"APPLICATION OF GREEN CONSTRUCTION TECHNOLOGY IN CONSTRUCTION PROJECTS"

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Under the supervision of

DR. ASHOK KUMAR GUPTA

(Head of the Civil Engineering Department)

By

SUMIT SIRKECK
(152603)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173 234

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CERTIFICATE

This is to certify that the work which is being presented in the thesis titled **"APPLICATION OF GREEN CONSTRUCTION TECHNOLOGY IN CONSTRUCTION PROJECTS"** in partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in "**CONSTRUCTION TECHNOLOGY AND MANAGEMENT** and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out By Sumit Sirkeck(Enrolment No. 152603)during a period from July 2016 to December 2016 under the supervision of **Dr. Ashok Kumar Gupta**, Head of the Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: - ……

Dr. Ashok Kumar Gupta **External Examiner**

Head of the Civil Engineering Department

JUIT Waknaghat

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ABSTRACT

With the Ascent in financial growth, there has been a significant development in the construction area bringing about a far reaching utilization of the common natural resources, which may be constrained. Additionally with the growing development in the infrastructure prerequisites for the improvement of urban areas, there has been a constant destruction in nature's domain. Hence, we are required to execute green building strategies for the advancement of technology without causing any harm to the natural environment. This might also promote certain advantages to the developers and the consumers. Increment in the cost of construction has been one of the major challenges in the execution of the green building procedures which has resulted to break off the project due to constraining cost, laborious deriving building materials, strenuous execution of technology and facilitators in the country like India. The advantages one could receive are corporeal and incorporeal benefits. The corporeal benefits result from the profitable money saving from the operations and decreased emission of carbon resulting in some credits and high cost of rentals or capital value. The incorporeal benefits come from the improvised working conditions inside the building. Non-sustainability discounts would become the primary source for the generation of revenues which would provide comparatively a higher rental value of the green building as compared to the conventional types of buildings in the area surrounding. Also credits received from decreased carbon and greenhouse gases emission would scale up the rental value which would benefit both the developer as well as the customer.

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Introduction of Green Buildings

1.1 Introduction

India has been presumed to produce about 110 million sq ft of green space in the upcoming years. This is a sign of a potential opportunity for both the developers and consumers to encourage green buildings construction. Also, it is essential to encourage the advantages of Green Buildings to society as this would enhance the awareness as well as scale up the requirement for Green Spaces in the market. This thesis follows the history of green building and its rating system. GRIHA rating system and the analysis made on the different criteria's under it.

The study involves understanding the actual costs in Green Building Project. The Study is done to analyse the tangible benefits one is entitled to get after implementation of Green Building Techniques based on case study of SJVLN Building, Shimla. The work involved is to quantify the cost incurred and benefits accrued by doing the Cost Benefit Analysis for the SJVLN Building, Shimla based on the assessment of the criteria's of GRIHA Rating System.

The Case being analysed is a Multi Dwelling Unit which is a GRIHA 3 star rated project. It consist a total built up area of **14033 sqm.** The analysis assumes a total lifespan of 30 years for the building. The operating and maintenance costs as well as annual benefits are assumed to be inflated at the rate of 5% every year. Year wise net benefit is taken and is discounted @ 12% to calculate the present value and by deducting the initial cost of we come to the Net Present Value of the building**.**

1.2 Introduction Green Buildings

The development sector presents a major threat to the environment. Buildings pose for a minimum of 40% of the used energy around the world. Buildings consume approximately 42% water and 50% of the raw material in their manufacture, construction, and period of operation are taken into consideration. In augmentation to this, building development exercises contribute around half of the world's air contamination, 42% of its nursery gasses generation, half of all water contamination, 48% of the strong squanders and half of the CFCs (chlorofluorocarbons) to nature.

The improvement zone postures natural difficulties in India as well. The entire developed region when added to business and home territories, it was just about forty. Eight million square meters in 2004–05 which roughly 1% of the normal floor region constructed every year around the globe. This swing suggests a regular boom of 10% over the approaching years. Constructing electricity consumption has extended from 14% to almost 33% from Nineteen Seventies to 2004–05 along with a sustained 8% growth in the every year power intake inside the residential and industrial regions. This intake of strength would continue growing unless appropriate movements are adopted to upgrade electricity performance without delay.

According to TERI estimates, there is a heightened requirement of about 5.4 billion kWh of power consistent with year to meet end-use need of electricity for residential and industrial homes. Buildings are dominant customers of water all through construction and operation. Water intake consistent with per capita in 1990 changed into 2464 m3 per capita per annum. However, by 2025, with a intended population of 1.four billion, it is likely to be less than 1700 m^3 per capita per annum. Data retrieved from the State Governments of India, as of March 2004 approximately ninety three% of city populace can get admission to ingesting water as suggested in terms of water availability. For instance, the poverty-stricken, especially the ones dwelling in run-down settlements, are normally denied from those simple privileges. Similarly, the problems concerning supply of water are crucial not just for the daily needs of drinking water but additionally for agricultural and associated activities. Even as we conflict with water shortage, the resource gap will be met via treating the waste water and reusing the identical for diverse purposes. As indicated by an assessment performed by the Central Pollution Control Board (CPCB) at the status of wastewater period and treatment in Class I urban areas and Class-II towns in the course 2003–04, around 26 254 million liters for every day (MLD) (9.51 billion cubic meter (BCM) was produced in 921 Class I urban communities and Class II urban areas in India (lodging over 70% of urban populace). The capacity for wastewater plant is to deliver around 7044 MLD which represents just 27% of waste water created in these two classes of urban focuses (2.57 BCM/year). Strong and municipal waste generated through the residents requires extreme management and attention. In keeping with the CPCB estimation, the cutting-edge quantum of strong waste production in India is 48 million tons in step with annum, out of which 25% of waste comes from production enterprise. This strong amount of waste poses a critical strain on solid waste management system. Additionally, approximately 42 million metric heaps (MMT) of solid waste are produced on every day foundation in the city regions of the USA. This occurs because of the insufficient isolation structures, terrible administrative aptitudes and poor cure offices for strong waste administration. Blended waste is being arranged into the pits or low lying territories which are available in and around the towns and is called as land filling. Civil strong waste comprises of around 30%-55% of bio-degradable (natural) squander, 20%-35% idle matter and 5%-15% recyclable matter. The natural substance of civil strong waste can be beneficially changed over into helpful items like fertilizer (likewise called as natural compost), methane gas, et cetera.

Ecological harm is the main sympathy toward us to determine as we advance through our improvement. It is fundamental for us to stop the demolition of the planet and direct important course adjustment methods to keep the harm the Mother Earth and who and what is to come. It has been built up that green structures give noteworthy potential to diminish the utilization and recover the reuses assets from waste and sustainable sources and help ensuring nature.

1.3 What Is Green Building?

Buildings have huge common impacts for the duration of their life. Assets comprehensive of ground cover, woods, water and quality are decreasing to give way to homes. Asset broad materials give structure to a building and arranging adding excellence to it, thus the

utilization of up water and pesticides to keep it. Progressed innovative controls adds insight to "lifeless" structures and this is a decent approach to react to changing conditions, and brilliantly screen and oversee valuable asset, assurance, and use of flame avoiding frameworks and diverse such structures inside the building. Water, which is a basic asset for the tenants, stays devoured ceaselessly all through building creation and operation. Numerous building approaches and occupant capabilities generate huge quantities of waste, which can be recycled for use or may be reused directly. Buildings are in like manner a standout amongst the most essential contaminations that influence urban air quality and add to climate trade. In this way, we have to lay out a green building development, the substance of which is to address a larger part of these issues in an included and logical way. It is a recognized truth that expenses of the plan will be costly contrasted with other ordinary structures. In any case, it's likewise a demonstrated reality that it costs considerably less to protect a green building that has splendid ecological points of interest and offers a higher area for the tenants to stay and work. In this way, the test of a green building is to accomplish all it's every one of its endowments effortlessly esteem.

A green building guarantees to exhaust the home grown assets to a negligible at some phase in its creation and operation. The reason for green building format is to restrain the request on non-sustainable resources, boost the use productivity of these benefits while being used, and amplify the reuse, reusing, and usage of inexhaustible resources. It expands the utilization of effective building materials and generation rehearses; upgrades utilizing nearby resources and sinks through bioclimatic engineering hones; makes utilization of insignificant vitality to power itself; makes utilization of green gadget to fulfill its lights, aerating and cooling, and diverse wishes; boosts utilizing sustainable resources of vitality; uses green waste and water administration practices; and gives casual and clean indoor working circumstances. It is advanced through a format framework that calls for contribution from all concerned – the draftsman; scene creator; and the ventilating, electrical, pipes, and power specialists – to artworks as a group to manage all components of building and machine making arrangements, outlining, generation, and operation. They fundamentally think about the impacts of every format choice and touch base at conceivable outline answers for breaking point the terrible effects and enhance the compelling impacts on the environment.

Figure 1: Construction of a Green building

1.4 Benefit of Green Building

A green building has brought down guide utilization in contrast with customary homes. The accompanying is the extent lessening of various resources in a building and their particular thought processes.

- Green structures devour 40%-60% less power when contrasted with ordinary structures. This is mostly on the grounds that they rely on upon latent compositional intercessions in the developing format, and over the top effectiveness materials and innovations in the designing format of the building.
- Green structures moreover endeavor to work toward on-site power era through sustainable power use to take into account its energy wishes. For instance, sun warm vitality can help create boiling point water and supplant the conventional electrical fountain in homes. Sun PV boards can help produce vitality which could lessen the structures reliance on lattice control.

