DESIGN OF NEW GREEN BUILIDNG USING IGBC RATNG SYSTEM

Submitted in partial fulfilment of the requirements

for the degree of

MASTER OF ENGINEERING

in

CIVIL ENGINEERING

(With specialization in Construction Engineering and Management)

by

Ashish Suresh Srivastava

(Registration Number: Anjuman-36**)**

Under the guidance of

Dr. R. B. Magar

Department of Civil Engineering

School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus

New Panvel, Navi Mumbai-410206

2017

A Dissertation Report on

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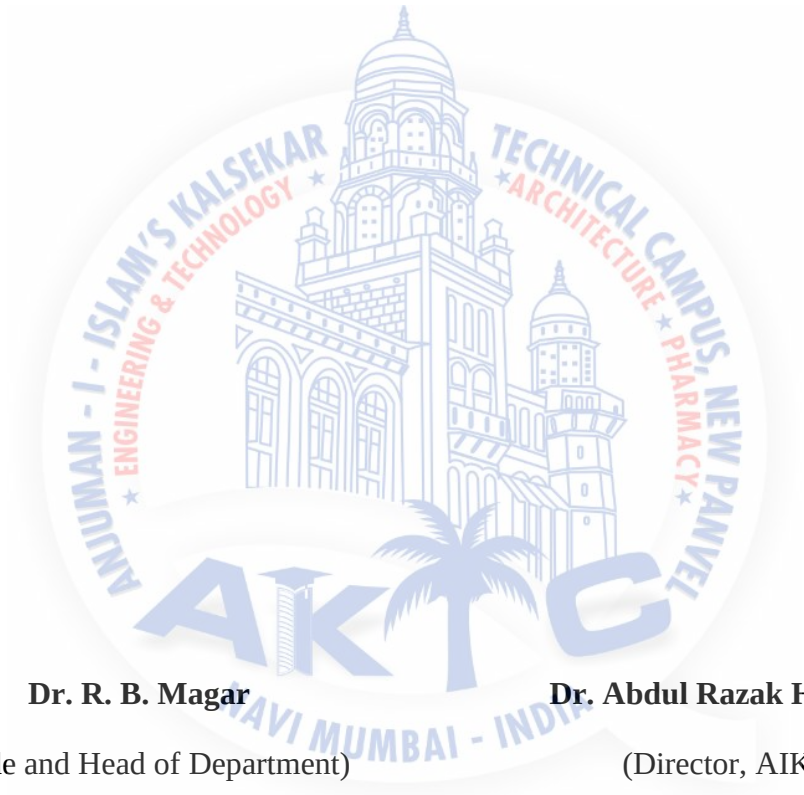
CERTIFICATE

This is to certify that the project entitled “Design of New Green Building Using IGBC Rating System” is a bonafide work of Mr. Ashish Suresh Srivastava (15CEM17) submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of “Master of Engineering” in “Civil Engineering (With Specialization in Construction Engineering and Management)”



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Dr. Abdul Razak Honnutagi (Director, AIKTC)

APPROVAL SHEET

This dissertation report entitled “Design of New Green Building Using IGBC Rating System” by Ashish Suresh Srivastava is approved for the degree of “Civil Engineering with Specialization in Construction Engineering and Management”

Examiners

1. ……

2. ……

Supervisors:

1. ……

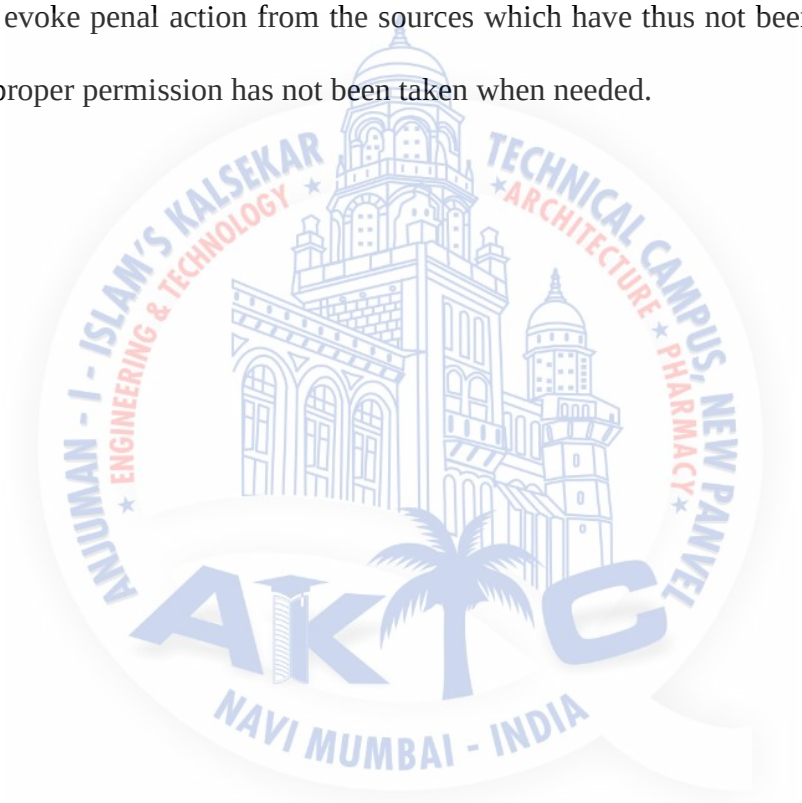
2. ……

Date:

Place: Panvel

DECLARATION

I declare that this written submission represents my ideas in our own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.



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ABSTRACT

The green building concept ensures the minimum wastage in every stage of construction and operation of the commercial building resulting in initial higher cost of approximately 16% as compared to the saving in long term with recovery within 2 to 3 years of the life cycle of the building. The green building is so planned and design so as to reduce the overall impact of construction material on natural environment and human health by efficiently using energy, water and other resources by protecting occupant's health and increasing the overall productivity of the setup, it also helps in reducing the waste, pollution and environmental degradation. The green features added and considered are minimal disturbances to landscape and site conditions, use of environmental friendly and recycled building materials, use of non-toxic and recycled/recyclable materials, efficient use of water and its recycling, use of energy efficient and eco-friendly equipment, use of renewable energy, quality of indoor air quality for human safety and comfort with efficient controls and building management system.

This study involves the evaluation of realistic rating aimed for the proposed office building, as per overall requirements as required for fulfilling the Indian Green Building Council (IGBC) rating program. This involves the identification for the reduction of greenhouse gases with financial implications and tangible benefits to a client over a life cycle period of the building in a specified time frame. To carry out the above study in accordance to American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE 90.1-2004)/ Energy Conservation Building Code (ECBC), performance rating method a simulation would considered appropriate for modeling assumptions, schedule of the project for various occupancies, air changes per hour, lighting density and U-factors for fenestration etc. is calculated.

Keywords: Green building, Sustainable building, Renewable Energy, Recyclable material.

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ABBREVIATION NOTATION AND NOMENCLATURE

IGBC	Indian Green Building Council
LEED	Leadership in Energy and Environmental Design
GRIHA	Green Rating for Integrated Habitat Assessment
TERI	The Energy and Resources Institute
ECBC	Energy Conservation Building Code
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
NBC	National Broadcasting Company
CII	Confederation of Indian Industry
IPMVP	International Performance Measurement and Verification Protocol
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
CPCB	Central Pollution Control Board
ECBC	Energy Conservation Building Code
MoEF	Ministry of Environment and Forests
CIR	Committed Information Rate
IOCL	Indian Oil Corporation Limited
AO/DO	Area office and Divisional Office
O&M	Operation and Maintenance
HVAC	Heating, Ventilation and Air Conditioning

Chapter 1

Introduction

1.1 General

Green building, also known as sustainable or high performance building is the practice of increasing the efficiency with which buildings and their sites use and harvest energy, water, and materials; and protecting and restoring human health and the environment, throughout the building life-cycle, conceptualization, design, construction, operation, maintenance, renovation and demolition. The `Green Building' concept is gaining importance in various countries, including India. These are buildings that ensure that waste is minimized at every stage during the construction and operation of the building, resulting in low costs, according to experts in the technology. The techniques associated with the `Green Building' include measures to prevent erosion of soil, rainwater harvesting, preparation of landscapes to reduce heat, reduction in usage of potable water, recycling of waste water and use of world class energy efficient practices (Kevadiya et al, 2006).

Sustainable development can be achieved by architects, engineers, town planners by working together to produce green buildings that are designed, built, renovated, operated or again used

in ecological and resource efficient manner. Green building is the call of mother earth. Green building is an approach that emphasizes the place of buildings within both local ecosystems and in global environmental also. Green building increases energy efficiency while reducing building impact on human health and environment by construction, operation and maintenance. It has become a marketing tool and most of the time is superficial practice approach based on westernized adoption. Leadership in Energy and Environmental Design (LEED) a green rating system is fully based on western. The Energy and Resources Institute (TERI), Green Rating for Integrated Habitat Assessment (GRIHA) and Energy Conservation Building Code (ECBC) are being devised but not practices very seriously. It is well known that energy efficiency and sustainability are very well interwoven and well rooted in Indian traditional architecture and Indian culture. India is a country of diversified climatic, topological and socio Cultural conditions. Each region has its own identity with climate responsive building design in the form of vernacular architecture. Lot of experimentation and local knowledge base evolution has taken place and being tested by time. Vernacular tradition recognized and encouraged, supported and serviced, complemented may prove to be the only realistic and sustainable solution for the future. (Paul, 2006). Today, the designers have ignored principles and importance of vernacular architecture. Vernacular architecture gives us the lessons about climate responsive planning techniques which can be helpful to generate green building design (Ganguly, 1993). the findings suggest that occupancy is not well understood and often incorrectly predicted during design, and that this affects various aspects of performance, including energy and water use. Also energy and water use modelling is often undertaken principally for building code/green rating compliance purposes and does not necessarily represent an accurate prediction of likely operational use (Gorgolewski et al, 2016).

1.2 Motivation of the Present Study

Motivations for building green are many and diverse but can be divided into ‘stick’ and ‘carrot’ categories. Stick elements require compliance by the building owners through provincial or local legislation such as building codes, governance requirements or financial penalties in the form of higher utility bills and emissions off-sets. Carrot elements are less easily defined but typically take the form of improved property values and improved interior environments which lead to longer tenant occupancies and green branding opportunities. One of the most interesting benefits of green office buildings is the reductions which can be achieved in absenteeism through providing a healthier working environment. The relationship between green buildings

and user wellbeing is difficult to pin down. While some organizations are forced to implement sustainable initiatives within their organizations through local or international compliance requirements, others choose to do so in order to achieve a better green profile or because such practices are deeply entrenched in their decision making processes. In many cases the buildings occupied by companies, institutions, civil services and individual entities act as a physical manifestation of their values and ethos. A sustainable building will hold its value longer. Sustainability is not only about water and energy, but about a building that makes sense in the longer term.

1.3 Scope of The Proposed Work

In view of the aforementioned problem as specified from the literature review, following scope is outlined for the present investigation. The programme prepared is intended to meet the demand for a quick, simple and affordable tool which can be utilized for the planning and assessment of the design of resource efficiency in order to escalate green building footprints in emerging markets.

