LIFE CYCLE COST ANALYSIS OF NORMAL BUILDING AND GREEN BUILDING

A Thesis

submitted in fulfillment of the requirements for the Degree

of

MASTER OF TECHNOLOGY
IN
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With specialization in

CONSTRUCTION MANAGEMENT

Under the supervision of

Dr. ASHOK KUMAR GUPTA

Professor and Head

by

SUMANT NEGI
(162607)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
WAKNAGHAT, SOLAN – 173 234
HIMACHAL PRADESH, INDIA

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CERTIFICATE

This is to certify that the work which is being presented in the project title **"study on life cycle cost analysis of normal building and green building"** in partial fulfillment of the requirements for the award of the degree of Master of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Sumant Negi** during a period from August 2017 to May 2018 under the supervision of **Dr. Ashok Kumar Gupta** Professor & Head, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

Date: -

Dr. Ashok Kumar Gupta
Professor& Head of Department
Department of Civil Engineering
JUIT Waknaghat

External Examiner

ABSTRACT

Life cycle cost analysis of any building is defined as the total costs involved in entire life span of a building. In this project we compare the life cycle cost analysis of normal residential building with life cycle cost analysis of green building. Life cycle cost involves acquisition cost, construction cost, operational and maintenance cost, demolition and disposal cost and salvage value of building after the service life of 30 years. In this project we have done life cycle cost analysis of SJVNL office Shanahan Shimla H.P. which is green certified building which gets 70-80 points as per GRIHA rating of green building. This green building is rated as three star green building as per GRIHA rating. After analyzing this we made a model of normal residential building having same area as green building. Then life cycle cost analysis of normal building has been calculated. In this project we used REVIT software for the estimation of constructional cost of a building. Then we compared all costs analyzed from the life cycle cost analysis of both the buildings, from this we found that the initial cost of green building is more than the cost of normal building and initial costs involves acquisition cost and development cost. This is because of green techniques used at the time of construction. But operational and maintenance cost of green building is less than the cost of normal residential building this is because of techniques used in the green building are energy efficient that saves annual bill of electricity, water charges and repair charges of building. Major and minor repairs of green building are also less as compared to the repair cost of normal residential building. Salvage value of the green building is large as compared to the normal building after its service life of 30 years. This is because the material and techniques used in green building have large resale value. So, the actual life cycle cost of both the buildings can be determined by subtracting total salvage value of building from the total cost (acquisition cost, construction cost, operational and maintenance cost and demolition and disposal cost) of building.

Key Words: LCCA, GRIHA, LEED, Green Building and Normal Building.

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Sumant Negi

162607

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LIST OF SYMBOLS

LCCA	LIFE CYCLE COST ANALYSIS
LEED	LEADERSHIP IN ENERDY AND ENVIRONMENTAL DESIGN
GRIHA	GREEN RATING INTEGRATED HABITAT ASSESMENT
IGBC	INDIAN GREEN BUILDING COUNCIL
BEE	BUREAU OF ENERGY EFFICIENCY

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

There are a large group of techniques right now being used in construction and advancement project examination around the globe. The motivation behind these techniques is to gauge the general total expenses of an project , whether with regards to comparing options or encouraging determination and design that guarantees the project facilitate will give the best an incentive at the most minimal general life cycle cost or cost of possession. At last, one can build up the lifetime spending plan for a structure that is reliable with the building's quality and additionally its proposed work. The estimations associated with recognizing this financial plan ought to be executed as right on time as conceivable in the outline procedure - enabling groups to tweak the outline to secure a huge lessening in life cycle costs.

Each life cycle cost examination should incorporate figuring for the numerous different expenses related with the securing, operation, maintenance, and discarding a building or complex of structures. Building-related expenses for the most part fall into these classifications:

- Introductory Costs: Acquisition and Construction
- Fuel and energy
- Support, Operation, and Repair
- Substitution of Components and Materials
- Residual Value: Resale, Salvage, or Disposal
- Financing Costs: Loan Payments
- Non-Monetary Costs and advantages

The total cost of obligation regarding asset is habitually significantly more noteworthy as compared to hidden capital cost and can shift essentially between different elective answers

for a given operational need. Thought of the costs over the whole presence of favorable position gives a sound introduce to fundamental authority. According to this information, it is possible to:

- Evaluate future assets prerequisites (by projections of foreseen organized detail costs for applicable assets)
- Evaluate relative expenses of potential acquisitions (speculation assessment or evaluation)
- Settle on wellsprings of supply (asset decision)
- Account for assets used presently or previously (revealing and examining)
- Enhance structure design (through upgraded appreciation of information design, for instance, work and uses over the typical life cycle).
- Improve operational and maintenance bolster (through additional detailed comprehensive of information prerequisites over the normal life cycle.
- Survey when assets accomplish the finish of their financial life and if reestablishment is required (through appreciation of changes in input prerequisites, for instance, work, chemicals, and utilities as the preferred standpoint ages)

The Life Cycle Costing technique could be as fundamental according to table of expected yearly costs or it could be an complex show that takes into consideration the production of situations in view of suspicions about future cost drivers. The degree and unpredictability of the life cycle cost examination ought to be and vast mirror the multifaceted nature of the preferences under investigation, the ability to suspect future costs and the importance without limits cost to be the decision being made by the affiliation. This undertaking is about a relative life cycle cost investigation of green building and a typical working over a time of 30 years to locate their financial feasibility.

1.2 NEED OF THE STUDY

Is it accurate to state that we are careful that our offices or residential structure could be hurting our environment? Is this possible that our structures are retching unsafe toxins without we examine that? We are more mindful about different natural issues, for example, an Earth-wide temperature boost, water and air contamination and the measures

that should be taken to anticipate them. On the off chance that we change to manageable engineering and green structures in India, not only for nature's purpose, but rather for ourselves, we couldn't just spare the earth yet additionally decrease our total ownership costs.

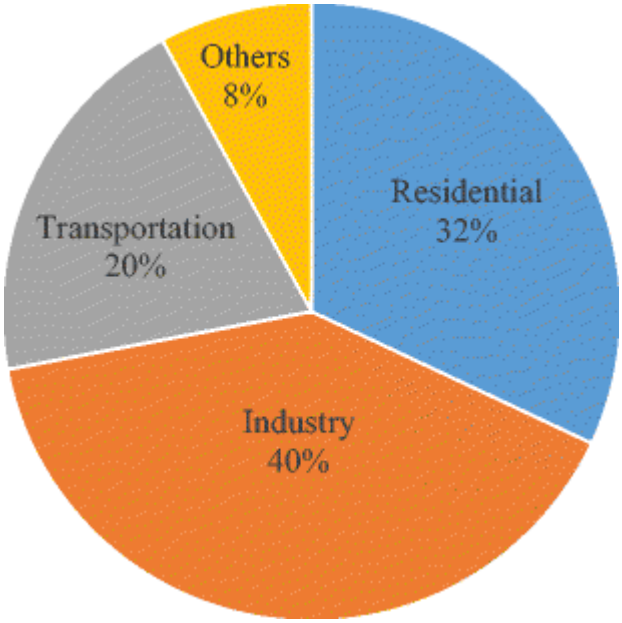


Figure 1.2.1 Energy consumptions in various sectors

The building development industry delivers the second biggest measure of demolition waste and ozone harming substances (35-40%). The real utilization of energy in structures is amid development and later in lighting or aerating and cooling frameworks. While, different civilities like lighting, aerating and cooling, water warming give comfort to building inhabitants, yet consume enormous amount of energy and add to contamination. Further, inhabitant exercises create extensive measure of solid and water waste too.

Practical engineering is the kind of design that tries to limit the destructive effect that structures have on the earth. Such reasonably constructed green structures are ecologically dependable and asset productive, appropriate from area determination to the obliteration after its life cycle closes. A green building utilizes less energy, water and other

common assets makes less waste and greenhouse gases and is healthy for individuals living or working inside when contrasted with a normal structure.

Building green isn't about somewhat more effectiveness. It is tied in with making structures that optimize on the utilization of nearby materials, neighborhood nature and in particular they are worked to decrease power, water and material requirement. In this manner, if these things are remembered, at that point we will understand that our conventional design was truth is told, extremely green. As per TERI gauges, if all structures in Indian urban territories were made to receive green building ideas, India could spare in excess of 8,400 megawatts of energy, which is sufficient to light 550,000 homes every year.

1.3 COSTS INVOLVES IN LIFE CYCLE OF BUILDING

There are various expenses related with gaining, working, keeping up, and discarding a building or building framework. Building-related expenses more often than not fall into the accompanying classes:

Land acquisition costs

Land procurement in India refers to the procedure by which the association or a state government in India obtains private land with the end goal of industrialization, advancement of infrastructural offices or urbanization of the private land, and gives compensation to the influenced land owner and their recovery and resettlement

Construction costs:

Cost acquired by a contractual worker for work, material, equipment, financing, administrations, utilities, and so on, in addition to overheads and contractor benefit. Costs, for example, that of land, structural outline, advisor and architect's charge are not development costs.

Energy and Water Costs:

Energy and water are complicatedly associated. All wellsprings of energy (counting power) require water in their creation forms: the extraction of crude materials, cooling warm procedures, in cleaning forms, development of harvests for biofuels, and controlling turbines. Energy is itself required to make water assets accessible for human utilize and utilization (counting water system) through pumping, transportation, treatment, and

desalination. Water and energy issues are associated with each other such that, disregarding some halfway and here and now achievement, fractional reactions will undoubtedly flop in the long haul. Reactions to both water and energy challenges should be composed into a fundamental reaction. Arrangements won't not comprise of elevating options proposed to deal with the vitality issues to the detriment of disturbing water shortage, enhancing access to water to the detriment of irritating energy issues or, far more terrible, elevating options endeavoring to enhance access to water and energy to the detriment of nature.

Energy utilization:

Measure of the aggregate vitality devoured in cooling or warming of a building or office in a period, communicated as British warm unit (Btu) per (cooled or warmed) net square foot.

Energy costs:

Monetary and non-money related costs, (for example, the natural effect) related with the generation, transmission, and utilization of energy.

Energy cost projections:

As in past augmentations of the World Economic Outlook (WEO), normal and-client process for oil, gas and coal are gotten from expected value inclines on discount or mass markets. Assessment rates are expected to stay unchangeable over the projection time frame. Last electricity costs depend on minor power age costs.

Water Costs:

Water valuing is a term that spreads different procedures to allot a cost to water. These procedures vary significantly under various conditions:

1. Bottle Water

Costs for filtered water are set in the market, yet should be seen not as much as a cost of water, than the cost of the comfort, container and transportation. It is equivalent to other packaged modest drinks (soda, beer,). Retail costs change broadly between nations, brands, bottle sizes (0.33 liter to 20 liters) and place of offer (grocery store, reasonable, eatery and so on.). They go from US$ 0.05 to US$6 per liter, comparable to US$ 50 to US$ 6,000 for each cubic meter. 1 liter costs 40 rupee.

2. Tanker Truck

Costs for water sold by tanker trucks in mass, which is normal in urban areas of some creating nations for family units without access to channeled water supply, are set in the

market. Costs for trucked water shift between about US$1 and US$6 per cubic meter.

3. Utility Tariffs

Costs for piped water supply gave by utilities, be they freely or secretly oversaw, are resolved authoritatively (see water levies). They differ from US$ 0.01 to nearly US$ 8 for every cubic meter (counting sewer duties).

4. Irrigation

Costs for irrigation water that is being given by an open office are additionally regularly decided officially, more often than not utilizing a level rate, since metering isn't basic in agriculture in many nations of the world.

The accompanying valuing frameworks exist for water system

- Zone based taxes, here and there separated by sort of product developed
- Volumetric valuing, which requires estimation

Taxes can be paid as work, which holds for the most part in collective sorts of administration in customary water system frameworks, or in real money. Levies can likewise change between seasons, with higher duties charged amid the dry season.