- Green structures expend 40% to 80% lesser water when contrasted with regular structures. With the guide of utilizing to a great degree low-accept the way things are furniture, double pipes structures, squander water reusing structures and rain-water gathering, green structures no longer best decrease their interest for water utilize however also investigate site supply other options to take into account its inward and outside (scene) water requests.
- Green structures create lesser contaminations both over the span of generation notwithstanding while being used. Through tasteful practices comprehensive of right carport of generation materials, blockading of the site online to forestall air and commotion contamination all through creation, right stockpiling and transfer of waste all through creation and operation, et cetera, guarantees diminished effect on the encompassing condition.
- Green structures guarantee right security, wellbeing and sanitation places for the works (for the length of development) and the inhabitants (in the meantime as being used).
- Green structures restrain utilizing high ODP (ozone exhausting ability) substances in their structures notwithstanding in completions.
- Green structures give higher reducibility and attractiveness.

1.5 Green Building Scenarios in India

Begun in 2001, the Indian Green Building Council is the Indian section of the World Green Building Council.
India, the seventh biggest nation inside the world, might be a main economy and private to more than one billion people living in differed ecological condition zones. The nation's economy has been developing at a fast pace as far back as the technique for financial changes began in 1991. Development assumes a truly fundamental part in its economy tributary on a middle 6.5 %1 of the esteem. Modern and private areas still are a genuine commercial centre for the advancement exchange. The segments devour a lot of vitality for the duration of the life cycle of structures so changing into a genuine supporter of nursery outflow discharges.

Given the whorled urban development, the amount of structures, vitality utilization and furthermore the resultant carbon outflows is on an expansion inside the nation. According to the seventeenth electric power Survey (EPS) of the Central Electricity Authority, the power request is likely going to stretch out by thirty-nine.7% in 2011-12 when contrasted with 2006-07, by another forty three.7% in 2016-17 when contrasted with 2011-12 and by yet one more thirty seven.5% in 2021-22 when contrasted with 2016-17. With a near reliable V-day ascend in yearly vitality utilization inside the private and business segments; building vitality utilization has seen an expansion from 14 July inside the Nineteen Seventies to pretty much thirty third in 2004-05. Power use in each private and business part is essentially to light, range learning, refrigeration, apparatuses and water warming.

The country private part keeps on managing an account vigorously on antiquated non-business fills like fuel wood and compost. According to 2001 Census of Bharat, just 43.5% of rustic families have Associate in nursing power alliance and more than eighty fifth of charged country families utilize it for lighting reason exclusively. The urban part depends intensely on modern powers for its vitality wants. It's measurable that on middle amid a run of the mill modern working in Bharat, around hr of the entire power is devoured for lighting, thirty second for region securing, and less than V-day for refrigeration. While amid a run of the mill private working, around twenty eighth of the entire power is devoured for lighting, forty fifth for zone procurement, thirteen anticipates refrigeration, 4WD for TVs and 100% for various machines in urban area.

The normal power utilization for house learning and lighting in Republic of India is around 8 kWh/m2/annum and a hundred and sixty kWh/m2/annum for private and business structures severally. Underneath a Business as was normal (BAU) situation and bolstered a tenth yearly increment in new settled space, the anticipated yearly increment in power request in business and private structures would be five.4 billion kWh3.

Vitality utilization in Indian structures is expected to stretch out well inferable from financial development, development and human improvement. The interest for vitality to run apparatuses like TVs, air con and warming units, fridges and mobile chargers can build well as expectations for everyday comforts ascend in Asian nation. Moreover the development in business area and furthermore the move from country to urban authority record keep on requiring place. This can end in an extensive increment in resultant outflows from the structures segment alone and wish joint endeavours to cut down the vitality utilization by structures through differed measures.

The IPCC Fourth report furthermore emphasizes the necessity of bringing material endeavours to cut down carbon outflows from the structures part. In its relative investigation of the vitality funds capability of the building division therewith of option monetary areas, it's learned that the building part has the best potential among all segments, on the whole nations, and in any regard esteems levels. This is valid for Republic of India additionally given the high rate of development in industry. This review is so a convenient start amid this bearing to attract relate endorsing way to decrease carbon emanations from the structures part.

1.6 The Green Building Concept

The originations of green building are regularly replicated to the vitality (particularly fossil oil) emergency and in this manner the surroundings contamination worry inside the Seventies. The unpractised building development inside the U.S. begun from the need and need for a considerable measure of vitality temperate and earth benevolent development rehearses. There are unit assortments of thought processes in building unpractised, and in addition ecological, monetary, and social points of interest. In any case, stylish property activities require AN incorporated and synergistic style to each new development and inside

the retrofitting of existing structures. Additionally alluded to as feasible style, this approach coordinates the building life-cycle with each green practice apply utilized with an outline reason to make a characteristic procedure among the practices utilized.

Green building brings along a gigantic exhibit of practices, methods, and aptitudes to downsize and eventually dispense with the effects of structures on the setting and human wellbeing. It as a rule underlines exploiting inexhaustible assets, e.g., abuse sunlight through latent sun based, dynamic sun oriented, and electrical marvel instrumentality, and abuse plants and trees through Green rooftops, rain greenhouses, and decrease of rain keep running off. A few distinct systems square measure utilized, similar to abuse low-affect building materials or abuse pressed rock or permeable cement as opposed to run of the mill cement or black-top to lift recharging of spring water.

While the practices or technologies utilized in Green building area unit perpetually evolving and will disagree from region to region, basic principles persist from that the tactic is derived: Siting and Structure style potency, Energy potency, Water potency, Materials potency, Indoor Environmental Quality improvement, Operations and Maintenance optimisation, and Waste and Toxics Reduction. The essence of inexperienced building is associate degree optimisation of 1 or a lot of those principles. Also, with the right synergistic style, individual inexperienced building technologies may match along to supply a larger additive result.

On the tasteful feature of Green building plan or property style is that the rationality of concocting a building that is blended with the normal alternatives and assets close the situating. There are many key strides in thinking of property structures: indicate "green" building materials from local sources, downsize hundreds, enhance frameworks, and create on-the-spot sustainable power source.

1.7 Green Building Grading System

The grading system for green building is a guiding tool which calculates the performance of a building on the environment through its lifecycle. They contain of a distinct set of parameters which covers all the specification associated with the construction and operational system of a building. The points are awarded on the basis of fulfilment of the parameters. All the points are then summed up and the final rating value of the venture is determined.

Globally, the grading system for green buildings is of discretionary character and has proved immensely successful by creating recognition for designing the green building. Each criterion sets performance standards and measurable goals.

The green building rating system has been established successfully in India. It clearly indicates that India is following the global drift towards saving the environment. These rating mechanisms define the level of green techniques and measures adopted during construction to make buildings eco-friendly. After suitable weighting the points are assigned to the building and the rating is given to the building based on the total score.

Globally, the green rating system evolved as an important tool in making the building construction sector to adopt sustainable development and eco-friendly practices. It is a discretionary scheme which encourages the consumer interest of the market as well as consumer in green buildings. In many regions the green building schemes have preceded the local standard and thereby have helped in creating awareness towards more sustainable development.

These buildings consist a composite array of sustainability parameters related to use of broad variety of products and material use. This is a quick way to increase outreach in the market and helps in building a good support for the customer creating awareness in the society. The need for green building rating practice requires to be implied as a standard in building construction so as to have sustainable and eco-friendly development. But to achieve this it should be comprehend by architects, cost consultants, techno-managers, owners, and occupants of the building.

The developer gets the advantage of building reputation and rank in the market with such landmarks projects which gives good occupational health and comfort to the occupants along with giving increased environmental performance of buildings. It also gives cost savings in the long run which comes in the form of energy savings and increased productivity. Awareness among the consumer and client about green buildings and client will affect the real estate market by increasing demand for green rating buildings. The ratings will help the buyer in making a choice. It will encourage the need for buildings which are efficient and requires less usage of resources. This way we can bring a change in the society and can make a step towards sustainable development.

Globally, many rating system have been developed in different regions affecting the real building sector towards green and sustainable techniques. All these rating system have evolved in the world are based on local climates and geographical conditions. Commercial

spaces for corporate and large retail stores demands green spaces for healthy and productive atmosphere saving environmental. They want a system which is simple to understand and easy to implement.

1.8 Objectives of the Study

- The main aim of green techniques is to minimize the demand on non renewable resources, maximize the utilization efficiency of these resources when in use, and maximize the reuse, recycling and utilization of renewable resources.
- To study different types of green construction techniques with minimum five star GIRHA rating for SATLUJ JAL VIDUYT NIGAM limited proposes to construct its corporate headquarters.
- To do a case study on different types of green construction techniques used in SJVNL headquarters at SHANAN, MALYANA, SHIMLA
- To study about green building system the proposed complex is conceptualized based Teri GRIHA green building rating system.
- To study initial and life cycle cost of green techniques used in SJVNL HEADQUATERS AT SHANAN, MALAYANA ,SHIMLA
- To study initial cost and life cycle cost of project if green techniques are not provided at project, and compare both techniques which is beneficial.

Chapter-2

2.1 Literature Review

1. **Cost-effectiveness of Green Building value in comparison with the Conventional Buildings (KAPLOW, 2010):** This archive demonstrates that green building fetches lesser value in contrast to a traditional building. Regardless of open discernment of the contrary, today here will be no statistically potential distinction when the development costs of LEED and non LEED buildings are compared. When compared LEED buildings with non LEED buildings, the LEED buildings will source out to be potentially 33% more energy cost effective. The green building business has developed enough for us to state today that the hard data perceived from performance proves that when examining the initial costs of green building with direct energy savings, it costs less value when compared with conventional buildings.