1.4 Aims and Objectives

The primary aim of this investigation is to find out the maximum savings with respect to the base case consumption of electricity, water, HVAC etc. More specifically, the research has the following objectives:

1. To study IGBC rating system for new green building.
2. To study and find a methodology to appropriately calculate the credit calculations with respect to the IGBC Abridge Reference Guide.
3. To devise a method in Microsoft Excel for various options of compliances to find out the credit points.
4. To prepare a case study using Microsoft Excel Programme prepared with an existing actual green certification.

1.5 Concept of Green Building

This day and age, you hear everyone talking about going green. Whether you want to admit it or not, at some point everyone will have to follow with the green movement. This is because at

the rate we are going, the earth is simply not sustainable. That means that over the years, we will begin to run out of certain natural resources that are needed in order for us to survive. That is alarming to some people, which is why there are so many people that focus on green building. Some people may think of a green, or sustainable building as just a building that doesn't really have as bad of an impact on the environment as another 'average' building. Other people may find it to be the type of building, and the actual surroundings of the building. The ideal green building would be a building project that would allow you to preserve most of the natural environment around the project site, while still being able to produce a building that is going to serve a purpose. The construction and operation will promote a healthy environment for all involved, and it will not disrupt the land, water, resources and energy in and around the building. Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building.

Green building, or sustainable design, is the practice of increasing the efficiency with which buildings and their sites use energy, water, and materials, and of reducing impacts on human health and the environment for the entire lifecycle of a building. Green-building concepts extend beyond the walls of buildings and include site planning, community and land-use planning issues as well.

The Green Building Concept:

- Sustainable site planning
- Building Design optimization
- Energy performance optimization
- Renewal energy utilization
- Water and Waste management
- Solid waste management
- Sustainable building material and construction technology
- Health, wellbeing and environmental quality

Sustainable development can be achieved by architects, engineers, town planners by working together to produce green buildings that are designed, built, renovated, operated or again used in ecological and resource efficient manner. Green building is the call of mother

earth. Green building is an approach that emphasizes the place of buildings within both local ecosystems and in global environmental also. Green building increases energy efficiency while reducing building impact on human health and environment by construction, operation and maintenance. It has become a marketing tool and most of the time is superficial practice approach based on westernized adoption. LEED a green rating system is fully based on western. TERI GRIHA and ECBC are being devised but not practices very seriously. It is well known that energy efficiency and sustainability are very well interwoven and well rooted in Indian traditional architecture and Indian culture. India is a country of diversified climatic, topological and socio Cultural conditions. Each region has its own identity with climate responsive building design in the form of vernacular architecture. Lot of experimentation and local knowledge base evolution has taken place and being tested by time. Vernacular tradition recognized and encouraged, supported and serviced, complemented may prove to be the only realistic and sustainable solution for the future. (Paul, 2006). Today, the designers have ignored principles and importance of vernacular architecture. Vernacular architecture gives us the lessons about climate responsive planning techniques which can be helpful to generate green building design.

1.6 Benefits of Green Building

- High performance green building emerged that will prevent pollution, save energy, natural resources and money.
- The 60% cost reduction in energy expected.
- Human performed better with the skylight and windows that bring natural, non-glare light inside the classroom.
- They can reduce respiratory disease by 10 -20% and healthy occupants in Green building.
- Improved Indoor Air quality and occupant comfort due to No-VOC emissions from building materials.
- They increase occupant performance by up to 25 %
- Their occupants have 15% less absenteeism compared to those in building.
- To Improved Productivity
- Green Building have higher market value.
- Tax benefits for Green Building.
- To Improved Retail sales.
- The Lower Utility Demands in green buildings.

1.6.1 Environmental Benefits

- **Emissions Reduction:** Pollutants released by fossil fuel fired electricity contribute to global climate change, cause air quality issues such as acid rain and smog, and pose risks to human health. Green building techniques like solar powering, daylighting, and facilitation of public transport increase energy efficiency and reduce harmful emissions.
- **Water Conservation:** Recycling rainwater and greywater for purposes like urinal flow and irrigation can preserve potable water and yield significant water savings.
- **Stormwater Management:** Stormwater runoff can cause waterway erosion, flooding, and carry pollutants into water sources. Harvesting and redirecting stormwater, building surfaces with permeable materials, and using green roofscan control and utilize overflow.
- **Temperature Moderation:** The heat retention properties of tall buildings and urban materials such as concrete and asphalt are the primary causes of urban heat island effect. These conditions may be offset by conscientious building design and site selection, as well as planting trees to accompany new developments.
- **Waste Reduction:** Construction and demolition generates a huge portion of solid waste in the United States. Building deconstruction as an alternative to full-scale demolition results in massive decreases of waste production.

1.6.2 Economic Benefits

A common impression about green building is that the green premium is too expensive to be considered economically feasible. However, studies have shown that the costs of green buildings are not substantially higher than regular development projects. Higher construction costs can generally be avoided by the inclusion of green design from the outset of the project. Additionally, green buildings provide an assortment of economic advantages.

- Energy and Water Savings: The resource efficiency provided by green design and technology leads to drastic reductions in operation costs that quickly recoup any additional project costs and continue to offer dramatic long-term savings (see statistics). Money previously directed toward utility costs may be used for other purposes.
- Increased Property Values: With energy costs on the rise, the low operating costs and easy maintenance of green buildings make for lower vacancy rates and higher property values.
- Decreased Infrastructure Strain: Efficient buildings exert less demand on the local power grid and water supply, stretching the capacity of local infrastructure.

- Improved Employee Attendance: Green design emphasizes increased natural lighting and control of ventilation and temperature-attributes that improve employee health and prevent absences. The U.S. Environmental Protection Agency reports major reductions in health care costs and work losses resulting from commonly recommended improvements to indoor environments (see statistics).
- Increased Employee Productivity: Employee productivity has been positively correlated to indoor environmental conditions, and shows improvements where green principles have been applied (see statistics).
- Sales Improvements: Studies show better sales in stores that utilize natural light. Retailers are increasingly using daylighting in an effort to harvest the associated sales benefits.
- Development of Local Talent Pool: With increased attention being paid to global climate change and the need for renewable energy sources, the field of building design and construction is moving toward sustainability as a permanent objective. As of July 2007, 23 states and more than 80 cities have legislated green standards for municipal buildings. Building green in Bloomington is an investment in the local economy, helping to foster a local talent pool: designers and builders experienced with green projects able to accommodate the growing market demand for sustainable development.

1.6.3 Social Benefits

- Improved Health: Poor indoor environmental quality (IEQ) resulting from insufficient air circulation, poor lighting, mold build up, temperature variances, carpeting and furniture materials, pesticides, toxic adhesives and paints, and high concentration of pollutants (typically 10 to 100 times higher than outdoors contribute widely to respiratory problems, allergies, nausea, headaches, and skin rashes. Green building emphasizes ventilation and non-toxic, low emitting materials that create healthier and more comfortable living and working environments.
- Improved Schools: An estimated 40% of schools in the United States are subject to poor environmental conditions that compromise the health and learning of students. The healthier environment and atmosphere in school buildings utilizing green design and construction principles is shown to lead to significant reductions in student absenteeism and improvements in test scores (see statistics).
- Healthier Lifestyles and Recreation: A key element of sustainable design is the preservation of natural environments, which afford a variety of recreation and exercise

opportunities. Green buildings also seek to facilitate alternatives to driving, such as bicycling and public transport, which eases local traffic while encouraging personal health and fitness.

1.7 Indian Green Building Council

It is important to note that the mandatory requirements and credits earned at the preliminary review is only considered as expected. These mandatory requirements and credits are not awarded until the final documents are submitted, along with additional documents showing implementation of design features. If there are changes in any 'expected credits' after preliminary review, these changes need to be documented and resubmitted during the final review.

1.8 Organization of dissertation

This dissertation has been arranged in seven chapters. A brief description of each chapter is given below.

Chapter 1 provides the general information of green building. The importance of the present study is described. Objectives of this research work, motivation of the study and the scopes of the present study have been explained in this chapter.

Chapter 2 provides a detailed review of literature about the green building by various referred journals and summary of the same.

Chapter 3 presents the detailed information of Indian Green Building Council (IGBC), benefits, rating system of IGBC, features, process of certification and overview of rating system.

Chapter 4 presents the methodology adopted and work flow of the study with the help of flow chart.

Chapter 5 describes the case study which includes the introduction, site location, site analysis architectural analysis, salient design feature of site and conclusion of the case study.

Chapter 6 describes the results and discussions which is obtained from case study.

Chapter 7 presents the brief summary and conclusion of the study based on results achieved through IGBC rating system.

Chapter 2

Literature Review

2.1 General

The various journal papers have been reviewed and is bought in a nut shell as given below, the studies conducted by the authors from all over the world on the sustainability and sub-topics of sustainability have been studied. The summary of the research papers has been reviewed in the end.

2.2 Overview of Literature Review

The environmental progress concept was commenced from 1970s and later in 1990 the green revolution commenced which raise the attention of the globe in the importance of preservation of environment and the role of human activities for environmental protection (Andrew 2010). It is certain that progress for these activities is upgrading but embarrassingly influence is not much in developing countries in compare to that of developed countries which are aware and have make their own rules and regulation as per their needs. In developing countries like Nepal,

India, Bhutan etc. we can observe the growth of infrastructure is tremendously increasing day by day so we need to be aware about the fact that environment which is the key factor must not be violated instead any construction in collaboration with the environment must be our main objective. It is expected that India alone is growing in the construction industry by average of 9.5% which is covering 5% of global. We can't neglect the fact that the construction practice which is going on is creating lots of problem as many resources are being destroyed, non-renewable resources are widely used, people are occupying the space and leading for deforestation whish are best instance in which environment are not considered at all. We must be aware that without environment our existence is impossible so it's time to work out so that we can create a situation in which people will consider environment more than their needs. Researchers around the globe are much more worried about the destruction that is taking place so as to rectify an engineering concept is being forwarded as Green building which indicates consider green (environment) and construct the houses applying Green building technology (Rebecca 2004). Green Building can be considered in tremendous way as we can preferably have called as Sustainable house or eco- friendly house, intelligent building and other tantamount things which overall give the reflection of a highly sophisticated and best performance building having high impact in human being and environment. It aids a lot to improve our health considering environment as the key factor which is today's main attention to be given in global arena. These types of building are considered for human comfort by conserving the environment which helps to increase the overall performance of life. This is nothing but the intellectual and creative use of the mind where simple things are given more priority and use of locally available materials and selection of more astute material in construction is its main motto. This technology is spreading rapidly all over the world and people are more prone to this technology. The need of this type of technology in developing countries has become more crucial nowadays. There are different organizations which are being associated with this technology and are responsible for spreading worldwide like US Green Building Council (USGBC) which is third party certification ,Bureau of Energy Efficiency (BEE), Indian Green Building Council and several other non-profitable government organization and they have also profoundly studied and came with good outcomes as green buildings are proven to be environmental friendly with lots of its merits in environment which indicate that mankind activities are leading for the detonation of component of the society but at the same time this can be rectified by giving more priority to environment which indeed aids a lot in reducing consumption of natural resources, pollution and waste and also improves the

health of people as per UNEP report forwarded in 2007 (National Association of Home Builders, 2009)

Robichaud and Anantatmula (2011), researched the cost and the trends of the green building for the greening management practices in the construction industry within acceptable cost constraint using matrix analysis and concluded with a guideline to be adopted while pursuing the green building. Throughout the design, construction, operation, and end-of-life-cycle processes that make up a building's life, the built environment of which it is a part exerts both positive and negative impacts on the earth, its resources, the people that live on it, and their communities. As part of the effort to reduce these negative environmental impacts and maximize benefits, the concept of "sustainability" has gained widespread acceptance over the past twenty years, encompassing ecological, economic and social aspects of the built environment (Ahn and Pearce 2007). In the building sector, green design and construction practices include: increasing efficiencies, thereby saving energy, water, and other resources; furnishing satisfying, productive, healthy, and high quality indoor spaces; using environmentally preferable materials; and educating building occupants about efficiency and conservation (Ahn & Pearce 2007; Kibert 2008). Mandatory restrictions will have to be imposed in the Govt. Policies regarding energy/water use and CO2 emissions (Gaur et al. 2015). Aside from energy/water efficiency, many other significant sustainability improvements can be made in existing buildings in terms of resource use, waste reduction via recycling programs (Shishri and Singh 2014). Sustainable purchasing policies, procurement, and ongoing operations and maintenance procedures which will improve a building performance (Shishri and Singh 2015; Sunita et al. 2015). According to Kohler (1999), sustainable building has three dimensions: ecological, cultural and economic sustainability.