5. Direct Abstraction

In many nations there is no charge for abstracting water straightforwardly from streams, lakes and aquifers. In any case, a few nations do demand volumetric charges or expenses for water reflection rights. These charges are commonly exacted on ventures, utilities and agriculturists. Charges for water deliberation and release exist for instance in France, where incomes are huge and are re-put resources into the water segment by water organizations built up in real bowls. In Germany reflection charges exist just for groundwater and just in a few states, and their returns go into the general state spending plan. Mexico likewise charges for water reflection and returns continue to utilities, however not to businesses. Outside the OECD nations couple of nations charge water reflection expenses. Where they are connected the level of charges has a tendency to be ostensible, for example, in Morocco, or implementation is fractional, for example, for groundwater deliberation expenses in Jordan. In all nations that have presented reflection expenses farming, the significant water client around the world, is exempted from deliberation charges. A few nations permit water rights to be exchanged, with the goal that the cost for water itself is shaped in the market. Such water exchanging exists in parts of Australia, Chile and the

Southwestern United States).

Operational, Maintenance, and Repair Costs:

The specialized significance of upkeep includes operational and useful checks, overhauling, repairing or replacing of essential gadgets, equipment, hardware, building framework, and supporting utilities in mechanical, business, administrative, and private installations. Over time, this has come to regularly incorporate both planned and preventive upkeep as financially cost effective practices to keep equipment prepared for task at the usage phase of a framework lifecycle.

Substitution Costs:

The substitution impact is the impact on request of a value change caused by a change to, or far from, a less expensive or more costly option.

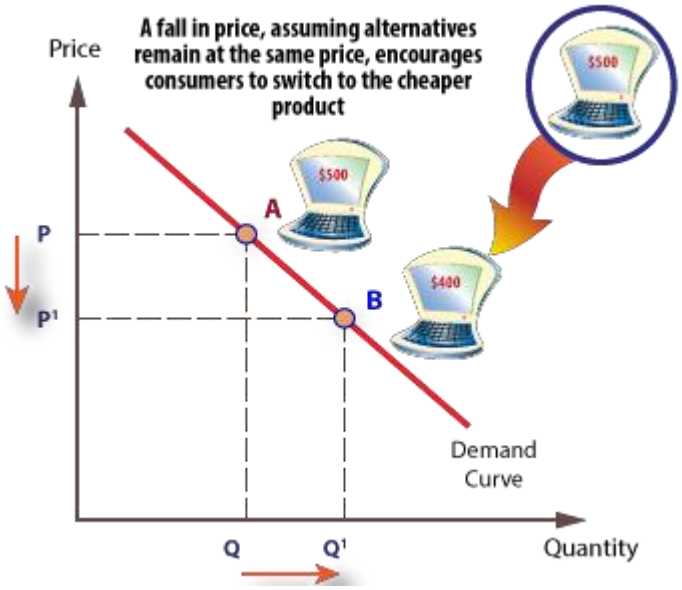


Fig 1.3.1 Price vs. Quantity of material demand curve

Residual Values:

Leftover value is one of the constituents of a renting math or task. It depicts the future estimation of a decent regarding supreme incentive in money related terms and it is now and again abridged into a level of the underlying cost when the thing was new.

Illustration: An auto is sold at a rundown cost of $20,000 today. Following a use of three years and 50,000 miles its esteem is authoritatively characterized as $10,000 or half. The credited sum, on which the intrigue is connected, in this way is $20,000 show esteem short

$10,000 future esteem.

Different Costs:

Finance charges and assessments

Stretching out credit to your clients can support deals by getting a more prominent scope of potential purchasers, yet offering on layaway likewise implies holding up for your cash. Surveying fund charges - another term for interest - on clients' exceptional adjusts encourage them to pay in an timely way.

1.4 PRIMARY RATING SYSTEM FOR GREEN BUILDING IN INDIA

For as long as couple of years, the word 'Green Buildings' is ceaselessly hoarding spotlight in the media. A few of us may have seen the Confederation of Indian Industry (CII) – Green Business Center working in Hyderabad which is one of the green structures in India. Presently the inquiry comes up – what precisely are these structures? How are not the same as different structures? What's more, why are they green?

We can characterize green buildings as structures that guarantee effective utilization of characteristic assets like building materials, water, vitality and different assets with insignificant age of non-degradable waste. Advances like proficient cooling frameworks have sensors that can detect the warmth created from human body and naturally alter the room temperature, sparing vitality. It applies to lighting frameworks as well. Green structures have a more astute lighting framework that consequently turns off when nobody is available inside the rooms. Straightforward advances like air based flushing framework in toilets that keeps away from water use by 100%, Use of vitality effective LED's and CFL's rather than traditional brilliant light, new age machines that devour less vitality, and numerous different alternatives help in influencing the structures to green and make them not the same as regular ones.

1. Green Rating for Integrated Habitat Assessment.
2. Indian Green Building Council.
3. Bureau of Energy Efficiency.

1. GREEN RATING FOR INTEGRATED HABITAT ASSESMENT (GRIHA)

Green Rating for Integrated Habitat Assessment (GRIHA) is India's own particular rating framework mutually created by TERI and the Ministry of New and Renewable Energy, Government of India. It is a green building plan assessment framework where structures are evaluated in a three-level process. The procedure starts with the online accommodation of archives according to the recommended criteria took after by on location visit and assessment of the working by a group of experts and specialists from GRIHA Secretariat. GRIHA rating framework comprises of 34 measures arranged in four unique segments. Some of them are – (1) Site determination and site arranging, (2) Preservation and proficient usage of assets, (3) Structure activity and upkeep, and (4) Development.

2. INDIAN GREEN BUILDING COUNCIL (IGBC)

The Leadership in Energy and Environmental Design (LEED) is the rating framework created for affirming Green Buildings. LEED is produced by the U.S. Green Building Council (USGBC), the association advancing maintainability through Green Buildings. LEED is a system for evaluating building execution against set criteria and standard purposes of references. The benchmarks for the LEED green building rating systems were created in year 2000 and are right now accessible for new and existing developments.

IGBC has built up the accompanying green building rating frameworks for various sorts of working in line and similarity with US Green Building Council. Till date, following sustainable buildings rating frameworks are accessible under IGBC:

1. Leadership in Energy and Environmental Development India for new development.
2. Leadership in Energy and Environmental Development India for center and shell.
3. Indian Green Building Council green homes.
4. Indian Green Building Council of green processing plant structure.
5. Indian Green Building Council of green SEZ.
6. Indian Green Building Council of green township.

Fig Shows 1.4.1 LEED-INDIA approach to green buildings

3. BUREAU OF ENERGY EFFICIENCY (BEE)

BEE built up its own particular specific rating system for the structures in light of a 1 to 5 star scale. More stars mean more energy efficiency. BEE has built up the Energy Performance Index (EPI). The Reserve Bank of India's structures in Delhi and Bhubaneswar, the CII Sohrabji Godrej Green Business Center and numerous different structures has gotten BEE 5 star evaluations.

Indians knew about Green Building ideas from the earliest starting point. Traditional homes with prepared red shading rooftop tiles and mud made dividers is a better than average case of energy productive structures that are utilized to keep cool amid summers and warm amid the winters. The greater part of rural India is as yet joined to this building innovation with normally accessible materials like dirt, wood, jute ropes, and so forth. At present we have propelled advancements that make more brilliant frameworks to control inside temperature, lighting frameworks, power and water supply and waste age. Green structures may be somewhat substantial on the purse but are useful for the earth. In this quickly evolving world, we ought to receive the innovation that causes us to spare valuable common assets.

1.5 BUILDING STANDARDS AND CERTIFICATION SYSTEM

Building has wide quick and backhanded impacts on our environment. In the midst of their development, inhabitance, remodel, repurposing, and pulverization, buildings use vitality, water, and crude materials, generate squander, and emanate possibly destructive environmental discharges. Realities have incited the making of green structure gauges, accreditations, and rating frameworks went for moderating the impact of buildings on indigenous living space through manageable outline.

The push towards the reasonable outline extended in 1990s with formation of Building Research Establishment's Environmental Assessment Method (BREEAM), the main green building rating framework in the U.K. In 2000, the U.S. Green Building Council (USGBC) took action accordingly and made and released measure likewise went for upgrading ecological implementation of buildings through its Leadership in Energy and Environmental Design (LEED) rating framework for new development. Extra evaluating frameworks have been produced that were affected by these early projects however are customized to their own nation needs and necessities or try to go past the points of confinement of current approach and building practices to address more extensive issues of maintainability or advancing ideas, for example, net zero vitality, and living and therapeutic building ideas that enhances regular habitat, or those that model nature's procedures.

1.5.1 ISO-DEFINED TYPES OF GREEN PRODUCT CERTIFICATION LABELS

Table No. 1.5.1.1 Shows certification labels for green product define by ISO

TYPE NO.	**ISO NUMBER**	**WHAT THE LABEL DOES**
Type 1	ISO 14024	Seal of endorsement for multi-property requirement.

Type 2	ISO 14021	Verifiable single-quality environment cases for issues, for example, energy utilization, outflows, or reused content. Can be first-party, self-pronounced producer claims. However numerous makers are starting to look for outsider check of those cases in light of industry request
Type 3	ISO>14025	Thorough natural item exposure and detailed item data. Like an Environmental Product Declaration (EPD)

1.5.2 GREEN PRODUCT CERTIFICATION

Table No.1.5.2.1 Shows green products certification

PRODUCT CERTIFICATIONS	**SINGLE OR MULTI-ATTRIBUTE**	**TYPE OF STANDARD AND CERTIFICATION**	**MANAGING ORGANIZATION**	**ISSUE OF FOCUS**
Energy Star	Single-Property	Govt. confirmation depending on producer gave information or outsider testing	U.S. EPA and U.S. DOE	Vitality expanding item
Water Sense	Single-Property	Govt. name in light of outsider testing	U.S. EPA	Showerheads, toilets, urinals, and valves
Forest Stewardship Council	Single-Property	Outsider affirmation	Forest Stewardship Council (FSC)	Forests and forestry products
SCS Global Services	Multi-Property	Outsider affirmation	SCS Global Services	Extensive variety of items (i.e. rugs, materials, wood items, protection)

Green Seal	Multi-Property	Outsider ISO Type 1 certification	Green Seal	Extensive variety of parts (paints, glues, light, electric chiller, window film, inhabitance sensor)
Green Guard	Multi-Property	Outsider affirmatio n	UL Environment	Indoor air quality, kids and school center
Green Squared	Multi-Property	Outsider ISO Type 1	TCNA	Tiles and tile establishment

1.6 IMPORTANCE OF LIFE CYCLE COST TO A UTILITY

A vital segment of an utility's exercises are organizing the capital improvement program, with the goal that it can meet its most squeezing needs. This prioritization happens toward the finish of the capital venture advancement process, that comprises of project identification/initial validation, risk reduction, and life cycle cost investigation, which is all, uses to set up last business case for every task. We can be found in Fig. 1.6.1 the life cycle cost examination is embraced as a major aspect of business case arrangement.