2. **Achievement of Silver LEED: Preparatory Benefit-Cost Analysis for Two Cities of Seattle Facilities, SBW Consulting**. Sustainable Building Policy was adopted by the City of Seattle in 2000 that required the new city facilities to achieve a Silver LEED rating value. The report assesses the impacts of the maintainable building approach with respect to two projects named as 'the Seattle Justice Centre' and 'Marion Oliver McCaw Performance Hall' completed in early 2003. That incorporates enumerating the expenses as well as advantages of LEED Silver certification, figuring the life-cycle benefit-cost ratios for individual projects within data restrictions and giving promptly reaction on the impacts of the economical building approach.

3. **Cost-Benefit Analysis of LEED Silver Certification for New House Residence Hall, SANATH K KALIDAS, Christopher L Weber Fall 2004.**This report depicts the target for the Project for New House Residence Hall at Carnegie Mellon University with the choice to seek after LEED silver confirmed. The venture assessed and metered the conceptual interests to the college originating from the LEED Certification and the interests to the detainees of New House by means of a union of skilled information and perception. Accordingly of measurement, the advantages were classified into four sorts: casual training of the occupants of New House, advantages to the college because of presentation, development usage benefits, and direct understudy wellness and execution welfare. A fifth gathering of advantages- inward edification and nobility among understudies and staff of Carnegie Mellon, was included by two of the specialists.
   The key constituents of the examination incorporated the posting and numbering of the interests alongside further displaying of past work measuring the exceptional additional cost to develop a LEED-confirmed building. To acquire the points of interest required for examining the costs and interests to the college, enter leaders required in the venture were talked about. An online overview to get a direct understudy advantage was composed with both the past and current detainees to

collect their manner to support the interests of living in New House. Once the costs were produced, a plausible beneficial copy was made utilizing statistic demonstrating programming. It was found that the advantages of building New House green was much more than the costs and the present aggregate estimation of these advantages to the college is conceivably in the millions or considerably more.

4. **The Expenses and Financial Interests of Green Building - A Statement to California's Sustainable Building Task Force, Kats and Capital E (2003) studied the expenses and perks of Green Buildings in California.** This review utilized current information on the cash values and edges of Green Buildings recuperated from designers, and pros inside the building business. The building an incentive for thirty three LEED enrolled (25 work environment and eight school) structures were collected from engineers, predominant building staff, California's property Building Task Force individuals, USGBC representatives, individuals from Green Building Valuation conductive bunch.
   The information was gathered as for name of the venture, the area, and the building sort, consummation of information, green premium and level of confirmation. The structures which were uncertified by the USGBC, were given LEED level of accreditation by the designer or customer. The test pushed that the normal of the premium for every one of the 33 LEED-ensured green structures was under 2%. It likewise said that the premiums for the green structures raised in the vicinity of 2001 and 2002 are not exactly the premiums for green structures built from 2003 to 2004. Hence, there is a clue towards a distinction in venture involvement: the cost is more for the general population who are developing a Green Building surprisingly than for the individuals who are as of now experienced. The creators additionally assumed that the budgetary advantages of LEED-confirmed Green Buildings incorporates profitability and medical advantages expanding by 70%, operational and support costs bringing down by 16%, vitality investment funds expanding by 11%, discharges and wastage of water diminishing by 2% and 1% separately. (Kats and Capital E,2003).

5. **Costing Green: An Extensive Cost Data and Budgeting Technique, Lisa Fay MATTHIESSEN & Peter Morris** As a cost-consulting company, Davis Langdon scrutinizes the detailed costs for a number of projects each year. Each of these projects has important data that can be used to contrast buildings and help fixing costs for future buildings. Corporate understanding over the last thirty years includes judging work of thousands of projects on every continent (including Antarctica) One of the targets of David Langdon's research department has been to set up an internal intelligence database to act as a clearing house of financial data for all projects estimated within the offices of Davis Langdon. At the time of announcement, the database has information from about 600 distinct projects in 19 different states, including a variety of building types, location, sizes and programs. The number of building programs and locations represented will continue to increase as content from new projects is added to the database. This listing provides an opportunity to gauge a large number of projects across a spectrum of types of projects. We keep a track of

the construction expenses and design guidelines of all of our projects. This comprises quantity standards of the buildings, as well as clear-cut feasible measures and LEED points targeted, or achieved, by the building. We also keep a record of the details of cost and program data and design.

2.2 Summary of Literature Review

The literature review regarding construction charges, consumption of energy, and the analysis of the life period of green buildings as compared to the conventional buildings are summarized here. The capital for the construction of green building are found to be 2%- 3% more than that the conventional building. This slight increase is balanced by the long term benefits. The 30% discount in electricity consumption in conventional buildings, inside the shape of faded service and preservation expenses, consequences in long-term financial profits which might be approximately 10 instances greater than the initial investment over 20 years. Besides these direct benefits, green buildings create a healthful inner environment, hence enhancing the productiveness

Chapter-3

GRIHA INDIA (GREEN RATING FOR INTEGRATED HABITAT ASSESSMENT)

3.1 Introduction

GRIHA stands for 'Green Rating for Integrated Habitat Assessment'. It is derived from Sanskrit language which means home. The building interacts with the nature in a number of ways in their whole life cycle. The resources are consumed in the form of materials and product, water and energy etc. The wastes from these resources are generated in the form of municipal solid or particulate emissions.

It makes an effort to reduce consumption of resources, generation of waste and overall environmental impact of a building to certain established standard. It also measure features such as consumption of energy, generation of waste and energy etc. and then reduces them to minimum extent possible. It assesses the building performance against certain standard parameters which is used by people to compare buildings.

3.2 Evolution of GRIHA

Population of India is increasing at a rapid rate. There is an enormous demand for buildings due to economic growth and urbanization which has taken place in the past few years. But it generates a subsequent pressure on the availability of natural resources which are limited. Also there is another challenge coming due to the decrease in the water table which has gone down drastically in the past few years.

There is tremendous pressure over the environment because of the rising demand for resources. The pollution, global warming, greenhouse effect have caused rapid change in the climate over the past few years. So to address all these problems there is an urgent need to implement policies and regulatory system throughout the nation. The Central and State Ministries along with some agencies have formed organizations to give clearance for environment so as to make the process easy. Also our Prime Minister Mr NARENDRA MODI has helped the developers and investors by launching single window clearance for development projects. All these steps will help the project to get successful completion of the project within the estimated time and cost. Therefore reducing the time and cost overrun in the projects also we need to make sure that there is optimal utilization of resources in projects especially in large projects whose built up area is thought to be around 20,000 square meter or more. The building which are commercial and needs more than 100kW of energy for air conditioning purposes should be as per the standard specification prescribed in ECBC. Now days the government is giving subsidiaries to the people in order to promote use of renewable services like solar and wind energy.

However there is huge scope for the utilization of renewable sources of energy. We need to promote and encourage this on a global scale as it gives energy without causing damage to the environment. It has long life as well as negligible maintenance cost. The life of a solar panel is at least 25 years and it can effectively be used. Since there is less awareness about the advantages of the green building in the long run but is only avoided due to the high initial cost so there is an urgent need for making policies to encourage more holistic approach towards life-cycle of a building. For this we need to set specific set of specification and compliances which can be easily understood by the people and can be adopted easily.

We need to reduce the resource consumption and greenhouse gas emission so as to save environment. Also we need to encourage the recycling and reuse of the resources like water, waste and other materials in the building sector. TERI plays a vital role by taking essential initiatives so as to mainstream the sustainable development and its effective implementation in India. With more than twenty years of practice on the green techniques and energy efficient buildings, the GRIHA (Green Rating for Integrated Habitat Assessment) was developed and introduced by TERI in India. The Government of India adopted it as the green buildings rating system in 2007.

Worldwide the development of rating systems for green building has successfully created awareness and favoured to design buildings as green buildings. However, all these rating methods have been formulated in such a manner considering the climatic and other factors as per the region.. This mechanism give both the quantitative and qualitative assessment based on the criteria's to give rating to a building.

3.3 The Basic Features of GRIHA

The grading system of GRIHA is designed to analyse and evaluate new buildings. The analysis of a building is performed with respect to its expected execution throughout the life cycle time period i.e. from the initial phase to operation phase. On the basis of this three stages are there for analysis. They are:-

- Pre-construction stage: This includes intra-site issues and inter-site issues like geological conditions at the site, its location and the existing biodiversity prior to start of construction activity, the existing landscape, proximity to public transport etc).
- Construction and planning stages: (issues related to preservation of resources and to decrease their demand, optimum use of resources, health of the occupants. The major things which are included in this are air, energy, water and green coverage.
- Operation and maintenance stage: It consists of all things related to operation and maintenance of building.

3.4 The Benefits

The society will gain from the green techniques on a huge scale by conserving the natural resources and environment and thereby reducing the emissions of green house gases and consumption of energy.

The list below shows the benefits which we will get from green buildings:

- Reduction in consumption of energy and increased level of comfort.
- Less damage to flora and fauna, and prevention soil erosion etc.
- Decrease in water and air pollution (giving direct health benefits)
- Lesser consumption of water
- Less generation of waste due to reuse and recycle
- Higher working efficiency of the occupants.
- Increase in the reputation of the developer/owner.

GRIHA comprises of approximately 34 criteria under different segments for instance selection and planning of site, efficient utilization and conservation of material, performance and maintenance of building and other factors..

