria under each domain of the rating system. Despite each rating system has its goal to achieve sustainability and to create an environmental balance in the ecosystem but they largely differ with each other in their approach. The large number of difference can be explained in terms of data required in format as prescribed and pre-defined in rating system chosen. They composed of checklist of weather a credit or a pre-requisite is attempted to meet the compliance. This checklist contains more number of quantities that are optional in nature than the criteria carrying prerequisite intent. Although , there may be some criteria with some points in two or more rating system but looking from the construction point of view it may be weighted heavily thus making the rating process subjective and leading an open debate.

No.	CATEGORY	LEED	IGBC	GRIHA
	MANAGEMENT/SUSTAINABLE SITE			

a)	Site selection/Reuse of land/Reclaimed land/Sustainable construction	✓	✗	✓
b)	Preserve and protect the landscape during construction /Preserve topsoil /Existing vegetation	✓	✓	✓
c)	Soil conservation/Top soil laying & stabilization/Hard landscaping &boundary protection	✗	✓	✓
d)	Brownfield redevelopment	✓	✗	✗
e)	Design to include existing site features	✓	✗	✓
f)	Building & site operation & maintenance	✗	✓	✓
g)	Project management	✗	✓	✓
	ENERGY/ENERGY EFFICIENCY/ENERGY USE			
a)	Renewable energy utilization	✓	✓	✓
b)	Minimum energy performance/Optimize ozone depletion	✓	✓	✗
c)	Fundamental building commissioning/Measurement & verification/ Energy monitoring/metering & monitoring	✓	✓	✓
d)	Ozone depletion	✓	✓	✓
e)	Additional commissioning	✓	✓	✗
f)	Energy improvement/Green power	✓	✓	✓

	INDOOR ENVIRONMENTAL QUALITY			
a)	Optimize building design to reduce the conventional energy demand/Naturally ventilated design/Localized ventilation	✓	✗	✓
b)	Day lighting & views / Visual comfort / Day lighting / External views /Artificial lighting minimization / Interior lighting normally specified.	✓	✓	✓
c)	Reduced heat island effects/Thermal comfort/Thermal insulation/Thermal performance of building	✓	✗	✗
d)	Low emitting material/Indoor chemical and pollutant source control/CO2monitoring and control / Hazardous material / Indoor air pollutants/ETS control	✓	✓	✓
e)	Minimize ozone depleting substance/HCFC & CFC free HVAC/Low &	✓	✓	✓
	Zero carbon technology			
	Acceptable indoor & outdoor noise levels / Acoustic performance/Background noise	✗	✗	✓
	HEALTH & WELL BEING			
	Minimum level of sanitation/Safety facilities for construction workers	✗	✓	✓
	Reduce air pollution during construction	✓	✓	✓
	RECYCLE, RECHARGE & REUSE OF WATER			
	Water consumption/Water	✗	✓	✓

	monitoring/Watermeter/Water usage Monitoring			
	Waste Water Treatment	✓	✓	✓
	Water recycle & reuse	✗	✓	✓
	Minimize waste generation/Waste segregation/Storage & disposal/Recovery from waste	✗	✗	✓
	Innovative waste water technologies/ Storm water management / Water recycling effluent discharge to foul sever.	✓	✓	✓
	MATERIALS			
	Building reuse/Reuse of façade/Reuse of structure	✓	✗	✗
	Conservation and efficient utilization of resources	✓	✓	✓
	Utilization of fly ash in the building structure	✗	✗	✓
	Storage and collection of recyclables/Construction water management / Resource reuse / Recycled content / Construction waste management / Recycled aggregates / Recycled content of concrete / Recycled content of steel / Recycled content of reused products& materials	✓	✓	✓
	Use low energy materials in the interiors	✗	✗	✓
	Sustainable procurement/Recycling waste storage / Sustainable construction/Sustainable products / Adaptability & Deconstruction / Sustainable forest products / Waste recycling facilities / Waste management	✓	✓	✓

	Local or regional materials	✓	✓	✗
	TRANSPORTATION			
	Alternative transportation / Public transport accessibility / commuting mass transport / Green transport / Local transport / Vehicular access	✓	✓	✓
	Alternative transportation/Cyclist facilities	✓	✓	✗
	Alternative transportation / Travel plan / Fuel efficient transport	✓	✓	✗
	Pedestrian route/ Local transport	✓	✓	✓
	Proximity to amenities/ Neighborhood amenities/ Amenities features	✓	✓	✗
	INNOVATION			
	Innovation in design	✓	✓	✓

Life Cycle Cost Analysis in green building :

The LCC analysis approach was established in the 1960s and applied by the US Department of Defense.There is an international standard particularly designated for GB LCC analyses: ISO 15686-5:2017, 'Building and construction assets – service life planning –part 5: LCC standard'. The Australian National Audit office provides a five phase definition of building life cycle including design, purchase and construction, operation ,maintainance, development and disposal(I.M. Chethana S.Illankoon et. al 2019)[3]. The net present value NPV technique used to calculate the life cycle cost Eq.1 shows the formula for the NPV calculation.

$$NPV\ (i, N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

where i denotes the discount rate, t denotes the time of cash flow, Rt denotes the net cash flow, and N is the total number of periods. Maintenance costs and annual savings occur annually throughout the life cycle of a green building. Therefore, to calculate annual costs and savings the present value of annuity (PVA) formula is used. Equation (2) shows the formula for PVA calculation.

$$PVA = Rm \times \left(\frac{1-(1+i)^{-N}}{i}\right)$$

where i denotes the discount rate, Rm denotes the annual maintenance cost, and N is the total number of periods. The discount rate is established considering the time value of money and the associated risk. The minimum attractive rate of return is commonly used as the discount rate(I. M. Chethana S. Illankoon et.al 2019)[3]. Externalities and social benefits are not considered in LCC, as these costs and benefits fall under whole-life instead of LCC. The life cycle of a GB is normally set as 60 years. Initial costs are developed based on the first-cost principles. Maintenance data is obtained through industry norms and technical manuals.

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