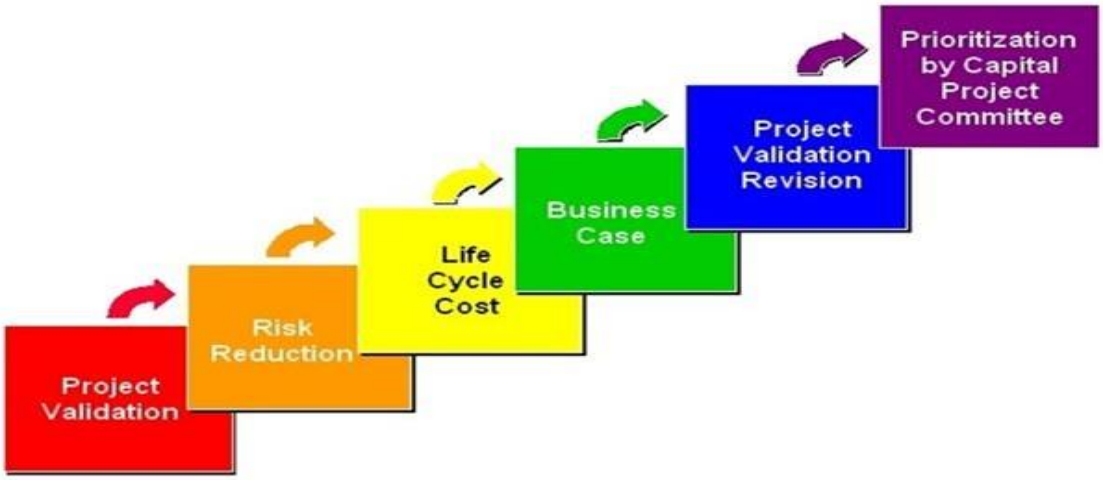


Fig.1.6.1 Importance of life cycle cost to a utility

The life cycle cost investigation enables utility to analyze anticipated life cycle costs for looking at contending capital and O & M venture arrangements and takes into account proper examination of options of different capital characteristics, and periods of time. Given the statement of the utility's benefits, the measures of capital open from the financial plan, and verifiable confirmation, the venture chief must choose which venture options will cause the minimum life cycle costs over the life cycle of the advantages included while conveying execution at or over characterized levels. Accordingly, these examinations will enable the utility to:

- Settle on choices for capital and O & M speculations in lights of minimum life cycle costs,
- Rank every one of the tasks in light of aggregate cost of proprietorship.
- Solidify costing information with the project validity and hazard reduction.
- Settle on more educated choices, and
- Enable better answering to key partners.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

In this part the writing audit started with a review of life cycle costing. Life cycle costing was made in the 1970's to consider the proprietorship and additionally the securing expenses of military frameworks, and to analyze costs over their life cycles. LCC is worried about all expenses related from beginning to retirement. Cost administration is a way distinguishing every one of the costs related and settling on educated decisions for the duration of the life cycle.

Key ideas regular to all utilizations of LCC:

- cost breakdown structure
- cost evaluating
- discounting
- inflation

Issues for LCC include: assessing costs – deciding introductory expenses isn't troublesome contrasted and the estimation of immediate and roundabout upkeep and task costs; numerous outside variables can be relatively difficult to anticipate. Expectation mistakes, estimation blunders (contrasts in estimation units) and testing mistakes (an example may not be illustrative) or mistakes in suppositions would all be able to antagonistically influence comes about.

Khoshbakht, M. Dupre. and Gou,Z (2017)

Found that green engineering experiences an absence of quantitative money saving advantage concentrates to quicken the application and utilize. Tragically, absence of clear and efficient investigations of structure costs has brought about the vagueness of green structure money saving advantages. This exploration planned to attract consideration regarding the significance of research philosophies and analyzed points of interest and impediments of every technique for count of various cost factors. This examination investigated just the standard strategies for green money saving advantage forecasts. The

looked into papers are comprehensive of the most approved research works in the field, however not restrictive to quantitatively contrasting the uses of various techniques. A methodical quantitative writing survey is then suggested as future examinations for assist examinations and investigations of existing strategies.

Exact encounters in view of target and subjective examinations in genuine structures have the advantage of exploratory controls and interior legitimacy of research outline. Be that as it may, the creation of such point by point and exact money saving advantage information is a requesting and tedious process. Furthermore, numerous relevant and non-logical components impact the money saving advantages of green structures, which mean the speculation of discoveries in light of a couple of building cost exhibitions isn't remotely approved. Information gathering from an optional source, by being less tedious and requesting, have the advantage of bigger example accumulation potential outcomes and upgrading outside legitimacy

In like manner, a harmony between the legitimacy of information sources and information test sizes is important to limit inspecting blunders and empower parametric factual tests. It is then prescribed that apparatuses like BIDS, which is an instrument in light of the meta-investigation of a few trusted and experimental examinations, to be created to collect generation of the vast example pool of approved database. The most widely recognized confinements and issues found in green money saving advantage writing can be condensed as:

- Restriction of databases and contextual investigations according to accessibility of information and reflecting just particular sorts of green structures.
- Generalization of discoveries in view of few contextual investigations and building cost exhibitions.
- Difficulty of requesting exact examinations.
- Lack of complex classification of green structure composes and mirroring the heterogeneity of green building costs, which may bring about finding false connections between factors.
- Normalization of information if accumulated from different sources to limit information gathering blunders.

Birajdar,S.V. and Pimplikar,S.S. (2016.)

Investigated that advantages of maintainable building can be huge, yet just if best practices are taken after not exactly at the plan/assemble organize, but rather than whole building life cycle. Inhabitants can expect enhanced efficiency and prosperity, bring down working costs, decreased natural effects, enhanced open picture. Building proprietors, administrators, and inhabitants who put resources into elite practical structures can understand triple primary concern benefits when they join forces with imaginative, collective organizations that take a gander at structures comprehensively, are ready and anxious to draw in with all partners right on time simultaneously, and utilize outline for-execution standards. For data analysis, total costs of two different buildings i.e. sustainable and traditional buildings were calculated. Also systems like roof mounted solar energy power plant, different sewage treatment plants are taken into consideration for their life cycle cost analysis. Some comparison made between various sewage treatment plants with considering their life cycle cost is shown below.

SBR - Sequencing batch reactors

UASB - Up-flow Anaerobic Sludge Bed

MBBR - Moving Bed Biofilm Reactor

Eco STP - Eco Sewage Treatment Plant

Liu,H.(2015)

Adhering to manageable improvement has turned into an agreement of the world; China is likewise currently advancing the practical advancement of development industry. Be that as it may, individuals' comprehension of the cost of green building will undoubtedly thwart its improvement. In perspective of this, we investigate the hypothesis of life cycle cost, joined with the status of green building, at that point break down the entire life cycle cost of green building, and make observational examination. The components that influence the cost of green building are mind boggling. In this paper, we utilize fundamental segments investigation technique and decide the six key elements, which are green building innovation, arrangement bolster, venture situating, development innovation, building materials costs and nearby conditions. On this premise, we set forward significant arrangement recommendations.

- **Enhance the idea of green building.**

A great many people think green building is a top of the line private house, however in reality green building does not mean high cost. A ton of purported "green structures" in China utilize a considerable measure of high innovation and hardware terminals, which have enormously expanded the underlying speculation, as well as been imperceptible to build the subsequent property upkeep costs, consequently it would build the support expenses of the proprietors in task arrange.

- **Clear the goals of green building projects**

Distinctive green targets will prompt diverse levels of cost, it is hence important to focus on viability of task; there are higher requests, which are decreasing the post operational vitality utilization, concentrating on vitality proficiency.

- **Private industrialization**

Utilizing the pertinent innovation, we have accomplished standards of green buildings, and spare the cost. As indicated by diverse areas of atmosphere, building materials ought to appear as something else. Through these practices, we can accomplish minimal effort, and furthermore acknowledge neighborhood normal agreement

- **Enhance laws and regulations**

The pertinent branches of the state might update and enhances assessment principles of green building. Government ought to give more monetary help to the evaluation and routine with regards to household green building, for example, tax reductions, exceptional reserve, diminishing the extra spending, enhancing the worry and acknowledgment of green building.

Dwivedi,A.A. and Bagare,P.V. and Gupta,S. (2015)

Discovered that building which can work utilizing an ideal measure of energy, consume less water, conserve common assets, produce less waste and make spaces for sound and comfortable living, when contrasted with regular structures, is a green building. Green building configuration is a sensible and atmosphere agreeable way to deal with building plan. Distinctive components, as geological area, existing climatic conditions, utilization of locally accessible and low encapsulated energy materials and outline thought noteworthy to the sort of use of the building are ordinarily contemplated. Such an approach guarantees least harm to the earth, while developing and utilizing the building.

Diminished working expenses by expanding profitability and utilizing less energy and water, enhanced open and inhabitant wellbeing because of enhanced indoor air quality, Reduced natural effects by, for instance, lessening storm water spillover and the warming impact

Regular strategies for building use tremendous amounts of material, a significant number of them non-sustainable and poisonous, and give careful consideration to the effect the building has on the earth. Green structures lessen these effects as well as more beneficial and expend less energy sparing cash over the long run.

Alborzfard,N. (2012)

Sustainability has been elevated to another level of significance, because of the current worldwide race for items and protection of our condition. Buildings are specifically noteworthy since they are huge supporters of utilization of assets. Since the commencement of the LEED (Leadership in Energy and Environmental Design) rating framework, there has been a steady increment in the quantity of LEED affirmed buildings "green" buildings. Do green buildings really give money related advantages? What system should be set up and taken after to check these advantages?

In view of the outcomes it can be seen that making a structure for owner to both track and understand the costs required with building green can be effortlessly settled as long as the specialist service provider is able to track the correlated data. Following and checking such data will furnish proprietors with the recorded information required to do such life cycle costs examinations. owner may likewise need to quantify and track distinctive measurements which can without much of a stretch be suited by the formation of subsystem LCCA runs or general building LCCA runs.

In view of the examination that was completed the system furnished the customer with the capacity to quantify their advantages or included expenses through the different energy and tasks and operational parameters that were chosen.

Rebitzer,G. and Ekvall,T. and Hunkeler,D. (2003)

Sustainable advancement requires techniques and devices to gauge and look at the natural effects of human exercises for the arrangement of merchandise and enterprises (both of which are condensed under the term "products"). Ecological effects incorporate those from outflows into the earth and through the utilization of assets, and additionally

different intercessions (e.g., arrive utilize) related with giving items that happen while separating assets, delivering materials, fabricating the items, amid utilization/utilize, and at the items' finish of-life (gathering/arranging, reuse, reusing, squander transfer). These discharges and utilizations add to an extensive variety of effects. A reasonable need, along these lines, exists to be proactive and to give complimentary bits of knowledge, aside from current administrative practices, to help lessen such effects.

Kneifel,J.(2009)

Establishes that energy effectiveness in new building development have turned into key focus to bring down across the national vitality utilization. The objectives of this paper are to gauge life cycle vitality reserve funds, carbon outflow diminishment, and cost viability of vitality proficiency measures in new ad structures utilizing an incorporated outline approach, and gauge the suggestions from a cost on vitality based carbon discharges. An aggregate of 576 vitality reenactments are keep running for 12 prototypical structures in 16 urban communities, with 3 buildings outlines for every building-area mix. Mimicked vitality utilization and building cost databases are utilized to decide the life-cycle cost-adequacy and carbon discharges of each outline.

The outcomes demonstrate traditional vitality productivity advances can be utilized to diminish vitality used in new advertisement structures by 20 to 30% all things considered and up to more than 40% for some structure writes and areas. These decreases should frequently be possible at negative life-cycle costs in light of the fact that the enhanced efficiencies permit the establishment of littler, less expensive HVAC hardware. These changes spare cash and vitality, as well as lessen a building's carbon impression by 16% and large. The costs on carbon discharges from vitality utilize expands the arrival on vitality productivity ventures since vitality is more costly, making some cost-ineffectual undertakings financially possible.

Senthil Kumaran, D., Ong, S. K., Tan, R. B., & Nee, A. Y. C. (2001)

Investigated early usage of cost examination models impacts the outline changes of item and gives clarifications of connections amongst cost and plan parameters. They add to cost lessening by recognizing high cost patrons. Nonetheless, there are numerous highlights of an item that can be examined utilizing an existence cycle cost examination demonstrate. The mix of rising expansion, cost development, diminishment in

buying power, spending confinements, expanded rivalry, and so forth., has made a mindfulness and enthusiasm for the aggregate cost of items, frameworks and structures. Not exclusively are the obtaining costs related with new frameworks rising, e.g. quality administration frameworks and natural administration frameworks, the expenses of working and keeping up frameworks as of now being used are additionally expanding quickly. This is the situation of an existence cycle costing (LCC) circumstance subject to the accompanying conditions:

- Bad nature of items, and frameworks being used.
- Engineering changes amid outline and advancement.
- Changing providers in acquisition framework segments.
- System creation or potentially development changes.
- Changes in strategic help capacity.
- Estimating and gauging errors.
- Unforeseen occasions and issues.

The use of LCC techniques amid item and framework plan and improvement is acknowledged through the achievement of LCCA. LCCA might be characterized as a deliberate diagnostic process for assessing different outlines or elective courses of activities with the goal of picking the most ideal approach to utilize rare assets.