Points achieved	GRIHA Rating
50-60	★
61-70	★★
71-80	★★★
81-90	★★★★
91-100	★★★★★

There are total thirty four criteria's out of which eight are mandatory and the others are non-mandatory. Every criteria has some point associated with it based on which the score is calculated. It requires a score of at least 50 for qualification process. For a scoring above 50 points the rating ranges from 1-5 stars where each star carries 10 points.

3.5 Criteria Selection

The list below shows all the criteria's on the basis of which rating is given:

Criteria 1	Site Selection
Criteria 2	Preserve and protect landscape during construction
Criteria 3	Soil conservation (post construction)
Criteria 4	Design to include existing site features
Criteria 5	Reduce hard paving on site
Criteria 6	Enhance outdoor lighting system efficiency.
Criteria 7	Plan utilities efficiently and optimise on site circulation efficiency
Criteria 8	Minimum sanitation and safety facilities for construction workers
Criteria 9	Reduce air pollution during construction
Criteria 10	Reduce landscape water requirement
Criteria 11	Reduce building water use
Criteria 12	Efficient water use during construction
Criteria 13	Optimise building design to reduce conventional energy demand
Criteria 14	Optimise energy performance of building
Criteria 15	Utilization of flyash in building structure
Criteria 16	Adopt energy efficient technology in construction

Criteria 17	Use low-energy material in the interiors.
Criteria 18 & 19	Renewable energy utilization
Criteria 20	Waste water treatment
Criteria 21	Water recycle and reuse
Criteria 22	Reduction in waste during construction
Criteria 23	Efficient waste segregation
Criteria 24	Utilization of flyash in building structure
Criteria 25	Adopt energy efficient technology in construction
Criteria 26	Use of low-VOC (volatile organic compounds) paints/ adhesives / sealants.
Criteria 27	Minimize ozone – depleting substances
Criteria 28	Ensure water quality.
Criteria 29	Acceptable outdoor and indoor noise levels
Criteria 30	Tobacco and smoke control
Criteria 31	Provide the minimum level of accessibility for persons with disabilities.
Criteria 32	Energy audit and validation.
Criteria 33	O&M protocol for electrical and mechanical equipment

Abstract for rating criteria (Mandatory and optional clauses as decided by GRIHA rating system)

3.5.1 Criterion1–Site Selection

It is the first process and needs to be done appropriately for sustainable environment. It should be completed before the design phase. The proper analysis to be carried out so that the living spaces and the local environment are in harmony the natural surroundings of the site should not be damaged because of the development. In fact nature balance restoring should be done by improving surroundings.

3.5.2 Criterion 2 – Protection and conservation of the land at the time of construction.

Commitment: During the process of construction the landscape should be preserved and protected from degradation. For this the construction timing should be adequate, prevention of top soil erosion and conservation of growing plantation, staging and to prevent the contamination of onsite from spilling of contaminated material. REPLANTATION of trees is the ratio of 1:3 which were cut down due to construction process.

3.5.3 Criterion 3 – Conservation of soil

Commitment: top layer of soil should be conserved after the construction activity is over. It can be done by laying of adequate top soil. The process of soil stabilization can be used to prevent soil erosion so that the adequate fertility of the soil can be maintained.

3.5.4 Criterion 4 - Existing site features to be constituted in the design.

Commitment: Restoration and protection of natural features of the onsite with innovation in building design. The site layout should be done after conducting careful examination so as to meet the building requirements in order to ensure sustainable development of the site in time keeping its geological, climatic, and ecological characteristics intact.

3.5.5 Criterion 5 – Hard paved onsite area should be minimized.

Commitment: Minimizing the imperviousness of the site by reducing the hard pavement and/or providing shading covering on hard-paved areas in order to reduce the effect of heat from the island on site.

3.5.6 Criterion 6 – Enhancing the efficiency of outdoor lighting system.

Commitment: Reducing the conventional energy usage by using renewable sources of energy. It enhances energy efficiency of the building as well as gives savings in cost. It should meet minimum allowable luminous effect and should promote utilization of the renewable sources of energy.

3.5.7 Criterion 7 – Effective planning of utility and adequate on-site circulation efficiency.

Commitment: The roads and pedestrian should be of minimum area by effective planning and providing gross corridors for utility lines. There by reducing on site transportation thereby reducing pollution and minimizing energy usage by site utilities.
Well-being and healthiness during construction

Objective – Pollution control and protection of health of the workers.

3.5.8 Criterion 8 – The sanitary facilities should be available to the workers at the minimum level.

Commitment: Health and security of the workers should be considered as of prime importance during construction. Providing a minimum personnel protective equipment (PPE) to workers and adequate basic facilities like drinking water and sanitation. Proper housekeeping of the site should be done. Disposal of waste and effluent should be as per standard measures.

3.5.9 Criterion 9 – Air pollution should be decreased and controlled during construction.

Commitment: Construction site activities generate a lot of dust thereby significantly causing air pollution. All these can lead to respiratory and other health problems. Hence, air pollution should be minimized by the application of effective mitigation measurements during construction procedures. The aim of this activity is to potentially decrease air pollution caused due to on-going construction activities at the site. Make sure that proper prevention measures like screening, covering of stockpile material, and water sprinklers are used.

2. Planning of building construction stage and activities

Objective – This is to enhance the system efficiency along with conservation and optimal use of natural resources like water, energy, and other materials.
Water

3.5.10 Criterion 10 – This is to reduce water demand in the landscape:

Commitment: The water demand for landscape purpose should be reduced as far as possible. It will decrease the pressure on the municipal water supply and will also prevent exhaustion of groundwater. Native plant and trees can be used and lawn areas should be reduced. Modern techniques like sprinkler irrigation can be used to enhance irrigation efficiency.

3.5.11 Criterion 11 – Minimize the use of building water.

Commitment: Installing low-flow fixtures etc. to reduce water consumption in the building.

3.5.12 Criterion 12 – Effective use of water during construction.

Commitment: Utilization of potable water during construction activities should be reduced. For instance, recycled water can be used for curing purpose. Also the wastage of water during curing should be minimized. Materials like pre-mixed concrete can be used for preventing loss.

Energy: end use

3.5.13 Criterion 13 – Innovative building design which makes use of natural lightning and reduces the demand for conventional energy. Commitment: The natural day lighting can help in decreasing the demand of conventional measures of energy production for conditioning of space and lighting of buildings. Efficient planning is required to reflect climate responses. Using renewable energy sources such as solar and adopting a suitable range of air conditioning and day lighting for the building

3,5.14 Criterion 14 - Optimizing the building energy performance within specified comfort limits.

Commitment: The indoor climate conducive should be efficient so as to optimize the energy system in the building within a certain limit.. The energy consumption of the building should be reduced between 10 to 40 % than a conventional building

Energy: manifestation and construction

3.5.15 Criterion 15: Use of fly ash in the building construction.

Commitment: Fly ash is produced in industries and is considered as an industrial waste which has got properties similar to that of the cement and can be used as a construction material. Use of fly ash instead saves cost as well as saves as for production of 1 ton of cement 0.9 ton of carbon dioxide is produced. Fly ash can be used in bricks, with walls filled in with fly ashes and load bearing structures, mortar, as well as binders.

3.5.16 Criterion 16 –Using efficient and time savings technique to reduce volume, weight, and time of construction (e.g. pre-cast, RMC, admixtures etc.). Commitment: Making use of local material so as reduce transportation cost as well as savings in time and cost. Using eco-friendly, low energy material and technologies as far as possible.

3.5.17 Criterion 17 – Utilization of low-energy material in the construction of interiors

Commitment: More than 70% of the material used for interior finishes should be low-energy finishing materials/ products minimizing the use of a natural resource i.e. wood or utilizing the industrial waste materials. The numerous interior finishing objects used in the building serve to provide the credit which is further categorized into the following three principal categories. If any interior finished object does not fall into this classification and are acclaimed for credits the applicant needs to confirm the criteria of the credit.

1. Sub-assembly/internal partitions/interior wood finishes/ panelling/false ceiling/in-built furniture/ cabinetry
2. Flooring
3. Doors/windows and frames

Energy: renewable

3.5.18 Criterion 18 – Use of renewable energy resources.

Commitment: Minimum 10% of the general lighting load should come from renewable energy sources like solar energy, wind energy and, energy from biomass etc. All the energy calculation are based on realistic assumptions based on the requirements that are subjected to verification during appraisal. These renewable sources also reduces load coming on the conventional energy sources along with the savings in the cost.

3.5.19 Criterion 19 – Solar water heater system or Renewable Sources Heating System

Commitment: At least 50% of the annual energy obtained from these resources is required for heating water for different purposes such as in canteen for cooking, washing, and bath rooms/toilets, except for space heating which should come from renewable energy sources.

The 3 R's: Recycle, recharge, and reuse of water

Objective – Promotion of water recycling and reuse.

3.5.20 Criterion 20 – Waste water treatment process

Commitment: Installation of water treatment plant to have safe disposal of the waste water generated in the building and utilization of its by-products produced during the process.

3.5.21 Criterion 21 – Reuse and recycled waste water (including rainwater)

Commitment: On-site utilization of treated waste water by applying rainwater harvesting and using it for various applications as well as recharging groundwater to improvise the groundwater level.

Waste management

Objective –To reduce generation of waste, streamline segregation, storage, and its disposal.

3.5.22 Criterion 22 - Minimizing waste during construction

Commitment: Making sure that all the waste which is generated during construction is safely disposed thereby reducing landfill.