There is no unique definition for green building in world. According to U.S. Green Building Council (2003), green building is defined as," Buildings that are designed, constructed and operated to boost environmental, economic, health and productivity performance over conventional building". According to Mc. Graw Hill Construction (2006) green building defined as," The careful design, construction, operation and reuse or removal of the built environment in an environmentally, energy-efficient and sustainable manner; may be used interchangeably with high performance building, green building, whole building design, sustainable building and sustainable design". According to Kohler (1999), sustainable building has three dimensions: ecological, cultural and economic sustainability. Depending upon the type of country due to regional variations expectation of people also changes likewise culture

also important aspect in achieving sustainability. Savings in energy consumption (about 25%-30%) without sacrificing the comfort levels (Garg, 2011; Greenomics, 2008).

Green buildings represent the response of the building sector to the need to minimize negative environmental, social, and economic impacts in the building sector. Through using green building practices, it is possible to work toward the aim of "meeting the needs and aspirations of today without compromising the ability of future generations to meet their own needs" (Brudtlland 1989). To achieve a green building, green design and construction strategies should be incorporated at the planning stage to the demolition phase of the building. A green building relies upon a fully integrated "whole building" approach that covers the entire phase of building cycle including design, construction, operation, and demolition (Boecker, et al. 2009).

Multiple studies have demonstrated how green buildings that incorporate green building practices offer benefits. For example, they can help mitigate building issues and problems, including environmental problems associated with existing buildings, and also provide healthier indoor environments to building users, (Ahn, et al. 2011).

The U.S. federal government and other third-party organizations, like the U.S. Green Building Council USGBC, have commissioned surveys, reports, and analyses to prove the environmental benefits of green building (U.S. Green Building Council 2006a, b). According to the Department of Energy, there were more than 76 million residential and 5 million new green buildings in 2002 in the U.S. (U.S. Green Building Council 2003). The built environment in the U.S. accounts for 30% of greenhouse gas emissions, 12% of potable water consumption, 70% of electricity consumption, and 39% of all energy use (U.S. Green Building Council 2006).

According to the Department of Energy, there were more than 76 million residential and 5 million new green buildings in 2002 in the U.S. (U.S. Green Building Council 2003). The built environment in the U.S. accounts for 30% of greenhouse gas emissions, 12% of potable water consumption, 70% of electricity consumption, and 39% of all energy use (U.S. Green Building Council 2006). TERI-GRIHA which is modified to GRIHA as national rating system after incorporating various modifications suggested by a group of architects and experts. So far 203 buildings received certification under LEED-INDIA rating system (GRIHA) that comprises of around 1 Billion square footages of built up area. GRIHA has certified 8 buildings so far and another 67 buildings are under review for certification awareness about green building construction is increasing day by day, thanks to IGBC, TERI and CII (Confederation of Indian Industries) efforts, (Balakrishna 2011).

Buildings have a significant and continuously increasing impact on the environment since they are responsible for a large portion of carbon emissions and also use considerable number of resources, Montoya (2009). Buildings account for one-sixth of the world's fresh water withdrawals, one quarter of its wood harvest, and two-fifths of its material and energy flows, Roodman and Lenssen (1995).

2.3 Summary

Green building concept gives tangible and non-tangible benefits from the stage of conceptualization of the project till the full useful life of the building, though initially in few projects the construction cost is higher than the base cost by approximately 16%, but this can be recovered within 2-3 years of the lifecycle of the building by the way of saving in the operation of the green building, thus it can be concluded that, the initial impact of the higher cost is negligible as compared to the total cost and operation of the building. A considerable saving of potable water can be achieved as compared to the base case for 12% or more of saving is potable water. Also saving in energy of about 30% to 50% of base case can be achieved using sustainable designs, which considerably reduces the consumption of electricity by around 70% as compared to the base case electricity consumption. The sustainable design has a considerable effect of ecological, cultural and economic sustainability of any society.

Chapter 3

Indian Green Building Council (IGBC)

3.1 Green Building Movement in India

The green building movement started in India in year 2001, when a new green building of 20,000sq.ft. was conceptualizing and constructed in Hyderabad in accordance to LEED where 56 points out of 59 points attempted were achieved, today we have more than 3939 green projects, which accounts to approximately 4.48 billion sq. ft. of construction area are in pipeline. The Table 3.1 shows the comparative figures of 2001 and till date for various benchmarks and professionals involved in green building movement.

Table 3.1 Green building movement in India (*source:* IGBC)

Sr. No.	Criteria	2001	Till Date
1	CEOS & senior people involved	50	12,000
2	No. of professionals trained on Green Building concepts	10	25,000
3	No. of registered Green Buildings	1	3,939
	Built – in Area (sq. ft.)	20k	4.48 Billion
4	Green Building products & equipment	5	150
5	IGBC Member Organizations (Founding Members)	0	2,101 (147)
6	IGBC Local chapters	0	21
7	IGBC Accredited professionals	0	2,209

3.2 Growth of green Buildings Over the years

The Figure 3.1 below shows the growth of all types of building all over country from year 2002 to 2016.

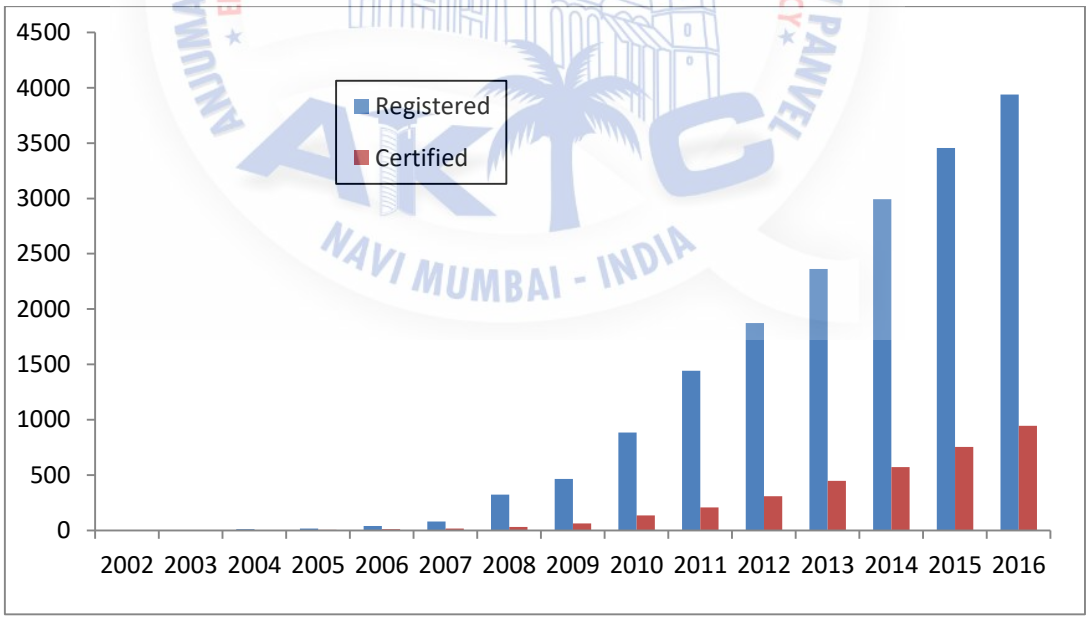

Figure 3.1 Growth of green building over the year (*source:* IGBC)

The above figure shows all types of buildings over the country, which includes Airports, Banks, Collages, Convection Centres, Factories, Hospitals, hotels, Institutions, IT Parks, Offices, Residential, Schools, SEZs, Townships.

3.3 What is Green?

In Pursuit of an activity the green building necessarily compliance with the following:

1. Energy Efficiency
2. Use of Recycled /recyclable Products
3. Use of renewable Energy
4. Water efficiency

The above ultimately leads to sustainable development.

3.4 Sustainable Development

Use of Resources to meet our Needs without depriving the Resources for future generations. The goals of sustainable development as set by united nation are set as 17 global goals which are as follows, no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace justice and strong institutions and partnership for the goals. Most of the above are developments based on sustainability which are meant for green societies.

Figure 3.2 Sustainable development

3.5 Green Building Vs Conventional Building

There is no difference in green building and conventional building since externally both the buildings look alike and the utility or the use of both the buildings are same. The difference in green building and conventional building is that, the green building conserves the natural resources and has a planning and environment for human comfort and good indoor environment with respect to light and ventilation along with saving on the operation of the building.

Figure 3.3 Green building vs conventional building

3.6 Tangible Benefits

The tangible benefits are the direct benefits with respect to the reduced operational cost, optimized lifecycle economic performance and sustained saving in energy of 30% to 50%, in water 20% to 30%, nowadays due to planning at the conceptualization stage and maximum use of recycled or recyclable material. The initial investment is coming out to be even lesser than a conventional building.

3.7 Benefits Experienced in Green Buildings

The Table 3.2 below shows the first 3 platinum rated buildings monitored to validate tangible benefits which were far exceeding the initial estimates.

Table 3.2 Benefits of energy saving in green building (*source:* IGBC)

Building	Sq. ft.	Normal Building (kwh)	Actual Building (kwh)	% Reduction	Annual Energy Savings (Rs in Lakhs)
Wipro	1,75,000	48,00,000	31,00,000	40%	102
ITC	1,70,000	35,00,000	20,00,000	45%	90
CII Godrej GBC	20,000	3,50,000	1,30,000	63%	9

Energy consumption depends on Local climate, Density of occupancy, occupancy schedule, orientation of the building, Internal loads

3.8 Intangible Benefits of Green Design

The intangible benefits are the benefits which are not related to the cost of the building, these benefits are the benefits which are indirectly gained through environmental benefits, reduced impact on environment, health and safety of the occupants which enhances the occupant comfort thereby improving the productivity of the occupants and the profit for the organization. Environmental benefits are

3.9 Do Green Buildings Cost More?

The cost of a green building in today's world is dependent on the green features and the value addition made for sustainability and the level of rating to be complied for the building.
The operational savings of a green building offsets the increased in initial investment for any green building. Table 3.3 shows the incremental cost of green building and the payback period from year 2003 to 2010, which clearly shows the declined in the initial investment due to use of recycled or recyclable material which is impacting on lower payback period.