Shabrin, N., & Bin Abul Kashem, S. (2017)

These days green building has high effect in the public arena. Presently planners comprehend that outside air, enhanced indoor condition, and water funds is likewise imperative. Green building is outstanding a direct result of its ecological advantage, In this report monetary and social advantage of green building has been examined. Parts of green working far and wide have been talked about. Quality, shortcomings, opportunity and risk (SWOT) investigation, Life-cycle cost count for green building was done on an anticipated green building. In financial examination, the aggregate money related cost and non-fiscal cost are included together as one request to know the remaining collects to the legislature. As shown in figure 2.1.1 SWOT examination comprises of quality, shortcomings, opportunity and danger. The following are the quality, shortcomings, openings and dangers for green building.

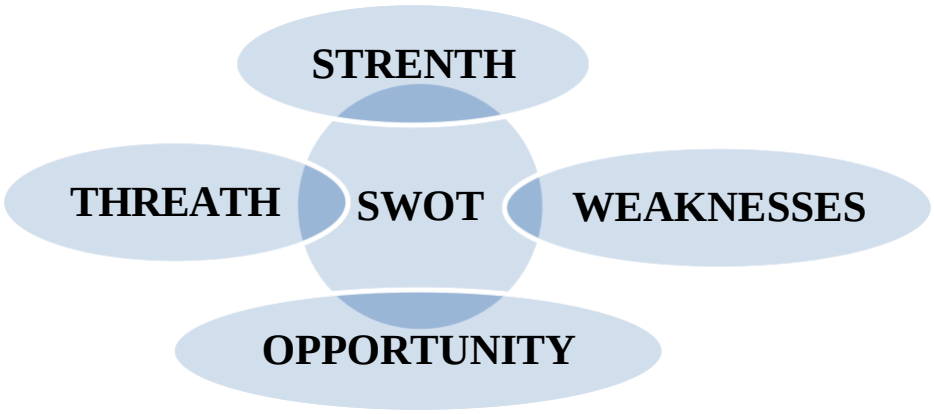


Fig.2.1.1 SWOT analysis of a project

Table No.2.1.1 Factor affecting the SWOT analysis of project

Strength	• Low energy intensity • Renewable(solar panel), energy efficient • Many reuse option • More motivation of real estate companies and demonstration project developers. • Carbon storage
Weaknesses	• Emission to air • Lack of expertise • Bureaucracy • Low investment activity
Opportunity	• New technologies, innovations • Clean technology for building • New regulations

	• Creation of jobs
Threat	• New regulations • Exposure to climate change • Energy price

Li, H.L., & Liu, S.H. (2016)

Found that development and advancement of green building is the important method for economic improvement of construction industry of our nation, the incremental cost of green working, as a critical variables upsetting the improvement of the green building, it is important to do the comprehensive rational investigation and research. This article breaks down the variables influencing the incremental cost of green engineering from the point of view of the entire life cycle and from outline, development, activity and upkeep and scrap decimation, and after that distinguish the periods of the incremental cost of quantitative, for green building sensible situating and giving a reference premise to basic leadership, executes the green building entire life cycle phases of the incremental cost control and administration adequately, advances the sustainable improvement of green building.

Mitropoulou, C. C., & Lagaros, N. D. (2016)

Inspected that design of economic structures sufficiently resistant to withstand amid their service life, without catastrophic disappointments, all conceivable loading conditions and to absorb the incited seismic energy in a controlled way, was subjected to escalated inquire about up until this point. Exorbitant and to a great degree touchy hardware, crucial in trade, business, training, and additionally human services speak to the substance of the contemporary auxiliary frameworks. Every now and again, structures themselves are less significant than their substance. Besides, following a disastrous cataclysmic event, nearby groups requires that correspondence and crisis focuses, healing centers, police, and fire stations to be completely operational. In regular developments, high floor increasing speeds

are experienced if there should be an occurrence of hardened structures or huge interstory floats in adaptable ones. These auxiliary executions attribute cause challenges in ensuring both building and its substance. As a productive elective design hone, base-detached structures are considered, contrasted with the ordinary settled base one. A basic assessment of enhanced settled and base-disconnected strengthened solid structures is performed in this examination, as for the underlying and aggregate cost considering the life-cycle cost.

Collinge, W. O., Thiel, C. L., Campion, N. A., Al-Ghamdi, S. G., Woloschin, C. L., Soratana, K., ... & Bilec, M. M. (2015)

Founds that improvement of green structure rating frameworks (GBRS) and maintainability measurements for structures, including building items, is checked on from a North American point of view. The Leadership in Energy and Environmental Design (LEED) framework and the Living Building Challenge (LBC) are featured as essential cases of various levels of GBRS. Life cycle evaluation (LCA) is presented as a favored strategy for evaluating maintainability, and its reconciliation into current GBRS is inspected a conspicuous building case. Two illustration utilizations of LCA to building items related with GBRS – cover and rooftop layers – are given. In the primary case, ordinary cover was contrasted and covers meeting the benchmarks of the LBC's materials prohibition criteria (Red List, by means of the declare item naming framework). In second case, LCA was connected to both the make and utilize periods of rooftop film choices for a building retrofit venture, one of which would have helped in accomplishing LEED affirmation. The recorded items improved in each LCA affect classification, and the GBRS preferred rooftop framework performed all the more inadequately in all LCA affect classifications, while recommending the requirement for extra LCA classifications. The two cases help to delineate the many-sided quality and tradeoffs experienced while incorporating the quantitative viewpoint of LCA and the subjective point of view of GBRS.

Samer,M.(2013)

Found that the current domesticated animals outbuildings and nurseries do not consent to the green building idea as they miss few or the vast majority of the properties that define the green building angle. Henceforth, the usage of the green building idea in rural structures is as yet restricted also, in this manner, ought to be conceptualized and

started. With a specific end goal to make the development of green buildings financially effective, the agricultural wastes, e.g. plant deposits, ought to be utilized as green building materials.

The part of agricultural and biological designers can be characterized as takes after:

(1) Examining the neighborhood agricultural materials that can be utilized as green building materials, e.g. mammoth reed, straw, dirt and so on.

(2) Fabricating biomaterials, e.g. separating bio-silica from plants, to be utilized for creating green building materials, e.g. bio cement, eco-bond, and green cement.

(3) Creating ranch green building evaluation and rating frame work

(4) Actualizing the rules of green structures while developing new ranch structures

(5) Retrofitting old homestead structures to satisfy the green building criteria.

Dwaikat,L.N. and Ali,K.N.(2014)

Found that from life cycle point of view, the green building has an extensive variety of unmistakable and impalpable advantages which are ordinarily evaluated utilizing life cycle costing approach. Reports and studies demonstrate an execution hole once fabricating is possessed.

The Earned Value Management (EVM) is a thorough cost execution estimation method broadly connected in the development part to gauge the cost execution all through the development stage which are noteworthy part of sustainable structure life cycle. As like, the development cost is a huge segment of green building life cycle cost. Consequently, broadening the usefulness of the as of now connected earned esteem administration is more down to earth than building up another way to deal with screen and control the genuine life cycle cost of sustainable structures.

Weerasinghe, A.S. , Ramachandra,T. and Thurairajah,N.(2016)

Finished up through members' review that the development cost of green structures is 20-25% higher than customary structures in Sri Lanka. The discoveries of this

examination demonstrate that the development cost of green building is 27 to 28% higher than that of customary building. Along these lines, the discoveries of the examination are comparable with the writing discoveries. Notwithstanding, the activity, support, and end of life costs are not as much as that of regular structures by 35 to 41%, 26 to 30% and 6 to 18% individually. Through and through, the LCC of green building is 24 to 28%less than the traditional structures due to the LCC advantages of green structures. Accordingly, the speculators can utilize those cost investigations as a base to execute green building ventures.

Bakhoum,E.S. , Garas,G.l.. and Allam,M.E.(2015)

Found that this paper exhibits a similar report between two basic frameworks utilizing traditional and eco-accommodating building materials with a specific end goal to assess the manageability of each write. A model of two stories was built utilizing eco-accommodating building materials. A comparative working with a similar region furthermore, structural format was for all intents and purposes evaluated utilizing regular skeleton basic framework (strengthened cement and blocks). A sustainable decision support system (SDSS) programming was utilized to think about between the two frameworks utilizing supportability estimations, life cycle evaluation technique, and multi-criteria choice examination system. This paper presents, by means of a straightforward contextual investigation, an outline of the capability of some eco-accommodating building materials to be incorporated into novel plans for made strides execution.

Results demonstrated that the eco-accommodating framework had preferable general maintainability rank over the ordinary framework by around 11% (67% for eco-accommodating framework and 56% for traditional framework).

2.2 OBJECTIVE OF THE STUDY:

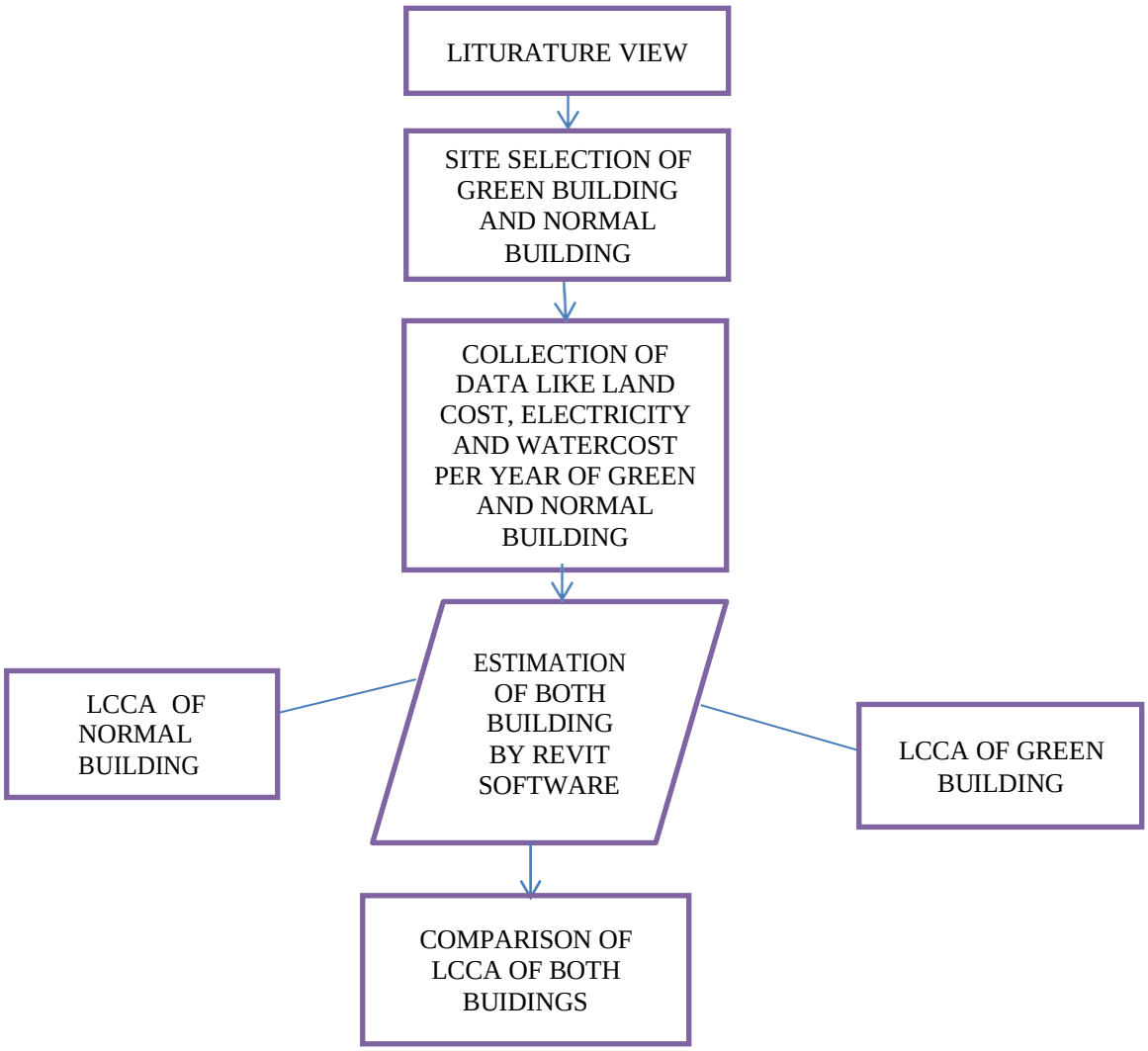
- Gathering of information for example land cost, material expenses, upkeep cost, development rate, expansion rate and so forth.
- Count of different cost related with life cycle of an ordinary structure and green structure.
- Count of the amount of materials required for development of typical structure and green structure.
- Comparison of the life cycle costs of the ordinary structures and green structure.