3.5.23 Criterion 23 – Segregation of waste efficiently

Commitment: Different coloured dustbins can be used to collect numerous types of waste materials from the building so as to segregate the wastes for effective recovery of the resources. It also promotes and creates awareness among people for waste segregation.

3.5.24 Criterion 24 - Storage and disposal of waste.

Commitment: Separate space should be allocated for the collected waste before sending it to recycle/disposal stations. This prevents the mixing of segregated waste before processing.

3.5.25 Criterion 25 - Resource recovery from waste.

Commitment: For biodegradable waste it is necessary to have resource recovery system as prescribed in the Solid Waste Management and handling Rules, 2000 of the MOEF. Local dealers should be contacted for waste recycling so as to maximize the source recovery from biodegradable and recyclable waste. It also reduces the prevalence of landfills.

Health and well-being during post-construction of the occupants

Objective – To provide healthy water and indoor air quality for occupants and keeping noise levels within the permissible limits. It reduces global warming.

3.5.26 Criterion 26 - Use of low-VOC (volatile organic compounds) paints/ adhesives / sealants

Commitment: Completing movement is a necessary piece of structures. This requires materials, for example, paints, sealants, and cements for the inside and in addition outside surfaces. Nonetheless, they are the potential supporters of the poor indoor air quality and can harmfully affect the soundness of the inhabitants. A wide assortment of volatiles is discharged because of oxidation of paints and glues which contains poisonous chemicals that gets discharged amid development and inhabitancy.

VOCs - particularly formaldehyde, urea formaldehyde, and urethanes - and other compound substances utilized as a part of the building materials which are harmful to wellbeing.

3.5.27 Criterion 27 - Substances causing depletion to ozone layer should be minimized.

Commitment: Use of ODP (ozone depletion potential) free insulation in the building. HVAC and refrigeration equipment's which are free from HCFC (hydro chlorofluorocarbon) and CFC (chlorofluorocarbon) should be use of HALON-free fire suppression and fire extinguishing systems. All these systems eliminate or control the release of ozone-depleting substance.

3.5.28 Criterion 28 - Ensure water quality.

Commitment: Make sure that the groundwater and municipal water meets the water quality norms as mentioned in the Indian Standards Code (Indian Standards for drinking [IS 10500-1991], irrigation applications [IS 11624-1986]. In case the water quality is not as per the norms, necessary treatment of raw water should be proposed so as to achieve the water quality as per the standard norms.

3.5.29 Criterion 29 - Acceptable outdoor and indoor noise levels

Commitment: Ensure that the open air clamour level adjusts to the Central Pollution Control Board–Environmental Standards–Noise (encompassing principles) and indoor commotion level fits in with the National Building Code of India, 2005, Bureau of Indian Standards 2005a, Part 8–Building Services; Section 4–Acoustics, sound protection, and clamour control.

3.5.30 Criterion 30 - Tobacco and smoke control.

Commitment: Providing separate ventilation for smoking rooms and for non-smokers zero exposure to tobacco smoke.

3.5.31 Criterion 31 - Minimum level of accessibility should be provided for persons with some physical disabilities.

Commitment: Make sure to provide accessibility facilities to employees, visitors, and clients with some physical disabilities.

3. Building Operation and Maintenance

Objective – Validate and maintain 'green' performance levels/adopt and propagate green practices and concepts.

3.5.32 Criterion 32 -Validation of energy audit

Commitment: The vitality review report ought to endorse by the inspectors of the Bureau of Energy Efficiency, Government of India.

3.5.33 Criterion 33 - Building operation and maintenance

Commitment: The operation and support of a green building is less when contrasted with a conventional building. For this we have to ensure that the agreement record contains a unique statement for the support of electrical and mechanical framework which is charged at the site by proprietor or provider. It should likewise be possible by giving office/benefit administration group, which will be in charge of the operation and support of all the electrical and mechanical frameworks after the appointing. For this the proprietor/manufacturer/benefit office administration group need to set up a completely reported manual of operations and upkeep, CD, sight and sound or a data handout posting the prescribed procedures/do's and don'ts/support prerequisites for the building. The names and addresses of the makers/providers ought to be specified for all the mechanical and electrical frameworks.

4. Innovation

3.5.34 Criterion 34 - Innovation points

Commitment: Under this criterion the applicants can apply for bonus points for any innovation in the building. Four points are available under the GRIHA rating system for adopting any criteria that enhances the green intent of a project. Some of them could be

- Environmental education
- Alternative transportation
- Company policy on green supply chain
- Lifecycle cost analysis
- Enhanced accessibility for physically/mentally challenged.
- Any other criteria proposed by the client

3.6 Evaluation System of GRIHA

GRIHA contains a 100-point system consisting of some core points, that ar obligatory to be met whereas the remainder ar non-mandatory or facultative points, which might be earned by obliging with the commitment of the criterion that the purpose is allotted.

Different levels of certification (one star to 5 stars) as awarded supported variety of points earned. The minimum points needed for certification is fifty. Buildings grading between 50–60 points, 61–70 points, 71–80 points, and 81–90 points can get one star, two stars, 3 stars, and 4 stars, severally. A building grading between 91–100 points can receive the utmost rating is that is 5 star rating.

Table 1. TABLE SHOWING CRITERIAS AND THEIR POINTS

S no	Description	Points	
Criterion 1	Site selection	1	Partly mandatory
Criterion 2	Preserve and protect landscape during construction/compensatory depository forestation	5	
Criterion 3	Soil conservation (post construction	2	
Criterion 4	Design to include existing site features	4	
Criterion 5	Reduce hard paving on site	2	Partly Mandatory
Criterion 6	Enhance outdoor lighting system efficiency	3	
Criterion 7	Plan utilities efficiently and optimize on-site circulation efficiency	3	
Criterion 8	Provide, at least, minimum level of sanitation/safety facilities for construction workers	2	Mandatory
Criterion 9	Reduce air pollution during construction	2	Mandatory
Criterion 10	Reduce landscape water requirement	3	
Criterion 11	Reduce building water use	2	
Criterion 12	Efficient water use during construction	1	
Criterion 13	Optimize building design to reduce conventional energy demand	8	Mandatory
Criterion 14	Optimize energy performance of building within specified comfort limits	16	Partly mandatory
Criterion 15	Utilization of fly-ash in building structure	6	
Criterion 16	Reduce volume, weight, and time of construction by adopting efficient technology	4	
Criterion 17	Use low-energy material in interiors	4	
Criterion 18	Renewable energy utilization	5	Partly mandatory
Criterion 19	Renewable energy based hot- water system	3	
Criterion 20	Waste water treatment	2	
Criterion 21	Water recycle and reuse (including rainwater)	5	
Criterion 22	Reduction in waste during construction	1	
Criterion 23	Efficient waste segregation	1	
Criterion 24	Storage and disposal of wastes	1	
Criterion 25	Resource recovery from waste	2	
Criterion 26	Use of low VOC paints/adhesives/sealants	3	
Criterion 27	Minimize ozone depleting substances	1	Mandatory
Criterion 28	Ensure water quality	2	Mandatory
Criterion 29	Acceptable outdoor and indoor noise levels	2	
Criterion 30	Tobacco and smoke control	1	Mandatory
Criterion 31	Universal accessibility	1	
Criterion 32	Energy audit and validation		Mandatory
Criterion 33	Operations and maintenance protocol for electrical and mechanical equipment	2	Mandatory
Criterion 34	Innovation (beyond 100)	4	

3.7 Understanding Green Building Costs

In order to successfully carry out the green building project, one need to understand the different types of expenses in relation to the building projects in general, and the ways in which the green buildings decreases the expenditure in the long term.

There are two separate and distinct ways to understand the "costs" of the project —

- **Environmental Costs**
- **Financial Costs**

3.7.1 Costs Associated With Environment

The setting value of a project refers to the imprint that the building project can leave on the environment, natural resources and therefore the individuals related to it and, eventually, addressing the building materials. The environmental value of the project is unsure in many ways that and could be a imprecise science, and it's positively not employment for under the building owner. It's the duty of the designer, the builder and therefore the builder's sub-contractors and vendor more over even so, it's the duty of the house owners to raise necessary queries and to lift the alertness for investment from project partners.

I. Origin of Products and Materials

What is the supply of the merchandise or materials employed in the development your building? What's the substance of that these materials area unit created (wood, stone, fibre, etc.)? Is that this material harvested, unearthed or derived in an exceedingly means that's viable, or in an exceedingly means that's harmful to the native setting, workers, the native population? What industrial processes, chemicals, or tools area unit employed in this derivation method and area unit they safe for employees and protecting of the environment?

Ii. Manufacturing of Products

The next set of queries to be addressed regarding the product's manufacture is wherever several of identical varieties of queries are applicable. Will the producing method contribute to pollution? However is that the pollution taken care of, and WHO is full of it? Will the producing method create health risks for staff or the encompassing public? However are these risks lowered? What quite waste is generated, and if it's toxic? However and wherever the scrap is disposed, and is that this worn out a secure, healthy way?

Iii. Comparison of Products and Materials

The third arrangement of inquiries focus on your utilization of the advancement materials or item utilized. What is the material's or item's capacity? Could that reason for existing be similarly served by alternate materials or item that has bring down "ecological" effects? Can misuse the item's utilization enhance or exacerbate your building's effect on the general population that can utilize it? Will its utilization enhances or decline your building's effect on your neighbours, your group, or your watershed - for instance, through rain keep running off that adds to local stream contamination, along these lines piercing the standard of drinking water)? Will its utilization enhance or intensify your building's warming effect?