Table 3.3 Cost of Green Buildings India Experiences

Building	Year awarded	Built-in Area (sq. ft)	Rating Achieved	% increase in cost	Payback (Yrs)
CII-Godrej GBC, Hyderabad	2003	20,000	Platinum	18 %	7 years
ITC Green Centre, Gurgaon	2004	1,70,000	Platinum	15 %	6 years
Wipro, Gurgaon	2005	1,75,000	Platinum	8 %	5 years
Technopolis, Kolkata	2006	72,000	Gold	6 %	3 years
Spectral Services consultant's office, Noida	2007	15,000	Platinum	8 %	4 years
Kalpataru Square	2008	3,00,000	Platinum	2 %	2 years
Suzlon one Earth, pune	2010	8,00,000	Platinum	2 %	2 years

3.10 What Green Buildings did differently?

The green building includes the integrated holistic design approach of team to create a sustainable building with a focus on recycled or recyclable materials, indoor air quality, site preservations apart from savings in energy and water. The process has created an environment for bettering the standards like NBC, ECBC / ASHRAE, IPMVP, SMACNA. The air-conditioning tonnage rate has been extended up to 600 per sq. ft in newer building by use of passive cooling and radiant cooling technologies and higher COP values of chillers or use of solar air conditioning and etc.

The conservation of water is achieved by providing metering for various areas and uses, by use of low consumption sanitary fittings and water less urinals. The waste water can be recycled for horticulture purpose by use of water treatment plants or use of root zone treatment systems using grey water. The natural lighting can be maximised by provision of passive architectural design and use of light pipes for indoor areas and basement areas. The use of recycled and recyclable construction materials like fly ash blocks and etc. can reduce the impact on natural resources. The solar irradiations or the heat transfer to indoor areas can be avoided by use of insulated walls, insulated roofs and insulated glazing for direct sun light areas. The indoor environmental quality can be enhanced by use of low emitting materials for paints, sealant and adhesives. The use of recycled and local materials reduces the overall impact on natural

resources. To achieve the above specialised tools and simulation methods for light, energy and ventilation are required to be used.

3.11 Information about IGBC Green Buildings Rating Systems

The IGBC green building rating system defines the scope of green building, it also recognises the achievement on green concepts with respect to consideration of local areas and thereby transform the markets to green and emphasize the use of green products in green building and day to day life.

3.12 General

The building sector in India is growing at a rapid pace and contributing immensely to the growth of the economy. This augurs well for the country and now there is an imminent need to introduce green concepts and techniques in this sector, which can aid growth in a sustainable manner.

The green concepts and techniques in the building sector can help address national issues like water efficiency, energy efficiency, reduction in fossil fuel use for commuting, handling of consumer waste and conserving natural resources. Most importantly, these concepts can enhance occupant health, productivity and well-being.

Against this background, the Indian Green Building Council (IGBC) has launched 'IGBC Green New Buildings rating system® to address the national priorities. This rating programme is a tool which enables the designer to apply green concepts and reduce environmental impacts that are measurable. The rating programme covers methodologies to cover diverse climatic zones and changing lifestyles.

IGBC has set up the Green New Buildings Core Committee under the leadership of Ar. Raghavendran, to develop the rating programme. This committee comprised of key stakeholders, including architects, builders, consultants, developers, owners, institutions, manufacturers and industry representatives. The committee, with a diverse background and knowledge has enriched the rating system, both in its content and process.

3.13 Benefits of Green New Buildings

Green New buildings can have tremendous benefits, both tangible and intangible. The most tangible benefits are the reduction in water and energy consumption right from day one of occupancy. The energy savings could range from 20 - 30 % and water savings around 30 - 50%. The intangible benefits of green new buildings include enhanced air quality, excellent daylighting, health & well-being of the occupants, safety benefits and conservation of scarce national resources.

3.14 National Priorities Addressed in the Rating System

The IGBC Green New Buildings rating system addresses the most important national priorities which include water conservation, handling waste, energy efficiency, reduced use of fossil fuels, lesser dependence on usage of virgin materials and health & well-being of occupants. The rating system requires the application of National standards and codes such as the NBC, ECBC, MoEF guidelines, CPCB guidelines, and several others. The overarching objective is to be better than the national standards so as to create new benchmarks.

3.14.1 Water Conservation

Most of the Asian countries are water stressed and in countries like India, the water table has reduced drastically over the last decade. IGBC Green New Buildings rating system encourages use of water in a self-sustainable manner through reduce, recycle and reuse strategies. By adopting this rating programme, green new buildings can save potable water to an extent of 30-50%.

3.14.2 Handling of Consumer Waste

Handling of waste in buildings is extremely difficult as most of the waste generated is not segregated at source and has a high probability of going to landfills. This continues to be a challenge to the municipalities which needs to be addressed. The rating system intends to address this by encouraging buildings to segregate the building waste.

3.14.3 Energy Efficiency

The building sector is a large consumer of electrical energy. Through IGBC Green New Buildings rating system, buildings can reduce energy consumption through energy efficient - building envelope, lighting, air conditioning systems, etc., The energy savings that can be realised by adopting this rating programme can be to the tune of 20 - 30%.

3.14.4 Reduced Use of Fossil Fuels

Fossil fuel is a slowly depleting resource, the world over. The use of fossil fuel for transportation has been a major source of pollution. The rating system encourages the use of alternate fuel vehicles for transportation.

3.14.5 Reduced Dependency on Virgin Materials

The rating system encourages projects to use recycled & reused material and discourages the use of virgin materials, thereby, addressing environmental impacts associated with extraction and processing of scare natural resources.

3.14.6 Health and Well-being of Occupants

Health and well-being of occupants are the most important aspect of IGBC Green New Buildings rating system. The rating system ensures adequate ventilation, daylight and occupant well-being facilities which are essential in a building. The rating system also recognises measures to minimise indoor air pollutants.

3.15 IGBC Green New Buildings Rating System

IGBC has set up the Green New Buildings Core Committee to develop the rating programme. This committee comprised of key stakeholders, including architects, builders, consultants, developers, owners, institutions, manufacturers and industry representatives. The committee, with a diverse background and knowledge has enriched the rating system, both in its content and process.

3.15.1 Features

IGBC Green New Buildings rating system is a voluntary and consensus based programme. The rating system has been developed based on materials and technologies that are presently available. The objective of IGBC Green New Buildings rating system is to facilitate a holisitc approach to create environment friendly buildings, through architectural design, water efficiency, effective handling of waste, energy efficiency, sustainable buildings, and focus on occupant comfort & well-being. (IGBC, green new building rating system, Abridge guide, version 3.0)

The rating system evaluates certain mandatory requirements & credit points using a prescriptive approach and others on a performance based approach. The rating system is evolved so as to be comprehensive and at the same time user-friendly. The programme is fundamentally designed to address national priorities and quality of life for occupants.

Some of the unique aspects addressed in this rating system are as follows:

- Recognition for architectural excellence through integrated design approach.
- Recognition for passive architectural features.
- Structural design optimisation with regard to steel and cement. This is a developmental credit. Projects are encouraged to attempt this credit, so as to help IGBC in developing baselines for future use.
- Water use reduction for construction. This is also a developmental credit.
- Based on the feedback from green building proponents, use of certified green products will be encouraged. IGBC has launched a new initiative to certify green products to transform markets. Products would be evaluated right from extraction to disposal.
- Handholding from IGBC Counsellors will now be available for the projects.
- A site visits and audit is proposed before award of the rating.
- Projects are encouraged to report energy and water consumption data on an annual basis, to facilitate research in this area.

3.15.2 Scope

IGBC Green New Buildings rating system is designed primarily for new buildings, both for air-conditioned and non-air-conditioned buildings. New Buildings include (but are not limited to) offices, IT parks, banks, shopping malls, hotels, hospitals, airports, stadiums, convention

centres, educational institutions (colleges, universities), libraries, museums, etc., Building types such as residential, factory buildings, schools, integrated townships will be covered under other IGBC rating programmes. IGBC Green New Buildings rating system is broadly classified into two types:

(1) Owner-occupied buildings are those wherein 51% or more of the building's built-up area is occupied by the owner.

(2) Tenant-occupied buildings are those wherein 51% or more of the building's built-up area is occupied by the tenants.

Based on the scope of work, projects can choose any of the above options.

3.15.3 The Future of IGBC Green New Buildings Rating System

Many new green building materials, equipment and technologies are being introduced in the market. With continuous up-gradation and introduction of new green technologies and products, it is important that the rating programme also keeps pace with current standards and technologies. Therefore, the rating programme will undergo periodic revisions to incorporate the latest advancement and changes. It is important to note that project teams applying for IGBC Green New Buildings rating system® should register their projects with the latest version of the rating system. During the course of implementation, projects have an option to transit to the latest version of the rating system.

IGBC will highlight new developments on its website (www.igbc.in).

3.16 Overview and Process

IGBC Green New Buildings rating system® addresses green features under the following categories:

- Sustainable Architecture and Design
- Site Selection and Planning
- Water Conservation
- Energy Efficiency
- Building Materials and Resources
- Indoor Environmental Quality
- Innovation and Development

The guidelines detailed under each mandatory requirement & credit enables the design and construction of new buildings of all sizes and types (as defined in scope). Different levels of green building certification are awarded based on the total credits earned. However, every green new building should meet certain mandatory requirements, which are non-negotiable.

3.16.1 When to use IGBC Green New Buildings Rating System

IGBC Green New Buildings rating system® is designed primarily for New Buildings (owner-occupied and tenant-occupied).

The project team can evaluate all the possible points to apply under the rating system using a suitable checklist (Owner-occupied buildings and Tenant-occupied buildings). The project can apply for IGBC Green New Buildings rating system certification, if the project can meet all mandatory requirements and achieve the minimum required points.

3.16.2 Registration

Organisations interested in registering their projects under IGBC Green New Buildings rating system Certification are advised to first register on IGBC website (www.igbc.in) under 'IGBC Green New Buildings Rating System' tab. The website includes information on registration fee for IGBC member companies as well as non-members.

Registration is the first step which helps establish initial contact with IGBC and provides access to the required documents, templates, important communications and along with other necessary information.

IGBC website provides all important details on IGBC Green New Buildings rating system® registration & certification - process, schedule and fee.

3.16.3 Certification

To achieve the IGBC Green New Buildings rating, the project must satisfy all the mandatory requirements and the minimum number of credit points.

The project team is expected to provide supporting documents at preliminary and final stage of submission, for all the mandatory requirements and the credits attempted.

The project needs to submit the following:

1. General information about project, including Project brief stating project type, different type of spaces, occupancy, number of floors, area statement, etc., General drawings (in PDF format only) and Photographs / Rendered images
2. Filled-in templates
3. Narratives and supporting documentation such as drawings, calculations (in excel sheets), declarations / contract documents, purchase invoices, manufacturer cut-sheets / letters / material test reports, etc., for each mandatory requirement and credit.