CHAPTER 3

METHODOLOGY

3.1 GENERAL

In this section the process of proposed work is discussed in detail. The process includes work plan, collection of data, from SJVNL office a green building, preparation of data sheet and use of REVIT software to estimate the construction cost of green building and normal residential building.



In this project first of all we assume two buildings, one of them is green building which is SJVNL office Shanahan, Shimla and other one is normal residential building of same area that we assume. Then we collect different data like land cost per Biswa in Shimla. After that we collect area of building in square meters. We find no. of green techniques install in the green building. Then with the help of REVIT software we estimate the construction cost of building. And then LCCA of both the building is done in which we find acquisition cost, construction cost, operational and maintenance cost, demolition cost and salvage value of both the building after 30 years.

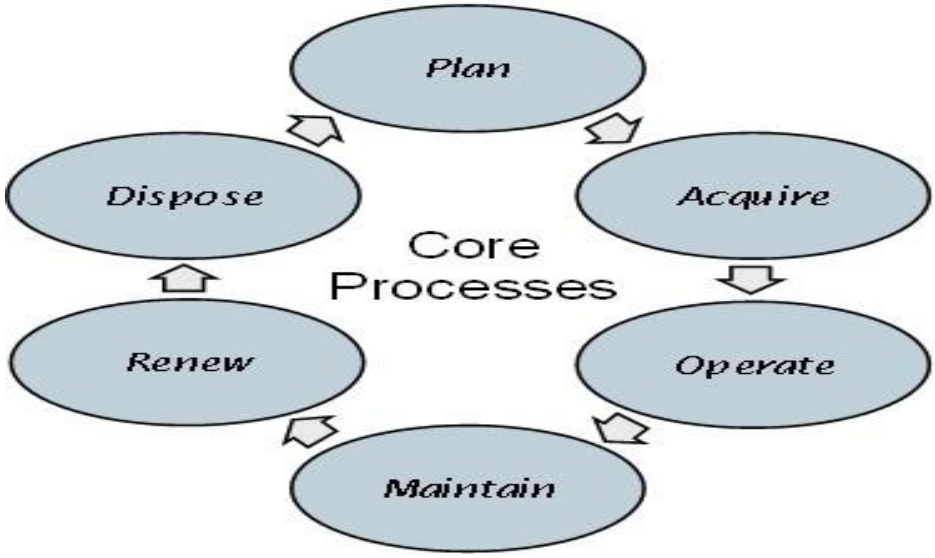


Fig. No. 3.1.1 Core process of life cycle cost.

Life cycle cost examination (LCCA) is the aggregate cost of developing and working a working over a chose time period or life of a building. There are different subjective furthermore, quantitative segments that can be utilized as a part of a LCCA, alluded to as contributions for the motivations behind this report. To build up a state of examination between SJVNL office, Shimla a green building and normal residential building of same area different information sources were utilized as a part of the LCCA.

LCCA Framework diagrams the arrangement of sources of info utilized as a part of this investigation to create a relative cost premise. The principal level of data sources including the Green (Sustainable) and Non-Green (Traditional Construction) inputs are subdivided into different information sources: development, activities and support, and utilization costs. These sources of info are advance sub-divided into mechanical, electrical and plumbing (water) inputs. This system took into consideration the foundation of 51 parameters for every LCCA. The LCCA spreadsheets in Appendix F are organized to examine contributions on a subsystem and task level.

3.2 Evaluation System of GRIHA

GRIHA rating system consists of 100 points framework that consist of some important requirement, which are required to meet while others are partially required. Different levels of confirmation 1 star to 5 stars are granted in view of level of points achieved. Point achieved by building between 50 to 60 points has 1 star rating. The building that achieves 60 to 70 points has 2 star rating. The building that achieves 70 to 80 points has 3 star rating. The building that achieves 80 to 90 points has 4 star rating. The building that achieves 90 to 100 points has 5 star rating.

Table No. 3.2.1 Show the 34 measures of GRIHA system

Sr. No.	**Description**	**Points**	
Measure 1	Site Selection	One	Partially Required
Measure 2	Save and secure landscape during development	Five	
Measure 3	Soil protection	Two	
Measure 4	Configuration to incorporate existing site highlights	Four	

Measure 5	Diminish hard clearing nearby	Two	Partially Required
Measure 6	Enhance outdoor lighting framework proficiency	Three	
Measure 7	Plan utilities efficiently and optimize on-site circulation efficiently	Three	
Measure 8	Give, in any event, least level of sanitation/security offices for development laborers	Two	Required
Measure 9	Reduce air pollution amid development	Two	Required
Measure 10	Reduce landscape water necessity	Three	
Measure 11	Decrease building water utilize	Two	
Measure 12	Efficient water use at development	One	
Measure 13	Improve building configuration to reduce conventional energy request	Eight	Required

Measure 14	Upgrade energy execution of working inside indicated comfort limit	Sixteen	Partially Required
Measure 15	Utilization of fly ash in structures	Six	
Measure 16	Diminish volume, weight, and time of development by embracing productive innovation for instance, pre-cast frameworks, ready mix concrete etc.	Four	
Measure 17	Use low energy material inside	Four	
Measure 18	Sustainable power source usage	Five	Partially Required
Measure 19	Renewable based on hot water framework	Three	
Measure 20	Squander water treatment	Two	
Measure 21	Water recycle and reuse (including rain water)	Five	
Measure 22	Reduction in waste	One	

	during development		
Measure 23	Productive waste isolation	One	
Measure 24	Capacity and disposal of waste	One	
Measure 25	Assets recovery from wastes	Two	
Measure 26	Use low VOC paints	Three	
Measure 27	Minimize ozone depleting substance	One	Required
Measure 28	Grantee water quality	Two	Required
Measure 29	Acceptable outdoor and indoor noise levels	Two	
Measure 30	Tobacco and smoke control	One	Required
Measure 31	General availability	One	
Measure 32	Energy review and approval		Required
Measure 33	Task and support convention for electrical and mechanical hardware	Two	Required

Measure 34	Advancement (past 100)	Four	

Table No. 3.2.2 Show GRIHA rating system according to point achieved.

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

GRIHA-(green rating integrated habitat assessment) SJVNL corporate headquarters office is 3-star rating and GRIHA point criteria are (71-80) points. There are 34 criteria's for 5-star rating of green building. SJVNL headquarter have achieved 12 criteria so it is GRIHA 3-star building.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 LIFE CYCLE COST ANALYSIS OF NORMAL BUILDING

4.1.1 Study Area Profile

Table No. 4.1.1.1 Shows study area profile of normal residential building

Building Location	Shimla
Land Acquired	60Biswa
Built-up Area	14033Square Meter
Building Type	Residential Building
Paint Used	High VOC Paint

4.2 VARIOUS COSTS ASSOSIATED WITH LCCA

4.2.1 ACQUISITION COST

Table No. 4.2.1.1 Shows total acquisition cost of normal building

Total land acquisition	2500 Square Meter
Cost of land per Biswa	Rs. 700000
1 Biswa	40.5 Square Meter
Total land acquisition in Biswa	60 Biswa
Total Cost of acquisition	Rs. 42000000

4.2.2 CONSTRUCTION COST

Table No. 4.2.2.1 Show total built-up area of building floor wise in square meter

Total built-up area of building	14033 square meter
Area of 1st floor	2494 square meter
Area of 2nd floor	2454 square meter
Area of 3rd floor	2279 square meter
Area of 4th floor	2209 square meter

Area of 5th floor	2073 square meter
Area of 6th floor	2524 square meter

Note: 1 Square Meter = 10.763 Square Feet

Total built up area in **Square Feet** = **151049.95**

With the help of REVIT software estimation of 1st floor

Figure 4.2.2.1 Shows model of 1st floor of normal building with REVIT software

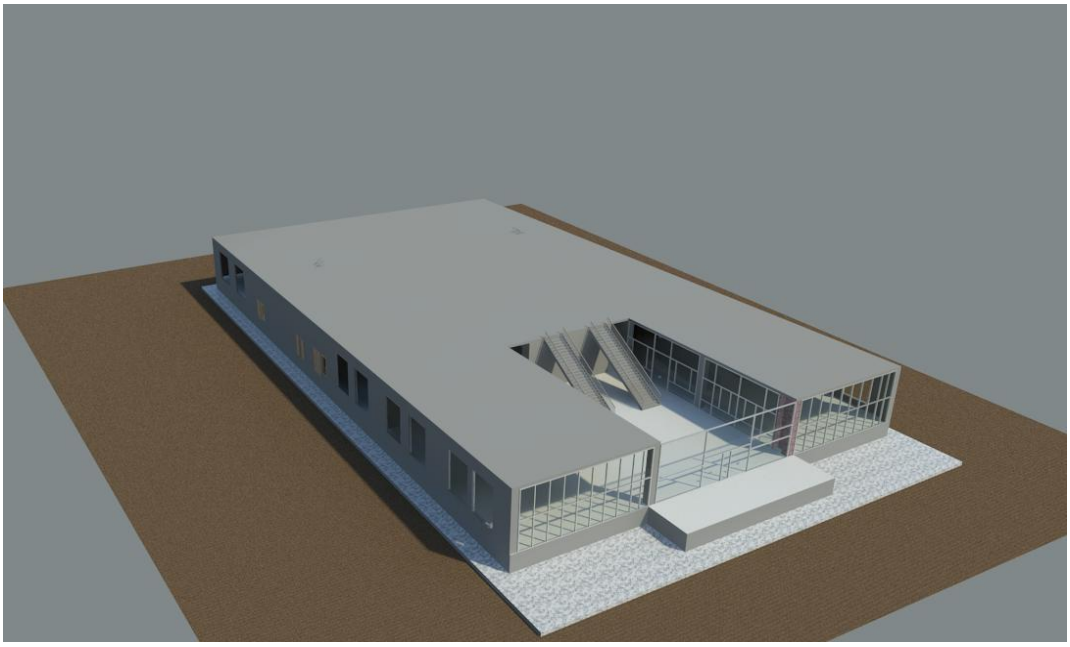


Figure4.2.2.2 Shows model of 1st floor with roof of normal building with REVIT software

Table No.4.2.2.2 Shows estimation of 1st floor of building with RIBET software

Family and Type	Material: Name	Material: Area	Material: Cost	Total Cost
Acoustic Ceiling Tile 24 x 24: 1	Acoustic Ceiling Tile 24 x 24	65945 SF	200	13189060
Aluminum: 4	Aluminum	7 SF	50	343
Basic Wall: Generic - 4" Brick: 23	Brick Common	2129 SF	82	174603
Basic Wall: Generic - 6" Masonry:8	Concrete Masonry Units	1555 SF	110	171039
Basic Roof: Generic - 9":1	Default Roof	24465 SF	300	7339421
Rectangular Column: 24" x 24":142	Default Wall	36346 SF	110	3998015
Single-Flush: 36" x 84":55	Door - Frame	1278 SF	250	319585
Single-Flush: 36" x 84":55	Door - Panel	2604 SF	250	650994
Glass: 146	Glass	6024 SF	85	512066

Sash: 9	Sash	325 SF	450	146080
Trim: 5	Trim	121 SF	210	25377
			Total	265266583

Total construction cost of building = 6*2652666583

= Rs. 159159498

4.2.2.1Abstract for Construction cost

Table No. 4.2.2.1.1 Shows total construction cost of building

Construction cost	Rs.159159498
Cost of painting per sq. feet	Rs. 27
Total painting cost of building	Rs. 4078323
Total construction cost	**Rs. 163237821**
Tool & Tackles @1% of total cost	**Rs. 1632378**
Water charges @2 % of total cost	**Rs. 3264756**
Sanitary fittings @5% of total cost	**Rs. 8161891.05**
Contractors profit@10% of total cost	**Rs. 15915949.8**
Total construction cost of normal building	**Rs. 192212795.9**