Iv. Probable Lifespan of Products And Materials

This is an issue with various ramifications. On the off chance that the materials or item are ones that help you to downsize your vitality costs or your carbon impression, would they be able to keep going for an extended time? In the event that a few materials or items are less 2moderate - will you have the capacity to supplant these things inside the near future as choices wind up noticeably accessible? Earth sound item with long life expectancies help you downsize your building's ecological effect subsequently of you are doing occasionally got the opportunity to create additional material or vitality use for substitution capacities.

V. Disposal of Products And Materials

Another proposed question to be asked in this setting is the thing that happens to the development materials when they are discarded. At the point when these materials are no longer helpful, how and where would they be able to be reused or discarded? By what means will the transfer influence the earth and how poisonous will this transfer turn out to be?

Vi. Embedded Energy in Products And Materials

At last, the question you have to get some information about lessening the ―embedded vitality that you're building contains. ―Embedded vitality alludes to the vitality that is utilized as a part of the way toward removing, refining, fabricating and transporting your building materials. From a natural point of view the better the building the lower the installed vitality is of your building. Understanding the idea of installed vitality can help you to measure choices, for example, reusing wood from a structure which you are extending or remodelling as opposed to just discarding it.

3.7.2 Financial Costs

To comprehend the budgetary expenses of green building advances, items, and techniques, the strategy known as "life-cycle examination and appraisal" should be taken after. This strategy is especially significant to building materials, innovations and techniques that effect your building's utilization of vitality and water.

3.8 Life Cycle Analysis and Assessment

The idea is direct. The cost of any building has two parts – its underlying development/buy cost and its cost of on-going operation. These two costs joined together give the aggregate cost of a building. In the event that just a single of this cost is considered without the other will produce an inadequate photo of the genuine cost of any building.

In this way, similar reasons remain constant for individual segments of the building – particular materials and innovations. The interest in a specific green innovations or materials has two expenses - the underlying price tag and also the cost of operation. On the off chance that we are contrasting the expenses of customary and green building materials or innovations, it is imperative to get what their aggregate expenses will be over their lifetimes. On the off chance that you don't comprehend the life cycle expenses of the materials and advances that make up your building, you don't comprehend your building's actual cost.

3.9 Initial Costs

Starting Costs of the building is an extremely basic, which is the reason for the most part individuals neglect to investigate it effectively. Notwithstanding the price tag of a building material, one have to note that underlying expense likewise comprise cost of transport and establishment. Coordinated plan of the building is a critical approach to spare cash and fabricates green. It is basic to ensure your designer, specialists and developers/installers comprehend the incorporated outline, have involvement with it, and are ready and ready to converse with each other and remain in agreement.

3.10 On-Going Operational Costs

On-going operational costs are what we annually spend for the proper functioning of the building. There are instances wherein the initial investment would be around 10 – 18 % more for energy efficient systems in your building over conventional system. But also at the same

time, the annual saving you have is around 35 – 42 % in operations. This means the break-even would be achieved in 5 years' time and thus later on you would continue to save money

On that energy consumption and then free up funds for other purposes

The association needs to ponder what it might consider a satisfactory "break even" period of time to look upon what amount of "premium" you might be eager to disburse for the operational cost saving that the green building technologies frequently offer. A standout amongst religious associations has, in this regard, may be that as the owners as well as operators of their own spaces might be utilizing their spaces for a long time. Due to this, religious assemblies might responsibly accept a longer payback period over that 5-year period that is a relatable point for most of the development industry.

3.11 Analysis of the Life-Cycle and Calculation Of The Net Current Value

Analysis of life-cycle of the building is a crucial and concluding step for calculating the overall cost of construction of the building via different procedures. This helps in understanding the cost of the building either over its expected life time or over a fixed interval of time which is determined by an individual which is also regarded as "break even" date. This is significant in comparing and contrasting conventional buildings against the green building options.

An important fact about the analysis of Life Cycle is that it takes the form of a spread sheet giving any opportunity to list the items to be compared and contrasted (like energy monitors/regulators or waterless urinals, etc.). The spread sheet helps in comparing and contrasting different cost values for individual items, the cost of annual operating system or an annual savings from each item for a fixed number of years, and then allows calculating the net present value (NPV) for each and respective item. This calculation mentions an interest rate for an individual's investment which reflects the consequences of inflation on the cost of rupee.

3.12 Payback Analysis

It is used to determine the number of years in which the initial extra expenditures for different alternatives are paid back. The simple Payback period can be calculated by the following.

Simple Payback Period = Initial Cost / Annual Savings

In this analysis the time value of money and future benefits are ignored, which can produce misleading results. For Clients seeking rapid turnover of funds this increases desire to decrease the payback time. However, it is not necessary that a smaller payback period indicates the bet economic investment but an alternate payback period with longer period of time may be more profitable if it continues to give savings for a that period of time.

Chapter-4

Case Study on Cost and Benefit Analysis SJVLN

4.1 Introduction

The SATLUJ JAL VIDUYT NIGAM Ltd constructed its corporate headquarters and allied building at SANHAN-11 MALAYANA, SHIMLA. one of the unique GREEN BUILDING having a GRIHA of 3 stars. Thus SJVNL headquarters is one of the best offices in NORTH INDIA. The following features help SJVLN in making it a 3 star GRIHA rating. The design of the building and its environs reflects a lot about it and its space. Natural resources, habitat and landscape are proposed to be preserved and integrated in to overall design. The layout of building has been so designed to create an inviting green approach to the complex.

4.2 Silent Features of the Building

The project consists of following blocks.

1. Total Plot Area for the Building : 29835 m2
2. Total Built-up Area - 14033 m2
3. Office block: 6 levels
4. Guest house blocks -7storeyed
5. Parking /Auditorium-5 storied
6. Service Block-Single Storey
7. Green Coverage Area - 14829.94 m2

S.NO.	**BUILT UP AREA-FLOOR WISE**	**AREA**
1	Level 1	2494sqm
2	Level 2	2454sqm
3	Level 3	2279sqm
4	Level 4	2209sqm
5	Level 5	2073sqm
6	Level 6	2524sqm
	Total built up area	**14033sqm**

SJVNL Corporate Headquarters

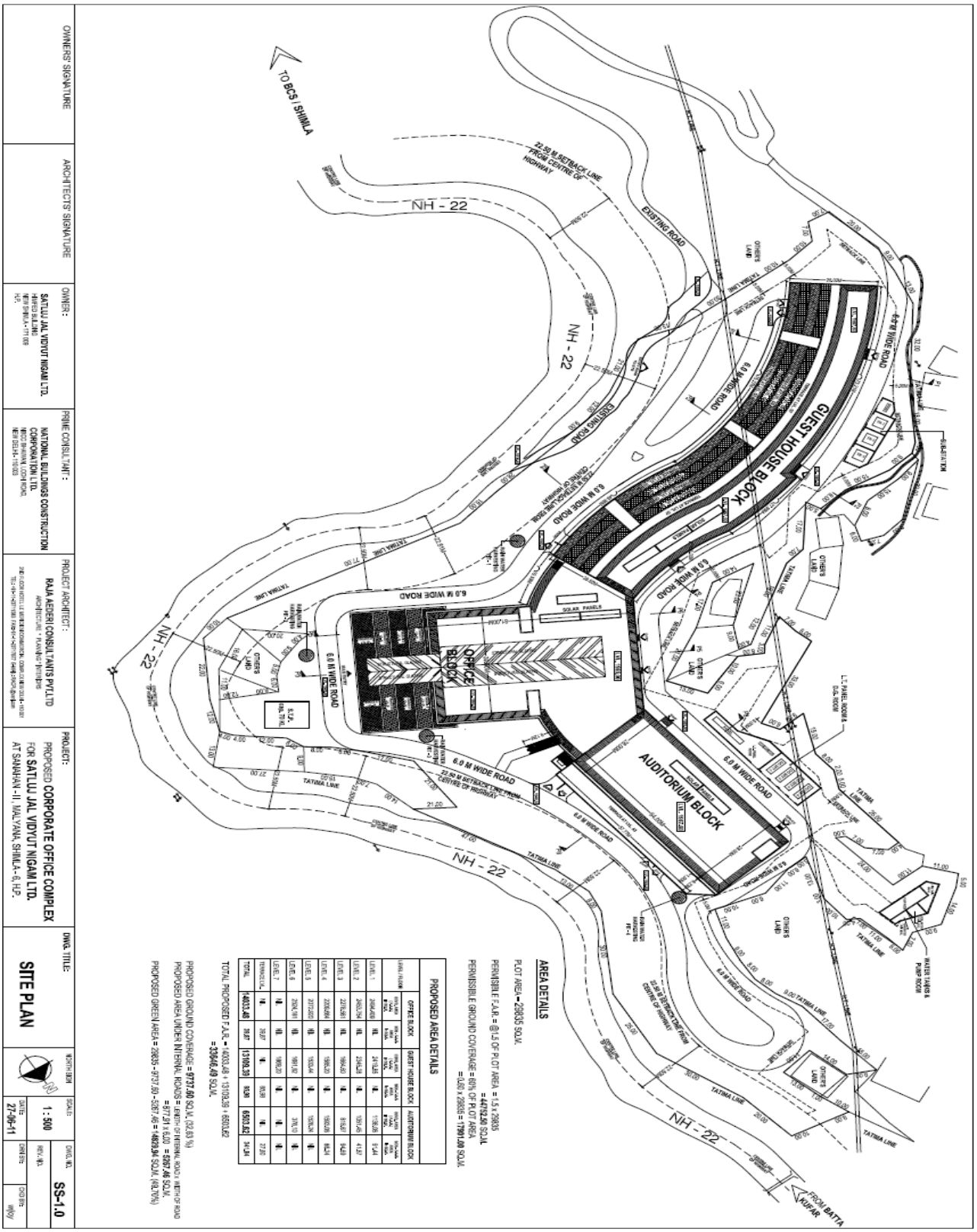

FIGURE 2: FEATURE MAKING SJVLN -3 STAR GRIHA RATING

4.3 Design, Site Planning and Construction

The complex has been designed and oriented to take the benefit of sun and the movement of wind to decrease the consumption of energy. It consist of a shading options to decrease the heat absorbed and yet gives natural lighting during the day. It gives an opportunity for architectural fenestration, elements and landscape. Each office space overlooks a naturally landscaped terrace at all levels.