The threshold criteria for certification levels are as under:

Table 3.4 Criteria for certification level (*source:* IGBC)

Certification Level	Owner-occupied Buildings	Tenant-occupied Buildings	Recognition
Certified	40 - 49	40 - 49	Best Practices
Silver	50 - 59	50 - 59	Outstanding Performance
Gold	60 - 74	60 - 74	National Excellence
Platinum	75 -100	75 - 100	Global Leadership

IGBC will recognise Green New Buildings that achieve one of the rating levels with a formal letter of certification and a mountable plaque. Certification Process indicating Certification level

3.16.4 Pre-certification

Projects (Tenant - occupied Buildings) by developers can register for Precertification. This is an option provided for projects aspiring to get Precertified at the design stage. Precertification also gives the developer a unique advantage to market the project to potential buyers.

The documentation submitted for precertification must detail the project design features which will be implemented. The rating awarded under precertification is based on the project's intention to conform to the requirements of IGBC Green New Buildings rating system. It is important to note that the precertification rating awarded need not necessarily correspond to the final rating. Pre-certified projects are required to provide the status of the project to IGBC, in relation to the rating, once in every six months until the award of the final rating.

3.16.5 Credit Interpretation Ruling (CIR)

In some instances, there is a possibility that the design team may encounter certain challenges in applying or interpreting a mandatory requirement or a credit. It can also happen in cases where the project can opt to achieve the same intent through a different compliance route.

To address this, IGBC uses the process of Credit Interpretation Ruling (CIR) to ensure that interpretations are consistent and applicable to other projects as well.

The following are the steps to be followed in case the project team encounters any difficulty:

- Refer the Abridged Reference Guide for description of the credit intent and compliance options.
- Review the intent of the mandatory requirement / credit and self-evaluate whether the project satisfies the intent.
- Review the Credit Interpretation Ruling web page for previous CIRs on the relevant mandatory requirement or credit. All projects registered under IGBC Green New Buildings rating system will have access to this page.
- If a similar CIR has not been addressed or does not answer the question sufficiently, submit a credit interpretation request. Only registered projects are eligible to post credit interpretation request. Two CIRs are answered without levying any fee, and for any CIR beyond the first two CIRs, a fee is levied.

3.16.6 Appeal

In rare cases, mandatory requirements / credits get denied due to misinterpretation of the intent. On receipt of the final review and if the project team feels that sufficient grounds exist to appeal a credit denied in the final review, the project has an option to appeal to IGBC for reassessment of denying mandatory requirements /credits. The documentation of the mandatory requirements / credits seeking appeal may be resubmitted to IGBC along with necessary fees. IGBC will take 30 days to review such documentation. If an appeal is pursued, please note that a different review team will be assessing the appeal documentation.

3.16.7 Fee

Registration, Precertification / Provisional Certification, Certification and CIR fee details are available on the IGBC website (www.igbc.in) or can be obtained from IGBC (igbc@cii.in).

3.16.8 Updates and Addenda

As the rating system continues to improve and evolve, updates, addenda and errata to the abridged reference guide will be made available through IGBC website. The additions thereof will be suitably incorporated in the next version of the rating system.

Chapter 4

Methodology

4.1 General

A Case study of new commercial green building for Indian Oil Corporation Ltd, at Kochi, Kerala state for its area office and divisional office has been considered for the calculations. Based on credit no, intent and compliance total number of credits has been obtained. Following are the intended activities which are considered for obtaining total number of credits as per IGBC rating system are Sustainable Architecture and Design, Site Selection and Planning, Water Conservation, Energy Efficiency, Building Materials and Resources, Indoor Environmental Quality and Innovation and Development.

Table 4.1 shows the credit points available for directional intent as given by IGBC for Sustainable Architecture & Design.

Table 4.1 Sustainable Architecture and Design

Credit No.	Description	Available Points
SA Credit 1	Integrated Design Approach	1
SA Credit 2	Site Preservation	2
SA Credit 3	Passive Architure	2

Table 4.2 shows the credit points available for directional intent as given by IGBC for Site Selection and Planning**.**

Table 4.2 Site Selection and Planning

Credit No.	Description	Available Points
Mandatory Requirement 1	Local Building Regulations	Mandatory
Mandatory Requirement 2	Soil Erosion Control	Mandatory
SSP Credit 1	Basic Amenities	1
SSP Credit 2	Proximity to Public Transport	1
SSP Credit 3	Low-Emitting Vehicles	1
SSP Credit 4	Natural Topography or Vegetation	2
SSP Credit 5	Preservation or Transplantation of Trees	1
SSP Credit 6	Heat Island Reduction-Non Roof.	2
SSP Credit.7	Heat Island Reduction-Roof.	2
SSP Credit 8	Out Door Light Pollution Reduction	1
SSP Credit 9	Universal Design	1
SSP Credit 10	Basic Facilities for Construction Work Force	1
SSP Credit 11	Green Building Guidelines.	1

Table 4.3 shows the credit points available for directional intent as given by IGBC for Water Conservation.

Table 4.3 Water Conservation

Credit No.	Description	Available Points
WC Mandatory Requirement 1	Rainwater Harvesting, Roof & Non Roof.	Mandatory
WC Mandatory Requirement 2	Water Efficient Plumbing Fixtures.	Mandatory
WC Credit 1	Landscape Design	2
WC Credit 2	Management of Irrigation System	1
WC Credit 3	Rainwater Harvesting, Roof & Non Roof.	4
WC Credit 4	Water Efficient Plumbing Fixtures.	5
WC Credit 5	Waste Water Treatment & Reuse	5
WC Credit 6	Water Metering	1

Table 4.4 shows the credit points available for directional intent as given by IGBC for Energy Efficiency.

Table 4.4 Energy Efficiency

Credit No.	Description	Available Points
EE Mandatory Requirement 1	Ozone Depleting Substances	Mandatory
EE Mandatory Requirement 2	Minimum Energy Efficiency	Mandatory
EE Mandatory Requirement 3	Commissioning Plan For Building Equipment & System	Mandatory
EE Credit 1	Eco-Friendly Refrigerants	1
EE Credit 2	Enhanced Energy Efficiency	15
EE Credit 3	On-Site Renewable Energy	6
EE Credit 4	Off-Site Renewable Energy	2
EE Credit 5	Commissioning, Post -Installation of Equipment & Systems.	2
EE Credit 6	Energy Metering & Management	2

Table 4.5 shows the credit points available for directional intent as given by IGBC for Building Materials and Resources.

Table 4.5 Building Materials and Resources

Credit No.	Description	Available Points
BMR Mandatory Requirement 1	Segregation of Waste, Post Occupancy	Mandatory
BMR Credit 1	Sustainable Building Materials	8
BMR Credit 2	Organic Waste Management, Post Occupancy	2
BMR Credit 3	Handling of Waste Materials, During Construction.	1
BMR Credit 4	Use of Certified Green Building Materials, Product & Equipment	5

Table 4.6 shows the credit points available for directional intent as given by IGBC for Indoor Environmental Quality.

Table 4.6 Indoor Environmental Quality

Credit No.	Description	Available Points
IEQ Mandatory Requirement 1	Minimum Fresh Air Ventilation	Mandatory
IEQ Mandatory Requirement 2	Tobacco Smoke Control	Mandatory
IEQ Credit 1	Co_2 Monitoring	1
IEQ Credit 2	Day lighting	2
IEQ Credit 3	Outdoor Views	1
IEQ Credit 4	Minimized Indoor & Out Door Pollutants	1
IEQ Credit 5	Low-Emitting Materials	3
IEQ Credit 6	Occupants Well Being Facilities.	1
IEQ Credit 7	Indoor Air Quality Testing, After Construction & Before Occupancy.	2
IEQ Credit 8	Indoor Air Quality Management, During Construction.	1

Table 4.7 shows the credit points available for directional intent as given by IGBC for Innovation and Development.

Table 4.7 Innovation and Development

Credit No.	Description	Available Points
ID Credit 1	Innovation in Design Porcess	4
ID Credit 2	Optimization in Structural Design	1
ID Credit 3	Water Use Reduction for Construction	1
ID Credit 4	IGBC Accredited Professional	1

Since, there is no present analytical calculation. The above activities and sub-activities has been extracted from *IGBC Green New Buildings Rating System*, Version 3.0 and systematically prepared in Microsoft Excel Sheet, developed own methodology for effective calculations. The certification rating of IGBC has been obtained based on seven important.

4.2 Work Flow

This work is organized into following six stages and as shown in Figure 4.1

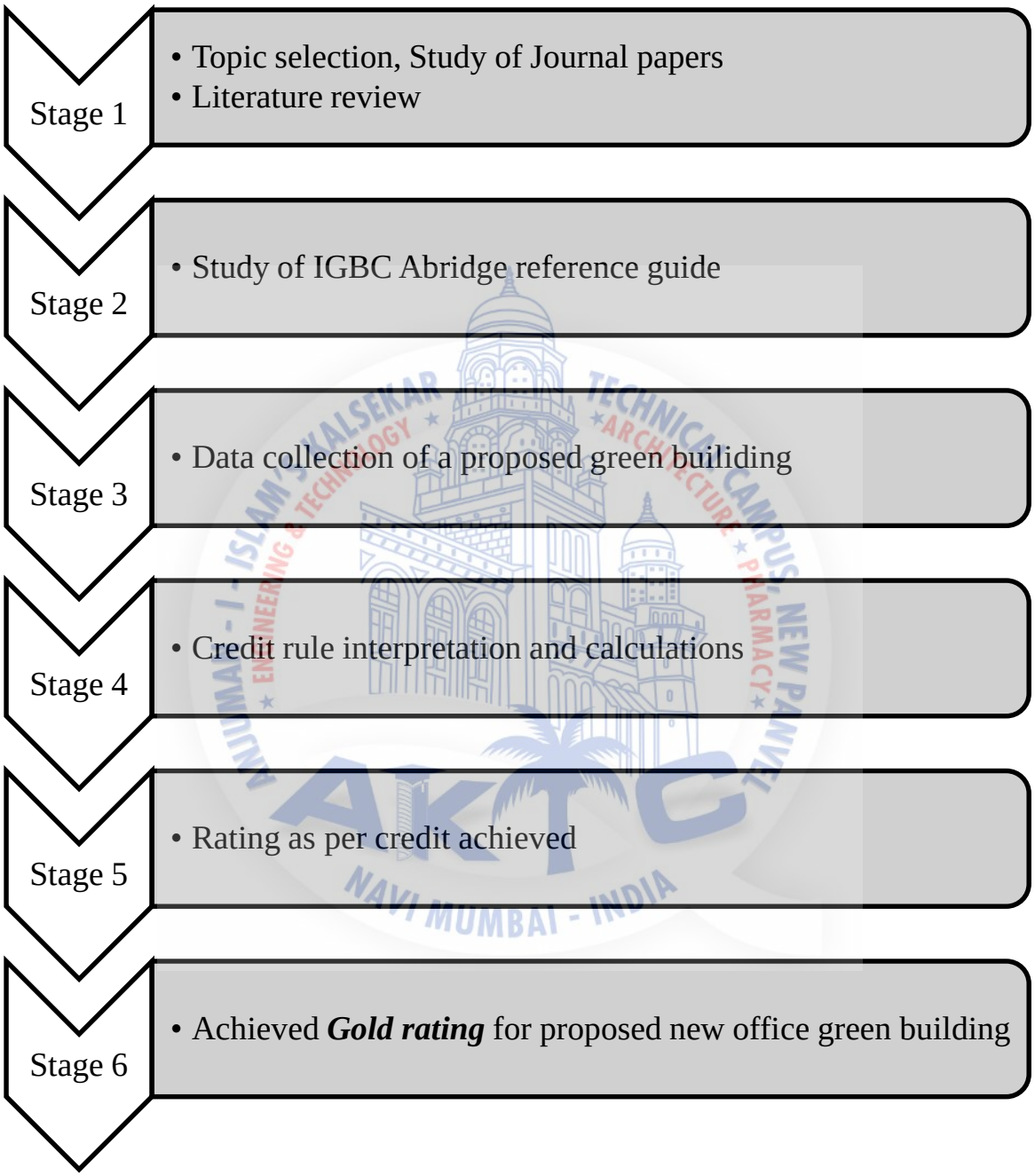

Figure 4.1 Methodology adopted in the present work

From the above Figure 4.1, the following stages as explain below are as follows:

Stage 1: The topic was selected based on the construction engineering and management, the green building topic was selected since, the popularity and government regulations are making green building more attractive for researchers, engineers and architect. Based on above various

journals on green building were researched and relevant journal paper were referred for the dissertation work, a brief of which is reproduced in literature review chapter.