4.2.3 OPERATIONAL AND MAINTENANACE COST

Table No. 4.2.3.1 Shows cost of operations per square feet

Total built up area of building in meter square	14033
Total built up area of building in square feet	151049
Cost of electricity per square feet	Rs.10
Cost of water supply per square feet	Rs.4
Cost of plumbing repair per square feet	Rs.16
Cost of painting per square feet	Rs.27

4.2.3.1 Annually Operational and Maintenance Cost

Table No. 4.2.3.1.1 Show total annual cost of all operations

Annual Electricity Bill	Rs. 1510490
Annual Water Usage	Rs. 604196
Annual Cost of Plumbing Repair	Rs. 2416784
Annual cost of painting	Rs. 4078323

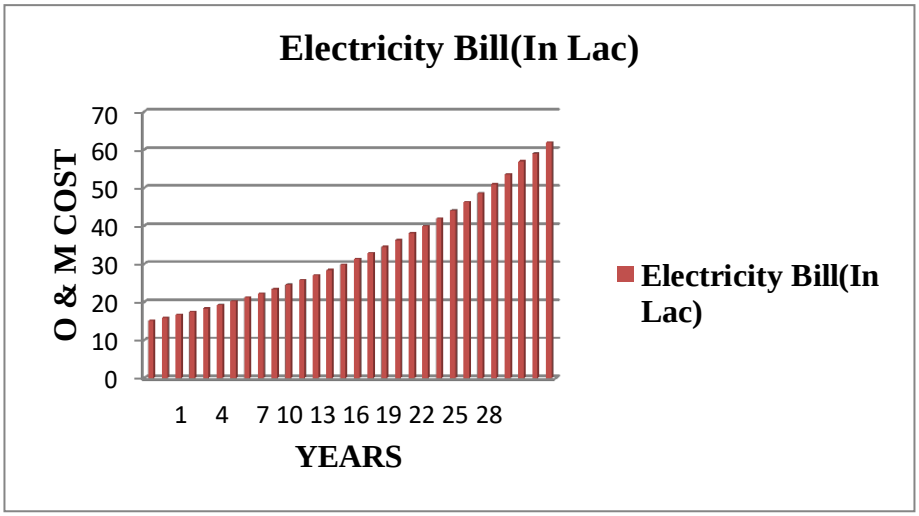


Figure No. 4.2.3.1.1 Show total electricity bill(In Lac) for 30 years

This chart shows total electricity bill (In Lac) of normal residential building for 30 years of service life. In this chart each column shows individually cost of electricity bill for each year in 30 years.

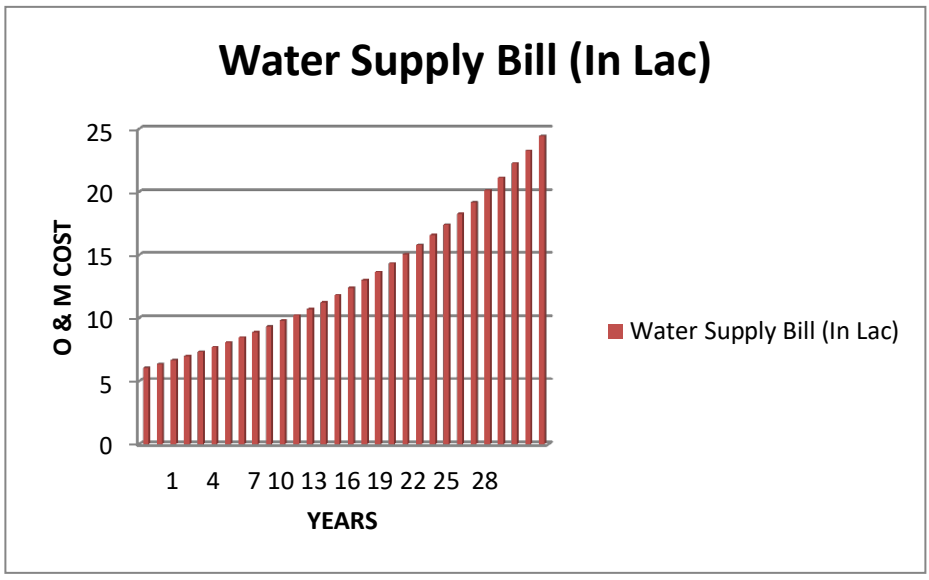


Figure No. 4.2.3.1.2 Shows total water supply bill (In Lac) for 30 years

This graph shows total water supply bill (In Lac) of the normal residential building for 30 years of service life. In this graph each column shows individually cost of electricity bill for each year in 30 year

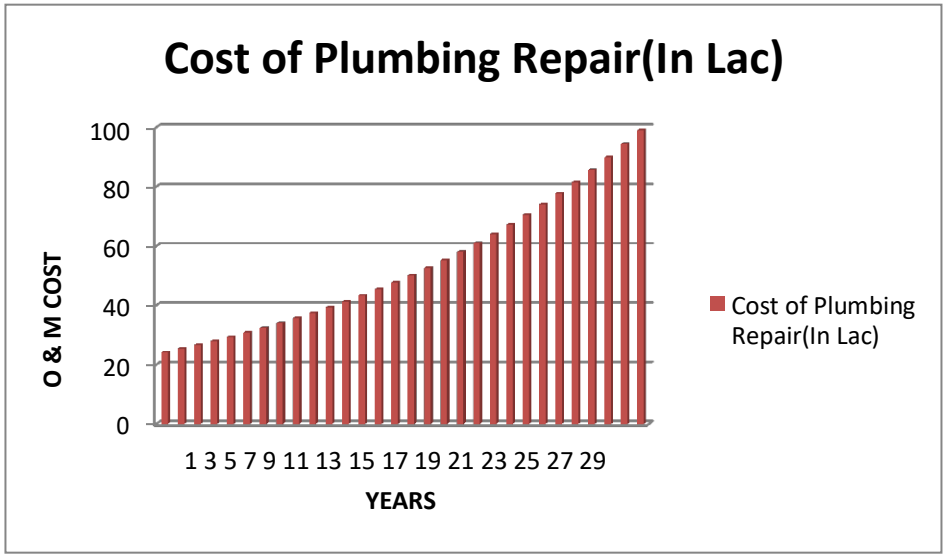


Figure No.4.2.3.1.3 Shows total cost of plumbing repair (In Lac) for 30 years

This graph shows cost of plumbing repair (In Lac) of normal residential building for 30 years of service life. Each column in graph shows individually cost of plumbing repair for each year in 30 years of service life.

4.2.3.2 Abstract of Operational and Maintenance cost for 30 years with 5% inflation rate

Table No. 4.2.3.2.1 Show total O&M cost of all operations for 30 years

Total electricity bill of building for 30 years	Rs. 1000.34 (In Lac)
Total water supply bill of building for 30 years	Rs. 396.19 (In Lac)
Total cost of plumbing repairs for 30 years	Rs. 1601.18 (In Lac)
Cost of major and minor repairs of building (3 times the construction cost of building)	Rs. 571790220.3
Total Operational and Maintenance Cost of building for 30 years	**Rs. 871390220.3**

4.2.4 Demolition and Disposal cost

Table No. 4.2.4.1 Show total demolition and disposal cost of building after service life

Area to be demolished	151049 square feet
Cost of demolition per square feet	Rs. 22
Total cost of demolition of building	**Rs.3323078**
Rubble to be disposed	151049 square feet
1 truck dispose	120 square feet
For 151049 square feet total numbers of trucks required	1259 No.s
Cost of disposal per truck	Rs. 5000
Total disposal cost	**Rs. 6295000**
Total demolition and disposal cost of building	**Rs. 9618078**

4.2.5 Salvage Value

Salvage value on an average is 5% of the construction cost of a building. Thus for our project the salvage value shall be **Rs.9529837**

4.3 Life Cycle Cost of Normal Building of area 14033 square meter

Table No. 4.3.1 Show total life cycle cost of normal building

Acquisition Cost	**Rs.42000000**
Construction Cost	**Rs.192212795.9**
Operational and Maintenance Cost	**Rs.871390220.3**
Demolition And Disposal Cost	**Rs.9618078**
Salvage Value	**Rs.9529837**
Life Cycle Cost	**Rs.1105691256**

4.4LIFE CYCLE COST ANALYSIS OF GREEN BUILDIN

4.4.1 Study Area Profile

Table No. 4.4.1.1 Show study area profile of green building

Building Location	SJVNL, Shanahan Shimla
Land Acquired	60Biswa
Built-up Area	14033 Square Meter
Building Type	Green Building
Paint Used	Low VOC Paint
Solar Panels	400 no.
Solar Water Heater	44 no.
Sewage Treatment Plant	STP OF 90 cubic meter
Water Fixtures	125 no.

4.5 VARIOUS COST ASSOSIATED IN LCCA

4.5.1 Acquisition Cost

Table No. 4.5.1.1 Show total acquisition cost of green building

Total land acquisition	2500 Square Meter
Cost of land per Biswa	Rs. 700000
1 Biswa	40.5 Square Meter
Total land acquisition in Biswa	60 Biswa
Total Cost of acquisition	Rs. 42000000

4.5.2 Construction Cost

Table No. 4.5.2.1 Show total built-up area of building in square meter

Total built-up area of building	14033 square meter
Area of 1st floor	2494 square meter
Area of 2nd floor	2454 square meter
Area of 3rd floor	2279 square meter
Area of 4th floor	2209 square meter
Area of 5th floor	2073 square meter
Area of 6th floor	2524 square meter

Note: 1 Square Meter = 10.763 Square Feet

Total built up area in **Square Feet** = **151049.95**

With the help of RIBET software total Construction Cost is **Rs.159159498**

At the time of construction of green building we includes some parameters.

1. Site selection and planning of building.

It includes innovative design of building and glass to receive maximum sun light, site selection of building and green materials used in the building.

Table No. 4.5.2.2 Show total initial plantation cost of green building

Initial plantation cost of building per Square Meter	Rs.300
Total built-up area of the building	14033 Square meter
Total initial plantation cost	**Rs.4209900**

2. Water efficiency of building.

It includes treated grey water by sewage treatment plant and water saves by the water efficient fixtures.

Table No. 4.5.2.3 Show total initial plantation cost of water efficient fixtures of building

Initial plantation cost of sewage or water treatment plant of capacity 90m3	Rs.4000000 (approx.)

Total no. of water efficient flow fixtures	125
Extra cost for 25% more efficient fixtures	Rs.780 per fixture
Initial plantation cost for flow fixtures	**Rs.97500**
Initial plantation cost of flush fixtures	**Rs.97500**

3. Energy efficiency of building.

It includes solar water heater system, solar panel system, CFC free equipment, efficient luminaries and energy saving by other appliances.