4.4 Composition

The layout and building should be in a manner to decrease the estimated mass and people by careful representation and integration of landscape. The building also incorporates modification in horizontal and vertical plane to reduce the bulkiness of the structure. The structure has an articulated architectural treatment that creates façade of constant motion.

4.5 Active Frontage

The layout of the site and building seeks to give optimum standard of the complex. The spaces with exciting pedestrian spaces are to be used for the used for the inmates and visitors for a memorable stay in complex.

These spaces are as transparent as possible with least hindrance to inmates and visitors. Ground level spaces in the building house function with a high rate of people coming at places such as lounges, café, and gym and sports complex. Façade should face a plaza, lined with trees and in built street furniture suitable for complex.

4.6 Roof Forms

Roof forms of a building are frequently neglected aspects of architecture. The roof form integrates with landscaped development. Roof top equipment's are enclosed and concealed and the enclosures are formed as integral part of the structure. Building facade material is mainly responsible for maintaining the indoor daylight and aesthetic beauty of the building. Windows are inset in walls and fenestration to reduce direct ingress of harsh day light and weather.

4.7 Energy Savings

The utilization of renewable sources of energy and low energy lighting fixtures result into energy savings. SJVLN uses 40 No of Solar water heating system of 5000 LPD, Solar panel system 400 No of 250 w (Vikrant made) installed for energy savings in the building along with energy efficient and CFC free appliances used in all the building. Energy efficient HVAC system, access control system etc.

	CERTIFIED	SILVER	GOLD	AVERAGE
Energy Efficiency (Above Standard Code)	18%	30%	37%	28%
On Site Renewable Energy	0%	0%	4%	2%
Green Power	10%	0%	7%	6%
TOTAL	28%	30%	48%	36%

4.7.1 Water Savings

Water is essential for life. The groundwater table has gone down drastically in the recent years. So there is an urgent need to save water in the present world it is one of the most diminishing natural resource currently. So it will prevent damage to the environment along with creating awareness and promotion towards saving water. Treatment of grey water through water treatment plant Rain water harvesting which can be utilised for various uses along with ground water recharge. Around 30% to 50 % of water saving can be done with the help of these technologies.

SJVLN uses its own Water Treatment Plant (STP) with a capacity of 90 LPD for the treatment of grey water along with water efficient fixtures, proper landscape design along with proper plantation so that less water is utilised in its maintenance as well as the recycled water is utilised and reused again.

4.7.2 Waste Reduction

The strategies for decreasing waste involve recycling of waste and its reuse for making some products. For this different coloured bins should be used so as to separate disposable and plastic material. Also sewage treatment plant can be installed in the building to treat grey water and reusing that water for irrigation purpose for plants and landscape purpose. This will reduce the landfill coverage. Proper care should be taken during construction for waste

reduction such as demolition etc. Flexibility in design by using the wooden partitions etc all these can lead to reuse of about 50% - 75% of the waste generated during construction. This reuse could be up to 100% for renovated projects.

4.7.3 Lower O&M Cost

The green building uses resources efficiently and have lower operation and maintenance cost. The less O & M cost is due to the materials and products used at the site like renewable sources of energy –solar panels, solar cells, fixtures of high quality with low water flow and for electrical fixtures of low power but with good capacity which gives savings for a long period of time with a payback period of around 5years. Reduction in the cost increases the cost of the assets of the buildings.

The benefits of green techniques for Occupants are in many ways few of which are stated below as

4.7.4 Increased Worker Productivity:

The increase in productivity is a very important benefit of the Green Building Techniques implementation. In fact, this may represent up to 70 percent of all financial benefits. So if the increase is productivity is very effective in cost saving and contribute as a major portion of cost savings.

Therefore the importance of productivity in the overall benefit is 20 to sometime 100 times the savings in energy cost.

The various areas of worker productivity are as follows:

- Decreased in the absent and sick leaves of the employees.
- Improved Quality of Work Performed.

4.7.5 Financial Benefits in respect of savings generated every month

The Figure below shows the pie chart for percentage breakdown for financial benefits generated by Green Buildings for the Occupants.

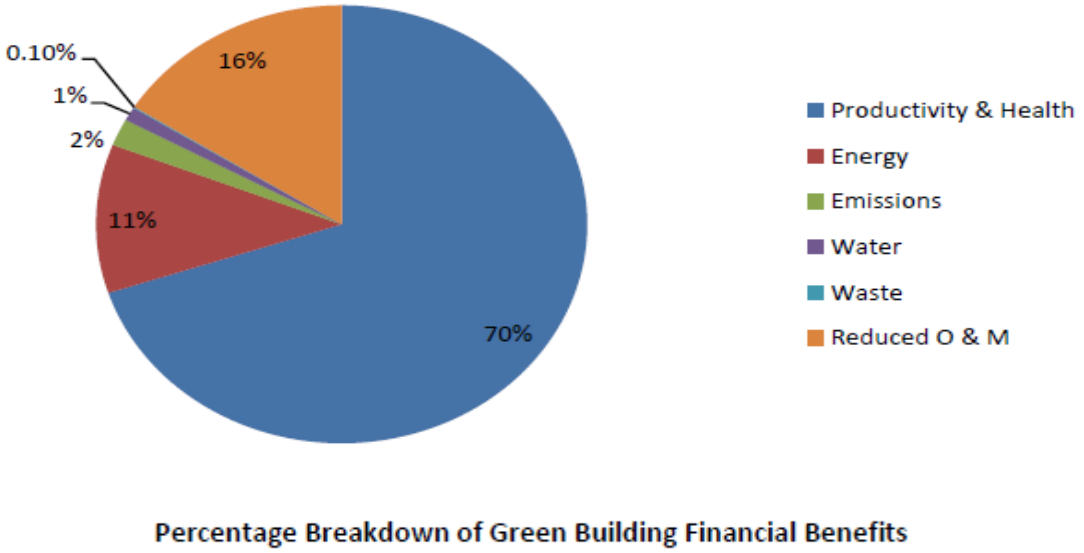

Figure 3: Percentage breakdown of Green Building financial benefits

4.8 Salient Features-SJVNL Building at Shanahan, SHIMLA

HVAC SYSTEM		
1	No. of heat pump	3 No's
2	Capacity and Make	139 TR(CLIMAVENETA)
3	No. of chillers	3 No's
4	Capacity and Make	125 TR(CLIMAVENETA)
5	AHU Units	Floor mounted 12 no's, ceiling suspended 8 nos.
6	LIFTS	2 No's
7	Capacity and Make	9 person (OTIS)
8	Escalators	8 no's
9	Make	OTIS
ELECTRICAL INSTALLATION		
1	D.G. set	2 No's
2	Make and Capacity	1010 KVA +500 KVA(Sudhir Make)
3	HT panel/VCB	11KV/.433KV(SCHNEIDER MAKE)
4	LT panel	44 Nos.-(SCHINEIDER/ABB)
5	Transformer	1 NO.1600KVA (Kirloskar Make)

SOLAR POWER GENERATION SYSTEM		
1	Solar Panel	400 Nos250W 9Vikram Solar)
2	Solar Water Heater	40 No's (5000)
WATER STORAGE TANK		
1	Capacity of main tank	Fire- 200 KL, Raw- 50 KL, Domestic -50KL
2	Overhead water tank at attic	Fire-20 KL, Raw -5KL,Domestic-5KL
3	Cafeteria with kitchen	1 No's
4	Multipurpose hall	1 No's
5	BOD Room	1 No's

6	Video Conference room	1 No’s
7	Conference room	2 No’s
8	Meeting room	6 No’s
SEWAGE TREATMENT PLANT(STP)		
1	Capacity	90KLD
WATER FIXTURES AND SANITATION		
1	Gents Toilets	57
2	Ladies Toilets	26
3	Handicapped Toilets	10
4	Urine stall	35
FIRE FIGHTING SYSTEM		
1	Smoke detectors	1251Nos
PUBLIC ADDRESS SYSTEM		
1	CCTV	83 No’s
ACCESS CONTROL SYSTEM		
PARKING		

4.9 SJVN Corporate Office SANAHAN Rating Points

GRIHA-(green rating integrated habitat assessment)

L SJVLN corporate headquarters office is 3-star rating and GRIHA point criteria is (71-80) points.

There are 34 criteria's for 5-star rating of green building.

SJVLN headquarters have achieved 12 criteria so it is GRIHA 3-star building.