Stage 2: A study of IGBC green new building rating system, version 3.0, Abridge reference guide, September 2016 (Edited with addendum 5.0) was studied for compliance of the rating programme. The objectives of IGBC green new building system were studied with respect to the intent in achieving each credit of modules with respect to architectural design, water efficiency, effective handling of waste, energy efficiency, sustainable building and focus on occupant comfort and well-being.

Stage 3: The data was collected through various resources like IGBC, Indian Oil, Structechindia, Godrej green building reports and etc. The case study data was collected from Structechindia including existing green field, survey plans with levels and architectural passive and sustainable designs for the proposed new green building.

Stage 4: Study of calculations of credit points based on the intent as given in the compliance module with respect to the compliance options and credit achievement based on the percentage of compliance, apart from mandatory requirements of IGBC.

Stage 5 and 6: Final rating calculations was achieved based on compliance as per the intent given in each module of IGBC green new buildings rating system was achieved and finally gold rating for the proposed was anticipated to be applied for interpretation of a mandatory requirement or a credit.

Chapter 5

Case Study and Data analysis

5.1 Introduction

Kochi also known as Cochin, is a major port city on the south-west coast of India by the Arabian Sea and the Laccadive Sea and is part of the district of Ernakulam in the state of Kerala. It is often called Ernakulam, which refers to the specific district. Area Office and Divisional office (AO/DO), Ernakulam is a state nodal agency responsible for development of new & renewable energy and non-conventional energy in the state of Kerala

Figure 5.1 Site Plan Showing the AO/DO office for IOCL

5.2 Location

SurveyNo: 360/4,360/5,360/19,360/23,360/27,360/28,360/29,360/1,360/3 at Chithrappuzha-Ponjassery Road, Irampanam Thrippunithura, Ernakulam, Kerala-682 301.

5.3 AO/DO

Ernakulam is a unique and successful model of Energy Efficient Solar Building, designed on solar passive architecture with the partial financial support of Ministry of New & Renewable Energy, GOI and Dept. of Science, Technology, Environment and Non-Conventional Energy, Govt. of Kerala.It is setup at Survey No: 360/4, 360/5, 360/19, 360/23, 360/27, 360/28, 360/29, 360/1, 360/3, Kerala

Site area: 1.76 acre (76845.50 Sq.Ft)

Total covered area: 28926.25 Sq.Ft. including 5785.25 Sq.Ft. Basement.

Architecture Style: Sustainable Architecture

The plans shown below depicts the green building planning from the conceptualisation stage and the design stage in which passive architecture and natural light and ventilation has been value added so as to reduce the energy consumed due to use of electricity. The natural topography of the site has not been disturbed and has been retained so as to minimise the impact on natural habitat, including restoration of natural ponds existing on site.

Figure 5.2 Front elevation of proposed AO/DO building

Figure 5.3 Back side elevation of proposed AO/DO building

The Figure 5.2 and 5.3 below are showing the proposed elevation of the building with maximum fenestration in the north face of the building, are internal atrium duct has been providing internally in south face of building so as to avoid direct sunlight and heat.

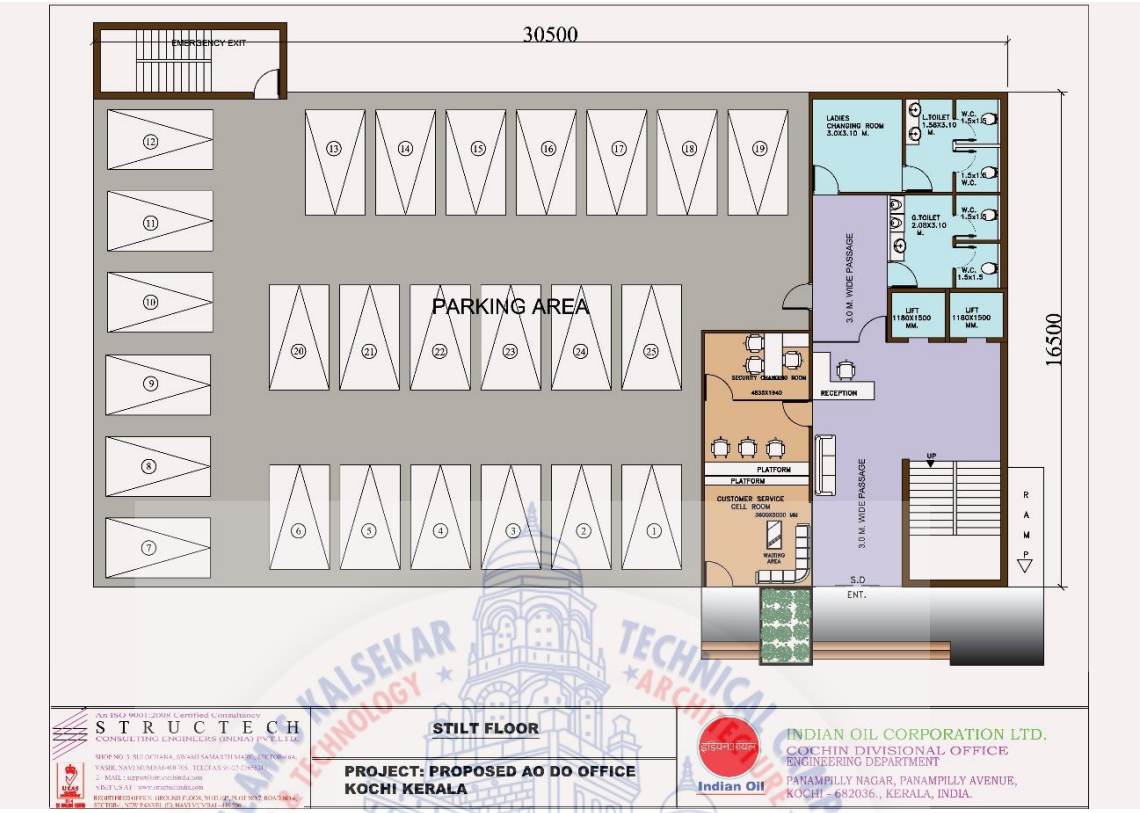

Figure 5.4 Plan showing stilt floor

The Figure 5.4 shows stilt floor plan in which approximately 80% of the covered area is provided for car parking so as to achieved heat island reduction, non-roof and take credit point of 2 for providing car parking more than 75%. The stilt floor plan also has main staircase including 2 lifts of 10 persons each apart from an emergency staircase which is provided diagonally opposite to the main staircase, which will cover full plan area for evacuation in case of emergency. The stilt floor plan has separate toilets for ladies and gents with a provision of universal design. The main entrance is provided with reception area with seating arrangement and customer service cell department and the approach for the main building and customer service cell department with a ramp for especially abled persons. The lifts have been provided with braille buttons so as to cater to visually impaired persons. One car parking each for physically handicapped person and electric car with charging point has been provided near the main entrance of the building.

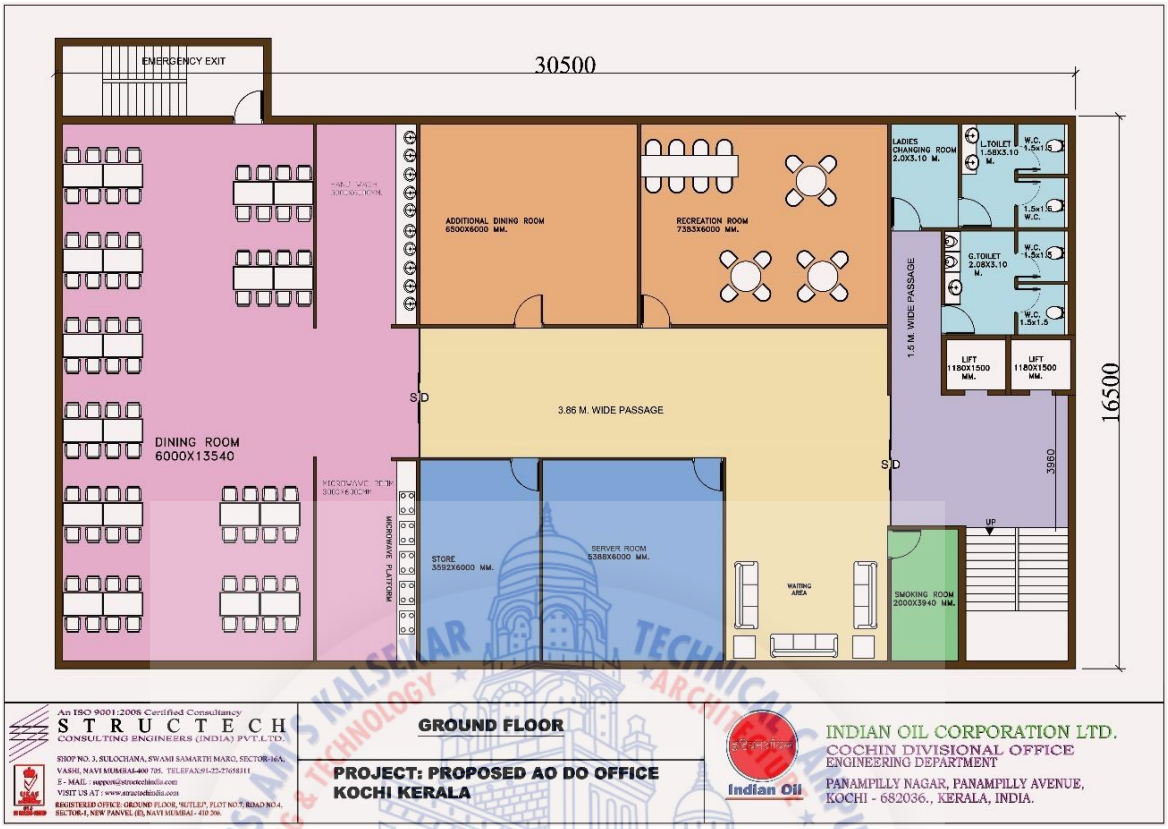

Figure 5.5 Plan showing ground floor

The Figure 5.5 shows the plan of ground floor which is at an upper elevation +3.3m from stilt floor consist of office staff dining area with a provision of microwave ovens to warm up their home made foods and hand wash on the other side of the oven room. A separate additional dining room has been provided for occasional buffets for special meetings and conferences, the same room on other days can be used by senior officers for dining purposes. A store room cum pantry has been provided next to dining room for running the small sized canteen kitchen. A recreation room has also been provided on this floor for staff. A master server room has been provided on this floor, in addition to waiting hall and separate smoking room apart from separate ladies and gent's toilet.