Table No. 4.5.2.4 Show initial cost of energy performance of building

Lump sum total window opening area of the building cost per square meter	Rs.300
Assume total window opening area in square meter	3500
Initial cost for energy performance of building	**Rs.1050000**

Table No. 4.5.2.5 Show total initial plantation cost of solar water heating system

Cost of 5000lpd solar water heater system	Rs.300000
Total no. of solar water heaters	44
Initial cost of solar water heating system	**Rs.13200000**

Table No. 4.5.2.6 Show total initial plantation cost of solar system

Cost of 1 solar panel of 250W	Rs14000
Total no. of solar panel	400
Initial cost of solar panel system	**Rs.5600000**

Table No. 4.5.2.7 Show total initial plantation cost of efficient luminaries and lightening power

Total built-up area of building in square meter	14033
Total cost @ Rs.250 per square meter	**Rs.3508250**

Table No. 4.5.2.8 Show total initial plantation cost of energy saving by other appliances

Total built-up area of building in square meter	14033
Total cost @ Rs.10 per square meter	**Rs.140330**

4.5.2.1 Abstract for construction cost

Table No. 4.5.2.1.1 Show total construction cost of green building

Construction cost of building by including all parameters	Rs.187062978
Cost of paint per square feet	Rs.52
Total painting cost of building	Rs.7854597.4
Total construction cost of building	Rs.194917575.4
Tool & Tackles @1% of total cost	Rs.1949175.75
Water charges @2 % of total cost	Rs.3898351.5
Sanitary fittings @5% of total cost	Rs.9745878.75
Contractors profit@10% of total cost	Rs.19491757.54
Total construction cost of green building	**Rs.230002738.5**

4.5.3 Operational and maintenance cost

Table No. 4.5.3.1 Show annual operational and maintenance cost for site selection and planning criteria

Operational and maintenance cost for site selection and planning criteria per square meter	Rs.25 per square meter
Total built-up area of building	14033 square meter
Annual operational and maintenance cost	**Rs.350825**

Table No. 4.5.3.2 Show annual operational and maintenance cost of sewage treatment plant

Operational and maintenance cost of sewage treatment plant of 90m3 per month	Rs.20000
Annual operational and maintenance cost of sewage treatment plant	**Rs.240000**
Annual operational and maintenance cost of solar system	**Rs.1500**

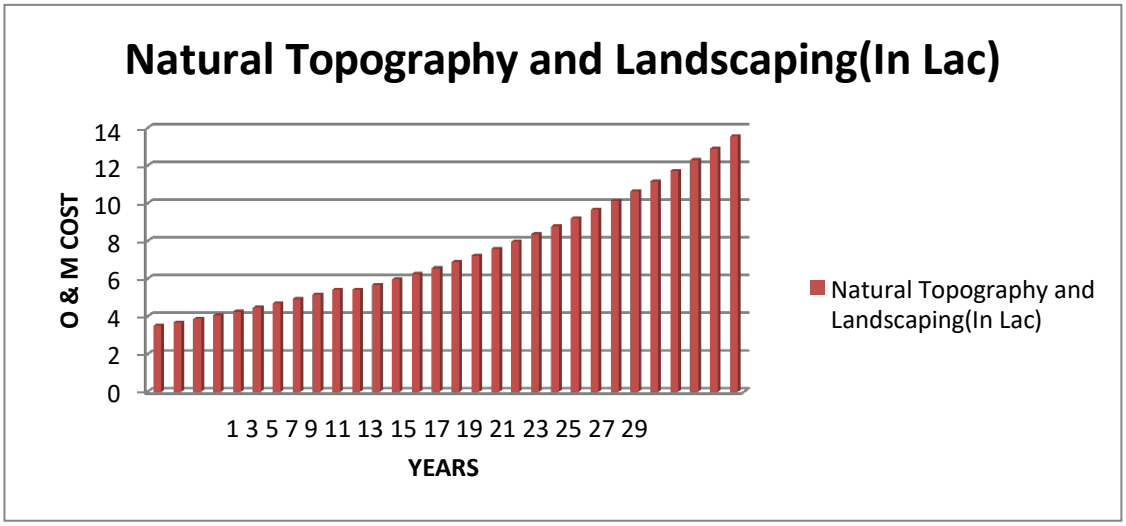


Figure No. 4.5.3.1 Show O & M cost of natural topography and landscaping (In Lac) for 30 years

This graph shows total cost involve in natural topography and landscaping of the green building for the service life of 30 years. Each column in the graph individually shows the annual operational cost for 30 years.

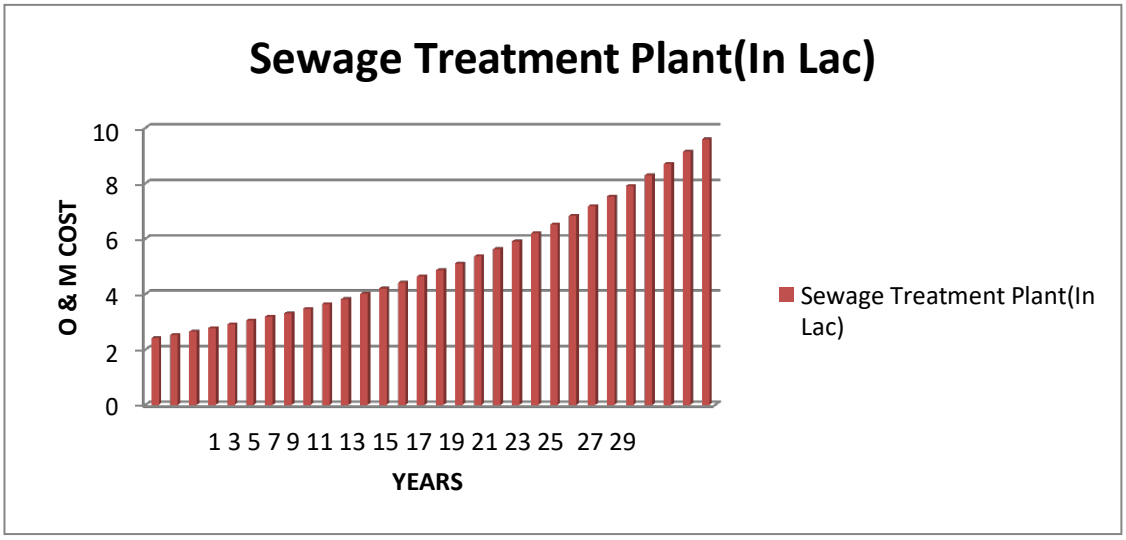


Figure No. 4.5.3.2 Show O & M cost of sewage treatment (In Lac) for 30 years

This graph shows the total operational and maintenance cost of sewage treatment plant (In Lac) for its service life of 30 years. Each column individually shows the annual operational cost for 30 years.

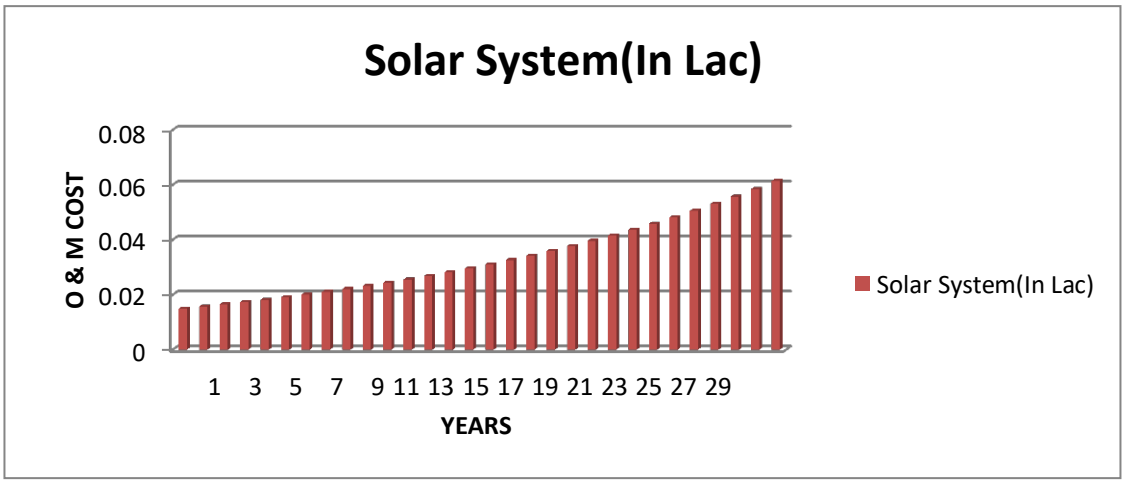


Figure No. 4.5.3.3 Show total O & M cost of solar system install in building for 30 years

This graph shows the total operational and maintenace cost of solar system of green building for 30 years of service life. Each column in the graph shows individually the operational cost for 30 years.

4.5.3.1 Abstract for Operational and Maintenance Cost for 30 years with 5% inflation

Table No. 4.5.3.1.1 Show total O & `M cost of green building for 30 years

Total electricity bill of building for 30 years	**0.9933** (In Lac)
Total water supply bill of building for 30	**155.557**(In Lac)

years	
Total cost for landscaping and planning for 30 years	**221.9**(In Lac)
Cost of major and minor repairs of building (1.5 times the construction cost of building for 30 years)	**Rs.345004107.8**
Total Operational and Maintenance Cost of building for 30 years	**Rs.382848437.8**

4.5.4 Demolition and Disposal cost

Table No. 4.5.4.1 Show total demolition and disposal cost of green building after 30 years of service life

Area to be demolished	151049 square feet
Cost of demolition per square feet	Rs. 22
Total cost of demolition of building	**Rs.3323078**
Rubble to be disposed	151049 square feet
1 truck dispose	120 square feet
For 151049 square feet total numbers of trucks required	1259 No.s
Cost of disposal per truck	Rs. 5000
Total disposal cost	**Rs. 6295000**
Total demolition and disposal cost of building	**Rs. 9618078**

4.5.5 Salvage Value

Salvage value on an average is 10% of the construction cost of a building. Thus for our project the salvage value shall be **Rs.23000273.85**

4.6 Life Cycle Cost of Green Building of area 14033 square meter

Table No. 4.6.1 Show total life cycle cost of green building after 30 years of service life

Acquisition Cost	**Rs.42000000**
Construction Cost	**Rs.230002738.5**
Operational and Maintenance Cost	**Rs.382848437.8**
Demolition And Disposal Cost	**Rs.9618078**
Salvage Value	**Rs.23000273.85**
Life Cycle Cost	**Rs.641468980.5**

4.7 COMPARISON OF COSTS

Table No. 4.7.1 Show comparison of all costs involve in life cycle of both building

COST OF	**NORMAL RESIDENTIAL BUILDING**	**GREEN RESIDENTIAL BUILDING**
Land Acquisition	Rs.42000000	Rs.42000000
Construction	Rs.192212795.9	Rs.230002738.5
Operational & Maintenance	Rs.871390220.3	Rs.382848437.8
Demolition & Disposal	Rs.9618078	Rs.9618078
Salvage	Rs.9529837	Rs.23000273.85
Life Cycle		

4.8 COMPARITIVE ANALYSIS

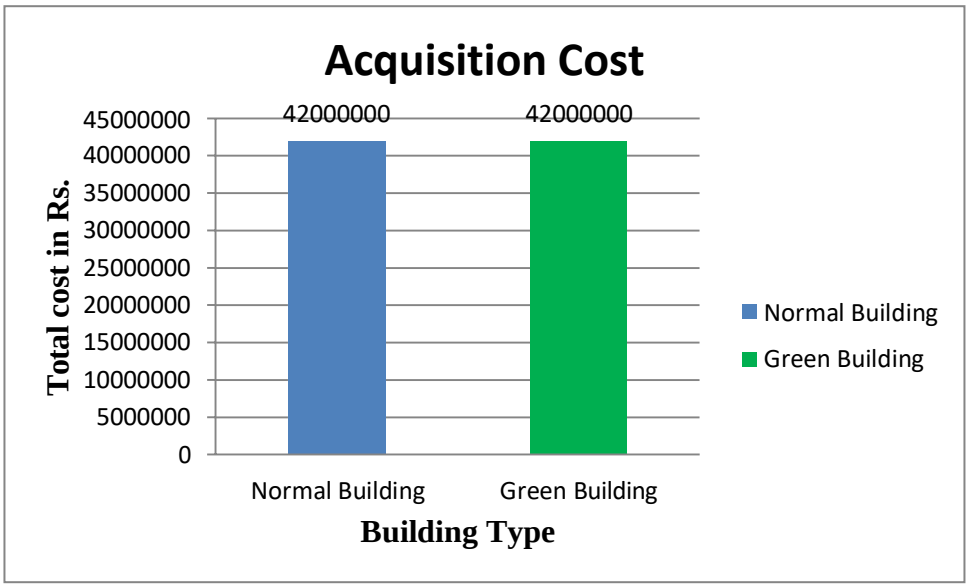


Figure No. 4.8.1 Show comparison of acquisition cost of both the building

This chart shows the comparison between acquisition cost of normal building and green building. The acquisition costs of both buildings are same equal to Rs. 42000000. This is because land acquired by both the building is same.