The techniques that are used by SJVLN headquarters are:-

- Sewerage treatment plant
- Water treatment plant
- Space frame (glass structure –laminated toughened and colour is tinted blue and green)
- Wooden partition-(sound proofs and density 32 kg and glass wool)
- Glass partition-(toughened glass)
- Solar system-(solar panels, solar water heating system, hybrid panels-to light up street light poles)
- Water supply system
- HVAC and automation system
- Services-(sprinkler system, public address system, lighting and automation sensor)
- Smoke detector and building management system
- ACCESS control system
- Diffuser and exhaust GI-ducts
- Air scrubber and air washer

Chapter 5

Cost Benefit Analysis

5.1 Introduction:

It is an analysis which evaluates a plan or venture so that investors can make decision related to their investments. With this method the estimated cost of project is calculated and is compared to the benefits which will be coming from project. And in this both the cost and benefits are changed in terms of money and adjustment is done for the time value of money and the cash flows for a period of time are calculated from which the present value is determined. It is particularly designed for the purpose of practical decision making for investors, financers with major focus on the environmental and social impacts.

In this the cost is calculated on the basis of credits which incurs different nature of costs. In this cost analysis, only those credits are considered which involves initial cost and operating and maintenance cost incurred by adopting green technologies and features.

Certain credits involve no additional cost hence they are considered under the construction cost which is not the part of this analysis. Certain credits incur miscellaneous additional cost. Aggregation of all miscellaneous cost is considered as equal to 1% of total initial cost.

Cost Parameters:

The calculation of various cost incurred by considered credits are done above. Operating & maintenance cost is assumed to be incurred at the end of each year post occupancy.

Criteria	Module Name	Nature Of Cost	Calculation Cost	Final Cost in lacs
1.Site Selection & Planning	Natural Topography/Landscaping	Initial Cost	Plot Area: 29835 sqm Landscape Area: 14830 sqm Initial Plantation Cost: Rs 200 per sqm Total Initial Cost= 300X14830=29,66,000	29.66
		Operation and Management Cost	Landscape Area: 14830 sqm Annual O & M cost/sqm: Rs 20 per sqm Annual O & M cost=20X14830= 296,600	2.96
2.Water Efficiency	Sewage Treatment Plant & Water Treatment Plant	Initial Cost	Per Capita/ day Water Requirement: 135 litres Total Treated Water Generated / Day= 0.8X135X600 64.8 m3	35

			Initial Cost of Plant Capacity 90m3 = 35,00,000	
		Operation and Management Cost	At the rate of 25,000 per month	3
	Water Efficient Fixtures	Initial Cost	1. Flush Fixtures Total nos of flow fixtures=128 Extra Cost for 20% Efficiency=Rs 750 per fixture Initial Cost=128X400=96,000	0.96
			2. Flow Fixtures Lump Sum Cost For All Fixtures =96,000	0.96
3.Energy Efficieny	Energy Performance of Building	Initial Cost	Lump Sum Total Window Opening Area In Building =4000 sqm Cost / sqm= Rs 300 Initial Cost=300X4000=12,00,000	12
	Solar Water Heating System	Initial Cost	Cost of 5000 lpd solar water heater=Rs 300,000 Total Nos of Solar Water Heater= 40 Initial Cost=40X300000=1,20,00,000	102
	Solar System	Initial Cost	Cost of 1 solar panel 250 W=Rs 15,000 Total Nos of Solar Water Heater= 400 Initial Cost=40X300000=15000X400=Rs 60,00,000	60
	For Both Solar System and Solar Water Heaters	Operation and Management Cost	At the rate of Rs 1,000 per year	0.01
	Efficient Luminaries and Lightning Power (Automation Sensor,cctv, etc)	Initial Cost	Total built up area = 14033 sqm Total Cost @ Rs 200/sqm=250X14033 = 28,06,600	28.06
	Energy Saving Measures in Other Appliances	Initial Cost	Total built up area = 14033 sqm Total Cost @ Rs 10/sqm=10X14033 = 140,330	1.4

TABLE 4: Statement of Cost Parameter

Cost Calculations:

The initial cost of green technologies associated with considered credits. It also shows the operating & Maintenance cost incurred by customer at the end of each year. Every year this cost gets inflated by 5% till the end of 30th year.

Benefit Parameters:

The calculation of various benefit provided by implementation the credits.

Benefit Analysis:

Considered credits gives annual benefits in terms of saving in every years. Health & Environmental benefits are aggregated and measured in the terms of increase in productivity. This increase in productivity is then converted in the monetary saving per annum.

Criteria	Discription	Calcualtion of Benefits Cost	Initial Cost
1. Site Selection ,Planning & Material	Innovative design and glass to receive maximum sulight,site selection, use of green material etc.	Assuming a lumpsum cost of Rs 200 per day Annual Saving = 200X365= Rs 73,000	0.73
2.Water Efficiency	Treated Grey water	Total Water Treated Per Day =64.8 m3 Assuming Muncipal Water Charge per m3=Rs 4 =64.8 x 365x4 = Rs 94,608	0.946
	Water Saving due to Efficient Fixtures	Landscape Area =14830 m2 Water required if normal fixtures are used @ 3.67 lit/sqm/day Water required @ 2.5 litres/sqm/day Assuming Muncipal Water Charge per m3=Rs 4 Annual Savings=365X(3.67-2.5)X14830X.004 =Rs25,332.60	0.253
3. Energy Efficiency	Solar Water Heating System	Electricity units saved by 1 solar water heater (5000LPD)/year =15000 Electric charges/unit = Rs.6 Total No. of Soalr Water Heater =40 Total Annual Saving = 6 x 12000 x 40 = 28.8 lacs	28.8
	Solar Panel System	Electricity units saved by Solar Panel System (250W;400 Nos) =100KW Electric charges/unit = Rs.6 Total Annual Saving = 6x100x365 = 2.19 lacs	2.19

	CFC Free Equipments	Total Built –up area =14033 m2 Annual Benefits @ Rs.50/m2 Annual Savings= 14033X50=Rs 7,01,650	7.01
	Efficient Luminaries	Total Built –up area for all flats=14033 m2	4.2
	& Lighting Power density	Annual Benefits @ Rs.30/m2 Annual Savings= 30X14033= Rs 4,20,990	
	Energy Saving Measures in other appliances & equipment	Total Built –up area for all flats=14033 m2 Annual Benefits @ Rs.30/m2 Total Annual Savings= 30X14033= Rs 4,20,990	4.2
Health & Environment Benefit	Increase in Productivity	**For Individual at Work** Increase In Productivity in min/day=5 minutes Assuming 25 working days per month so increase in year= 25X5X12=1500 minutes Assuming 8 working hours in a day; increase in productivity in days/year =1500/(60X8)=3.125 Assuming average income as 5 lacs p.a. & 300 working hours per year,per day income= 5 lacs/300= 0.0167 lacs Assuming 600 people working total increase in income/year= 0.0167X600X3.125=31.3125 lacs	31.312

Table 5: Statement of Benefit Parameters

Benefit Calculations:

Occupants will get certain annual benefits when they will be utilizing the installed green technologies, once they occupy the building. This annual benefit gets inflated by 5% till the end of 30th year. Table shows the annual benefit.

Net Benefit:

There will be year wise operation cost which is the summation of all operating costs incurred in different credits in that particular year. There is also year wise benefit which is summation of all benefits occurred in different credits in that particular year.

Table shows the net benefit cash flow. The following are the components of table

Cost:

Cost contains initial cost which is Rs. 272.74 lacs as an upfront cost and Operation & maintenance cost for 30 year by considering the inflation of 5%. The values are taken from table of cost calculations.

Benefit:

These are the year wise benefits occurred from implementation of various credits. Inflation of 5% is taken to compute the benefits for successive years. The values are taken from table of benefit calculations.

Net benefit:

This is the year wise difference between cost and benefits.

Present Value (PV):

PV is calculated by discounting the future cash flows. Following equation is used for calculation of PV.

$PV = \Sigma \{C_n/ (1+ R)_n \}$

Where, n= year number (i.e. 1, 2, 3.....20)

C_n = net cash flow at the end of year n (in our case it is annual benefit),

R = Discount rate (in our case R= 12%)

Using this, PV for considered project is Rs. 900.62 lacs

Net Present Value (NPV): NPV is measured as follows,

• NPV = PV – Initial cost = 900.62 – 272.74 = 627.88 lacs

• Hence NPV of entire project is Rs. 627.88 lacs.

• Total built up area of a project = 14033 sqm.

• Hence NPV per sqm = (827.88 x 10^5) ÷ 14033 = Rs. 4,474.31

5.2 Payback Analysis

It is gives the number of years in which the initial extra expenditures for different alternatives are paid back. The simple Payback period can be calculated by the following.

Simple Payback Period = Initial Cost / Annual Savings

= 272.74/79.64

= **3.42 Years**

Conclusion

Notwithstanding the specialized perspective, there is a point of view from monetary execution. As attention to natural maintainability furthermore, vitality productivity is turning far reaching, there's additionally a matter of rate of profitability. As power rates run higher alongside costs for flammable gas, the expenses to warmth and cool structures are relied upon to increment bit by bit. Structures that utilize creative, vitality productive materials help inhabitants battle with heightening service bills to advance the utilization of vitality proficient and supportable materials that prompt less power and water utilization.

By and large, the development business devours 40% of the aggregate vitality and around one-portion of the world's real assets. Consequently, it is basic to direct the utilization of green materials and less vitality utilization in development industry. Economical use of assets assumes a critical part in the advancement of economic development. Be that as it may, unless the methods for making these green structures reasonable for the average folks are created, we can't achieve full maintainability. A genuinely green building ought to be vitality productive, fuse solid that contains minimal measure of Portland bond, also, utilize substantial volumes of supplementary cementitious materials and reused concrete. To actualize the manageability and imaginative framework innovation, green building in the end requires the change of green solid innovation into development destinations

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