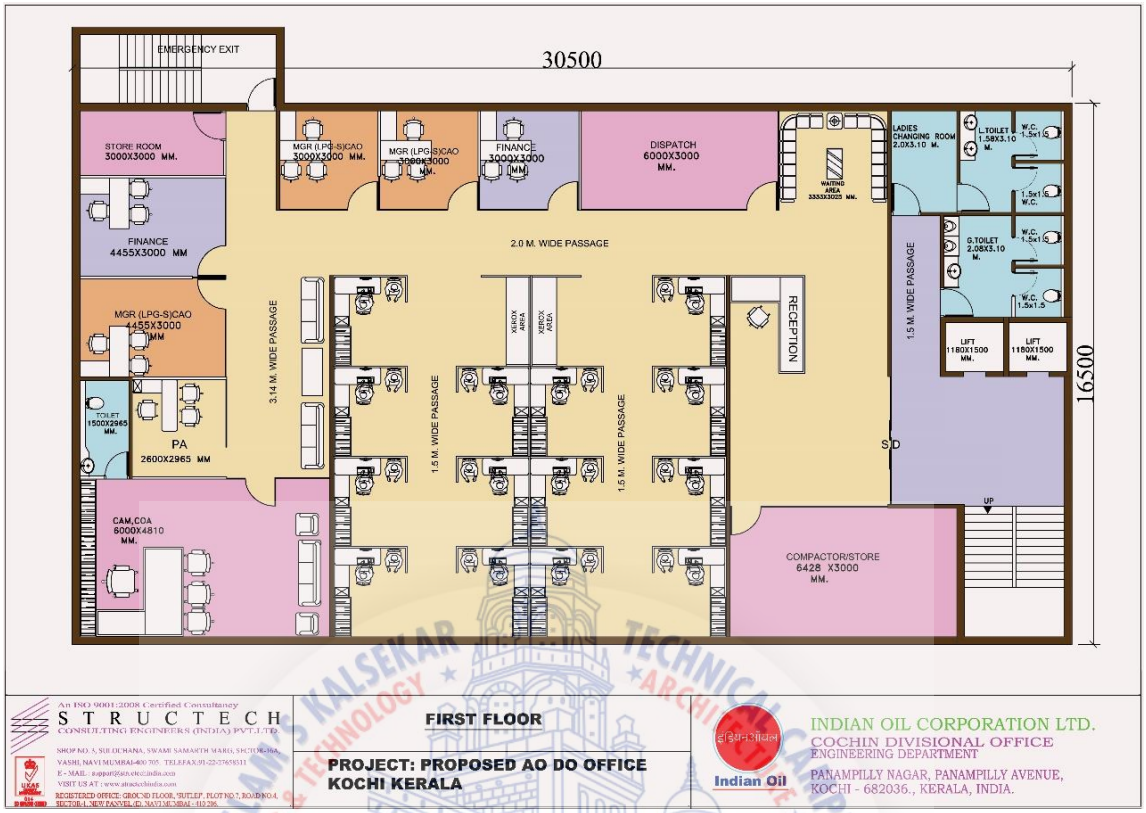

Figure 5.6 Plan showing first floor

The Figure 5.6 above is a first floor of the building which is at 6.9m above stilt floor level. This floor is totally dedicated for area office of Indian Oil Corporation Ltd., Kochi, the floor consists of two lobbies, one at lift area and other at reception area which consist of larger seating arrangement for the visitor coming to area office. The floor consists of separate toilets for ladies and gents in addition to two lifts and two staircases on the floor. The reception area has an approach to compactor/file store room for storing records of area office. A separate dispatch room has been provided for area office. The office area consists of 14 work stations with a provision for one visitor seat in each work station. In addition to place for printers and other office equipments. Three mid-level managers cubical in addition to two cabins for senior level managers are provided. One large cabin for the head of department has been provided facing front side, with a provision of separate toilet, cubical for personal assistant and VIP visitors seating lounge is provided on this floor. A small store room to keep finance department files has been provided near the emergency staircase.

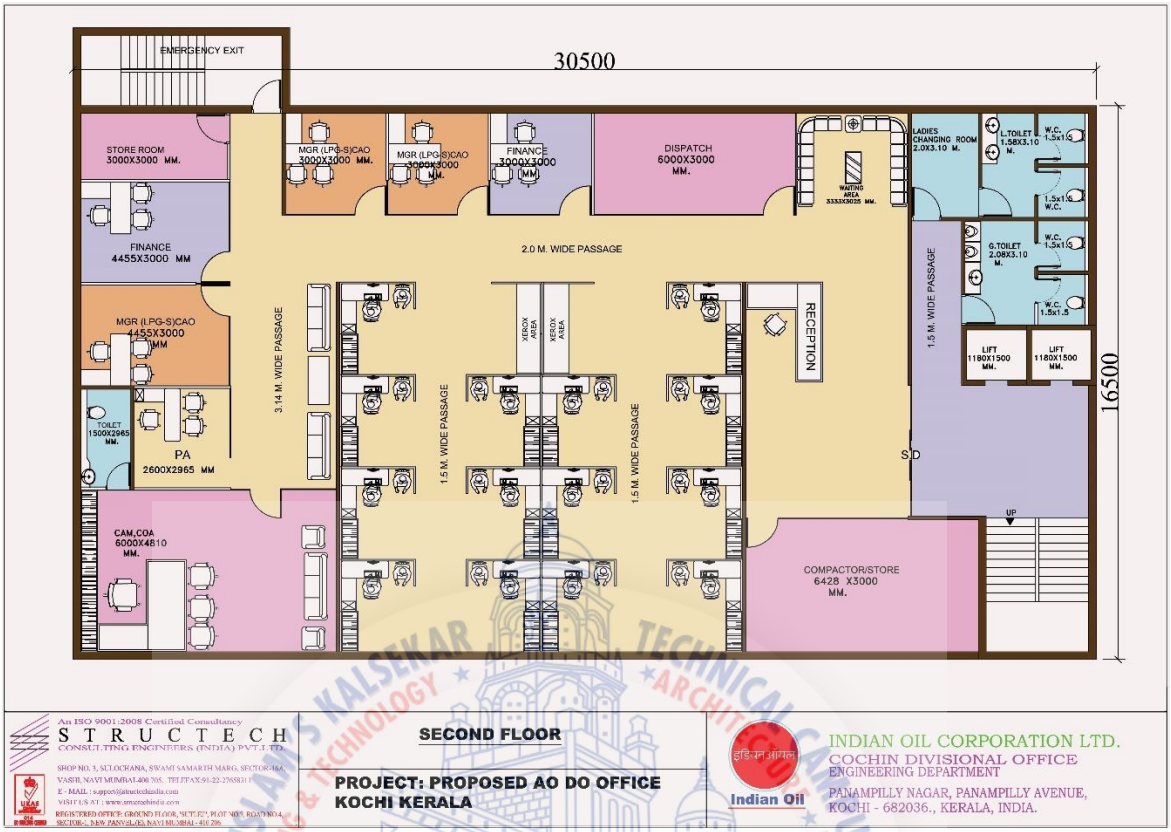

Figure 5.7 Plan showing second floor

The Figure 5.7 above is a second floor of the building which is at 10.5m above stilt floor level. This floor is totally dedicated for divisional office of Indian Oil Corporation Ltd., Kochi, the floor consists of two lobbies, one at lift area and other at reception area which consist of larger seating arrangement for the visitor coming to area office. The floor consists of separate toilets for ladies and gents in addition to two lifts and two staircases on the floor. The reception area has an approach to compactor/file store room for storing records of area office. A separate dispatch room has been provided for area office. The office area consists of 14 work stations with a provision for one visitor seat in each work station. In addition to place for printers and other office equipments. Three mid-level managers cubical in addition to two cabins for senior level managers are provided. One large cabin for the head of department has been provided facing front side, with a provision of separate toilet, cubical for personal assistant and VIP visitors seating lounge is provided on this floor. A small store room to keep finance department files has been provided near the emergency staircase.

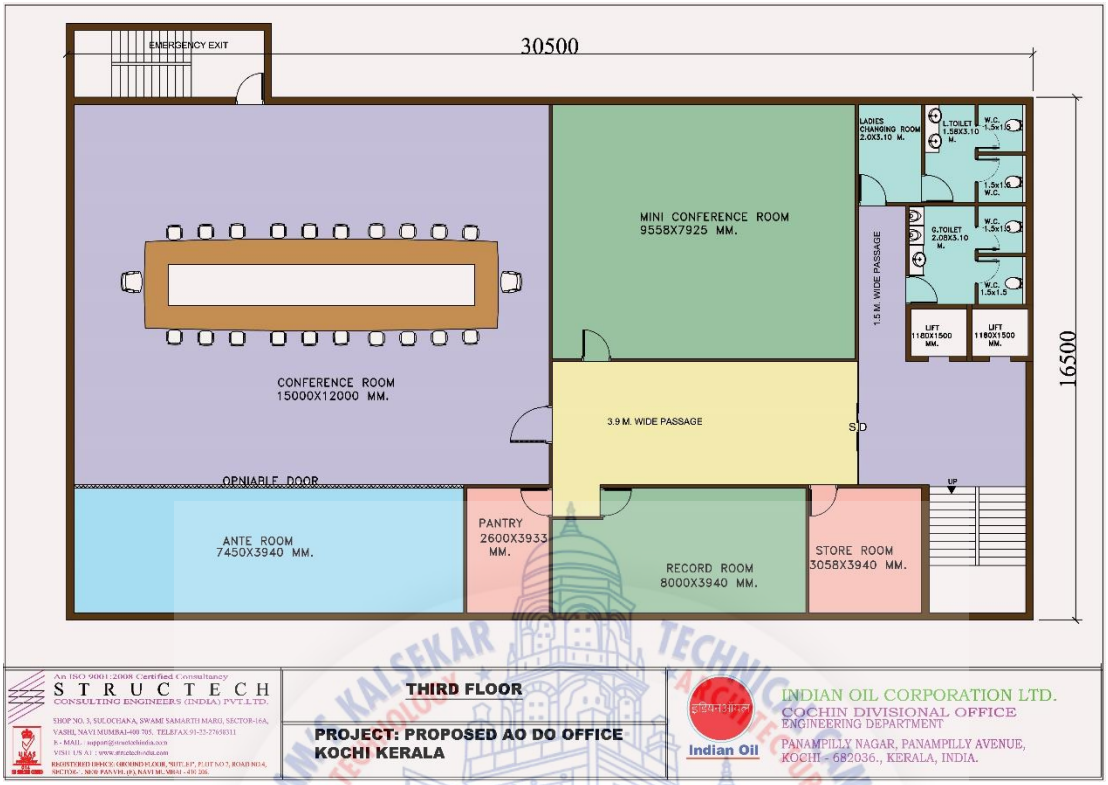

Figure 5.8 Plan showing third floor

The Figure 5.8 above is a third floor of the building which is at 14.1 m above stilt floor level. The floor consists of one main staircase and one emergency escape staircase which is routed through main conference room provided in this floor. The floor has lift lobby area and conference lobby area in addition to separate ladies and gent's toilet in this floor, two lifts of 10 persons each capacity is also provided on the floor. The floor consists of one mega conference room to seat 40 persons is provided with an attached (openable door) ante room for in conference dinning and high-tea purpose which is attached to a small pantry and service area. A mini-conference room to seat 20 persons is provided next to main conference room to cater for internal meetings. A separate record room has been provided on this floor for keeping common records of area office and divisional office. A small store room has also been provided on this floor for storing marketing department, retail sales and consumer departments materials. This is the top floor of the building above which an approachable terrace is provided for placement of solar panels so as to generate electricity in addition to solar water heater.