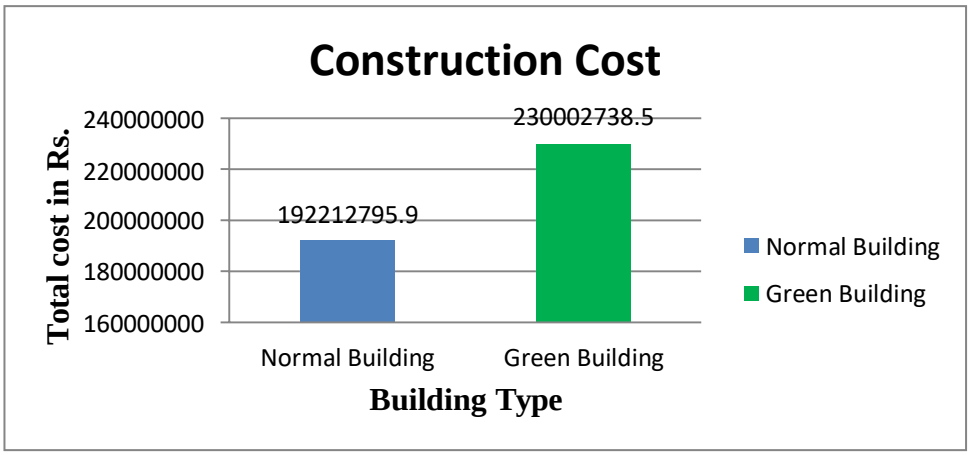


Figure No. 4.8.2 Show comparison of construction cost of both building

This chart shows the comparison of construction costs of normal and green building. The total construction cost of normal building is Rs. 192212795.9 and total cost of green building is Rs. 230002738.5. Construction cost of green building is generaly more as compared to the normal residential building because of green techniques used in structure.

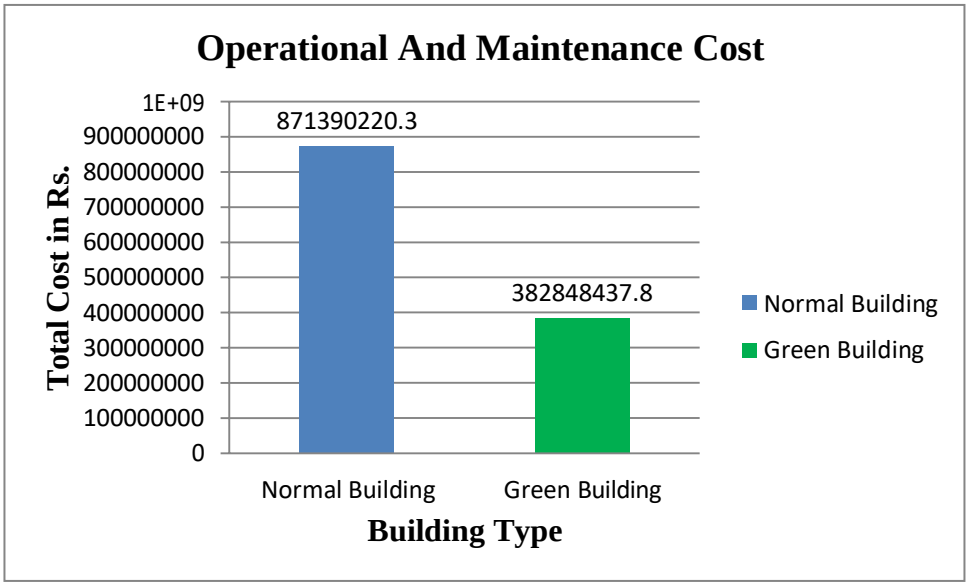


Figure No. 4.8.3 Show comparison of operational and maintenance cost of both buildings

This graph shows comparison between operational and maintenance cost of both buildings. The cost of normal building is Rs.871390220.3 and the cost of green building is Rs.382848437.8. Operational and maintenance cost of green building is less than normal building because of green techniques used in the green building. Due to these techniques the operational and maintenance cost of building is less than half of cost of normal residential building.

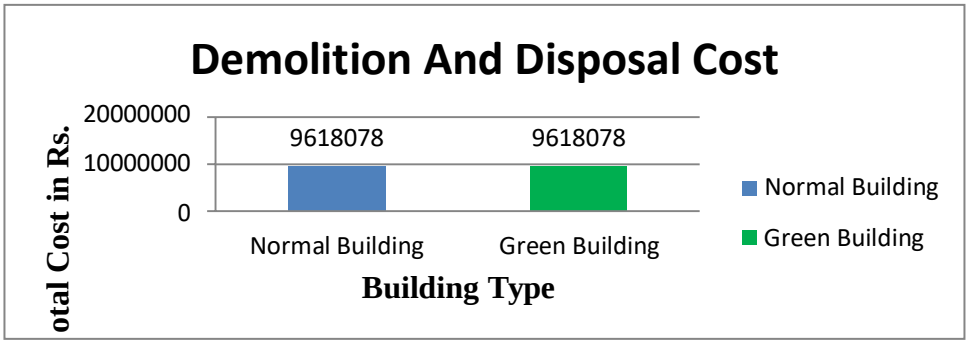


Figure No. 4.8.4 Show comparison of demolition and disposal cost of both building

This graph shows total cost of normal residential and green building for their total service life of 30 years. This cost is same for both the building because the total built-up area of both building is same. The cost of the both building is Rs. 9618078

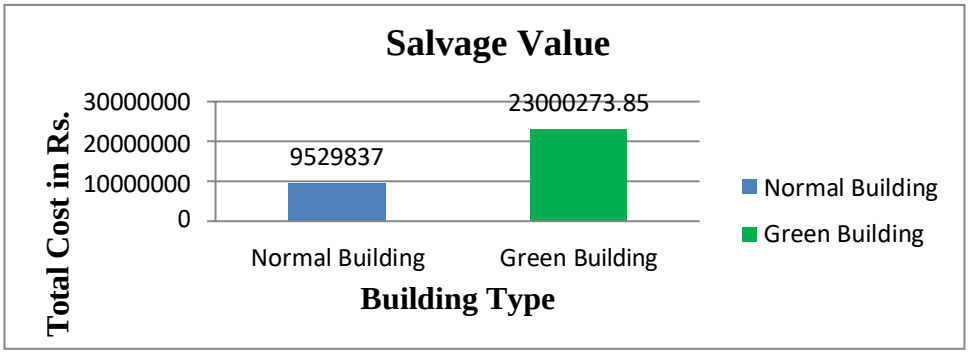


Figure No. 4.8.5 Show comparison of salvage value of both building

This chart shows the total salvage value of normal building and green building after their 30 years of service life. The total salvage value of normal residential building is Rs. 9529837 and total salvage value of green building is Rs. 23000273.85. The salvage value of green building is generally high because the resale value of green techniques and product is more than the components used in the normal residential building.

CHAPTER 5

CONCLUSIONS

5.1 GENERAL

The significant parameters that effect the life cycle of a building incorporate development cost, operational and maintenance cost and the rescue estimation of the structures.

1. Development cost of the two structures shifts significantly due to change in the material utilized for development and furthermore because of the expansion of reasonable advances in the green building.

2. Operational and maintenance cost of green building is less as compared to the normal building because in green buildings the return is higher due to implementation of green technologies in green structure.

3. To the extent more the salvage value of the green structure is concerned, this can be credited to way that the material utilized as a part of development of green building, however expensive, could be reused much more productively than typical building material, which have a restricted use.

4. Subsequently it is exceptionally find from the study that the life cycle cost of green structure and the profits related with it are more than that of normal structure. Subsequently, been the need of great importance, green building development ought to be more accentuation on and ought to be advanced.

5.2 FUTURE SCOPES

Green building industry will develop by 20 % in India in the following three years, essentially because of natural control and rising interest, a report said.

The new report finds that by 2018, the green building industry in India will develop by 20 % driven to a great extent by environmental controls and interest for more advantageous neighborhoods," USGBC said in an announcement.

Today, there are about 75,000 business ventures taking an interest in LEED over the globe, with 1.85 million sq. ft. of building space which LEED is confirming each day.

In India, there are in excess of 1,990 ventures, containing in excess of 822 million sq. ft. of

room, taking an interest in LEED.

The development of LEED mirrors its worldwide flexibility as the world's most generally utilized and perceived framework managing the plan, development, tasks and support of green structures," Mahesh Ramanujam, COO, USGBC, said.

The report found that green structures offer huge operational cost investment funds contrasted and traditional structures.

To this impact, respondents expect 14 % investment funds in operational expenses more than five year reserve funds for new green structures and 13 percent funds in operational expenses more than five years for green retrofit and redesign ventures.

Building proprietors additionally report that green structures - whether new or redesigned - summon a 7 percent expansion in resource esteem over regular structures.

REFERENCES

.

[1] Khoshbakht, M., Gou, Z., & Dupre, K. (2017). Cost-benefit prediction of green building: SWOT analysis of research methods and recent applications. *Procedia engineering, 180*,167-178.

[2] Birajdar, S. V., & Pimplikar, S. S. (2016). Study of sustainable building based on life cycle cost. *International research journal of engineering and technology, 725*,719-722.

[3] Dwivedi, A. A., Bagare, P. V., Dwivedi, A., & Gupta, S. Engineering Economics and Life Cycle Cost Analysis of Green Building. *International journal of scientific engineering and research*, *35*, 29-33.

[4] Liu, H. (2015). Evaluating Construction Cost of Green Building Based on Life-cycle Cost Analysis: An empirical analysis from Nanjing, China. *International Journal of Smart Home, 9(12)*, 299-306.

[5] Alborzfard, N. (2012). A frame work for life cycle cost analysis of sustainability features in buildings. *International TCM conference transactions, 1174.*

[6] Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., & Pennington, D. W. (2004). Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications. *Environment international, 30(5)*, 701-720.

[7] Kneifel, J. (2010). Life-cycle carbon and cost analysis of energy efficiency measures in new commercial buildings. *Energy and Buildings, 42(3)*, 333-340.

[8] Senthil Kumaran, D., Ong, S. K., Tan, R. B., & Nee, A. Y. C. (2001). Environmental life cycle cost analysis of products. *Environmental Management and Health, 12(3)*, 260-276.

[9] Shabrin, N., & Bin Abul Kashem, S. (2017). A comprehensive cost benefit analysis of

green building. *University Malaysia Sarawak, 40*, 25-35.

[10] Li, H.L., & Liu, S.H. (2016). The study about incremental cost of green building based on life cycle theory. *International conference on civil, architectural and hydraulic engineering, 928*, 922-926.

[11] Mitropoulou, C. C., & Lagaros, N. D. (2016). Life-Cycle Cost Model and Design Optimization of Base-Isolated Building Structures. *Frontiers in Built Environment*, *2*, 27.

[12] Collinge, W. O., Thiel, C. L., Campion, N. A., Al-Ghamdi, S. G., Woloschin, C. L., Soratana, K., ... & Bilec, M. M. (2015). Integrating life cycle assessment with green building and product rating systems: North American perspective. Procedia engineering, 118, 662-669.

[13] Samer, M. (2013). Towards the implementation of the Green Building concept in agricultural buildings: a literature review. *Agricultural Engineering International: CIGR Journal, 15(2)*, 25-46.

[14] Dwaikat, L. N., & Ali, K. N. (2014). Green Buildings' Actual Life Cycle Cost Control: A Framework for Investigation. In *13th Management in Construction Research Association Conference and Annual General Meeting. International Islamic University of Malaysia*.

[15] Weerasinghe, A. S., Ramachandra, T., & Thurairajah, N. (2017, September). LIFE CYCLE COST ANALYSIS: GREEN VS CONVENTIONAL BUILDINGS IN SRI LANKA. In *Proceeding of the 33rd Annual ARCOM Conference* (Vol. 4, p. 6).

[16] Bakhoum, E. S., Garas, G. L. K., Allam, M. E., & Ezz, H. (2017). The Role of Nano-Technology in Sustainable Construction: A Case Study of Using Nano Granite Waste Particles in Cement Mortar. *Engineering Journal (Eng. J.), 21(4)*, 217-227.