5.4 Site Analysis

The below Figure 5.9 shows the location of the proposed plot in Irrumpanam area of Kochi, Kerala, which is a green field plot with a dried pond near the highway, thick vegetation has

grown in the dried pond which needs to be restored and developed. A minor perennial river is flowing adjusting to the plot, a proposed national highway is separating the proposed plot and the perennial river. The natural topography of the plot has been retained for sustainable design.

Figure 5.9 Location of AO/DO office (*source:* Google map)

Location: Area office and Divisional office for Indian Oil Corporation Limited Ernakulam, Kerala-682 301.

Country: India

State: Kerala

Time Zone: IST(UTC+05:30)

Coordinates: Latitude 10.8505°

Elevation: 25M

Climate: Composite

Maximum Summer Temperature: 35°C

Minimum Winter Temperature: 29°C

Annual Average Rainfall: 3107MM

Context and Site Microclimatic: Architectural building design needs to respond to the composite climatic context of the site. The final design solution needs to satisfy the diverse and often conflicting conditions of a hot-dry, hot-humid, temperate and cold period of Ernakulam

The Climatic Condition: Two months of hot-dry, Hot-humid (two months) and Cold period (two months). Occasional hazy sky hot winds in summer, Low humidity in summer & high in monsoons cold winds in winter and strong wind in Monsoons.

Require Strategies of Design: Cooling in the hot dry period, Natural ventilation in the hot-humid period and Heating in the cold period. Cooling remains as the predominant requirement since the total over-heated period extends from mid-April to mid-August.

5.5 Architectural Analysis

Building: Area office and Divisional office for Indian Oil Corporation Limited

Architect: Structech Consulting Engineers India Pvt. Ltd, Mumbai

Architectural Design: Sustainable Architecture, this building has a 3 Dimensional form responding to solar geometry i.e., minimizing solar heat gain in hot dry period and maximizing solar heat gain in cold period. Overlapping floors at different levels in space floating in a large volume of air, with interpenetrating large vertical cut-outs enclosed within an envelope. These are integrated with light wells and solar activated naturally ventilating, domical structures.

Daylight: On the south western facade, dome shaped concrete structures have horizontal and vertical intersecting fins with glass fixed in the voids to allow natural light with reduced glare. These allow indirect light to enter the building in summers and direct sunshine in winters. The atrium is covered by a lightweight shell roofing of 10 cm of high-density EPS (extruded polystyrene) sandwiched between high-grade FRP (fibre-reinforced plastic) sheets and reinforced with steel; specifically angled to allow sun in winters and block in summers.

Maintaining Thermal Comfort: The envelope attenuates the outside ambient conditions and the large volume of air is naturally conditioned by controlling solar access in response to the climatic swings during summer and winters. The large volume of air is cooled during the hot period by a wind tower, integrated into the building design, and in cold period this volume of air is heated by solar penetration through the roof glazing generating a convective loop. The thermal mass of the floor slabs helps attenuate the diurnals swings

5.6 Salient Design Features of AO/DO for IOCL in context of Green Building

Orientation and Sun Path: Solar Passive Complex has been developed in response to solar geometry i.e. minimizing solar heat gain in cold period. The building envelope attenuates the outside ambient conditions and the large volume of air is naturally conditioned by controlling solar access in response to the climatic swings.

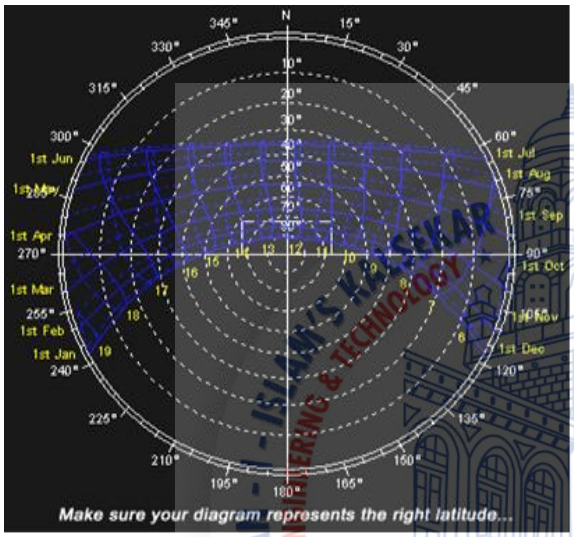

Figure 5.10 Sun path diagram

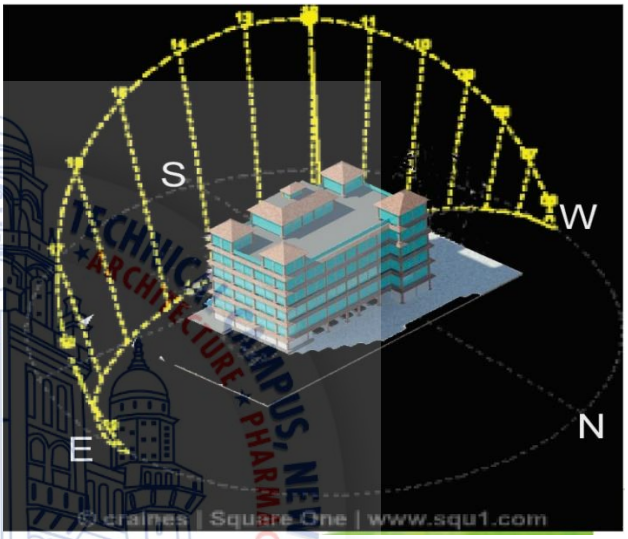

Figure 5.11 Orientation of building

The above Figure 5.10 shows the sun path for the whole year for our location, which depicts that the maximum sun shall be on the southern side of the proposed building.

The above Figure 5.11 shows the orientation of the building with respect to the sun moment in all season throughout the year and which shows that the rear side of the building is facing south thus, the maximum control of light and heat has to be done from this side.

Unique Shell Roofing on Central Atrium: The Central atrium of the complex having main entrance, reception, water bodies, cafeteria and sitting place for visitors constructed with hyperbolic shell roof to admit daylight without glare and heat coupled with defused lighting through glass to glass solar panels. The roof is supported with very light weight space frame structure.

Solar Power Plant: 25Kwp building integrated solar photovoltaic power plant has been set up to meet the basic requirement of electricity in the complex

Water Bodies: The water bodies with waterfalls and fountains have been placed in the central atrium of the complex for cooling of whole the complex in the hot and dry period

Cavity Walls: The complex is a single envelope made up of.its outer walls as double skin walls having 2" cavity in between. The cavity walls facing south and west are filled with further insulation material for efficient thermal effect.

Unique Floating Slab System: The system of floating and overlapping slab with interpenetrating vertical cut outs allow free and quick movement of natural air reducing any suffocating effect.

Wind Tower Coupled with Solar Chimney: The wind tower centrally placed coupled with solar chimney. The domical structures for scientific direct & indirect cooling and scientific drafting of used air.

Insulated Roofing: All the roofs have been insulated with double insulation system to avoid penetration of heat from the roof.

Auditorium: A unique auditorium scientifically designed to control heat penetration, light & sound distribution is placed in the north under the shade of main building

Insulated Roofing: All the roofs have been insulated with double insulation system to avoid penetration of heat from the roof.

Auditorium: A unique auditorium scientifically designed to control heat penetration, light & sound distribution is placed in the north under the shade of main building

Big Exhibition Centre: The complex is having a proper designed exhibition centre for display of renewable & non-conventional energy devices/equipment.

Unique Work Station: Scientifically designed and fully equipped unique workstations have been made for the employees having comfortable environment, good ergonomics with sufficient natural light and air.

5.7 Summary

Evaporative cooling towers work best with open floor plans that permit the air to circulate throughout the building without any obstacles. Good thermal mass of the building helps the building to perform in extreme conditions. Appropriate building design and orientation having properly placed building elements reduced or minimize the solar gain in summer. Elements like light Vault, Solar chimney, Hyperbolic parabolised atrium roof help to minimize the solar gain.

Chapter 6

Results and Discussions

6.1 General

Certification is initiated at a very early design stage when the details of project IOCL, AO/DO office building was entered into the Microsoft Excel Programme and compliance green options are selected. The project has achieved the IGBC standard of a 20% savings in energy water and materials as compared against local construction practices. When the project achieves this the project shall be registered for certification.

6.2 Credit point compliance statement

Table 6.1 shows the credit points achieved for directional intent as given by IGBC for Sustainable Architecture & Design.

Table 6.1 Sustainable Architecture and Design

Credit No.	Description	Points Credited	Available Points
SA Credit 1	Integrated Design Approach	1	1
SA Credit 2	Site Preservation	2	2
SA Credit 3	Passive Architure	2	2

Table 6.2 shows the credit points achieved for directional intent as given by IGBC for Site Selection and Planning.

Table 6.2 Site Selection and Planning

Credit No.	Description	Points Credited	Available Points
Mandatory Requirement 1	Local Building Regulations	Mandatory	Mandatory
Mandatory Requirement 2	Soil Erosion Control	Mandatory	Mandatory
SSP Credit 1	Basic Amenities	1	1
SSP Credit 2	Proximity to Public Transport	1	1
SSP Credit 3	Low-Emitting Vehicles	1	1
SSP Credit 4	Natural Topography or Vegetation	2	2
SSP Credit 5	Preservation or Transplantation of Trees	1	1
SSP Credit 6	Heat Island Reduction-Non Roof.	2	2
SSP Credit.7	Heat Island Reduction-Roof.	2	2
SSP Credit 8	Out Door Light Pollution Reduction	1	1
SSP Credit 9	Universal Design	1	1

SSP Credit 10	Basic Facilities for Construction Work Force	1	1
SSP Credit 11	Green Building Guidelines.	1	1

Table 6.3 shows the credit points achieved for directional intent as given by IGBC for Water Conservation.

Table 6.3 Water Conservation

Credit No.	**Description**	**Points Credited**	**Available Points**
WC Mandatory Requirement 1	Rainwater Harvesting, Roof & Non Roof.	Mandatory	Mandatory
WC Mandatory Requirement 2	Water Efficient Plumbing Fixtures.	Mandatory	Mandatory
WC Credit 1	Landscape Design	1	2
WC Credit 2	Management of Irrigation System	1	1
WC Credit 3	Rainwater Harvesting, Roof & Non Roof.	3	4
WC Credit 4	Water Efficient Plumbing Fixtures.	2	5
WC Credit 5	Waste Water Treatment & Reuse	3	5
WC Credit 6	Water Metering	1	1

Table 6.4 shows the credit points achieved for directional intent as given by IGBC for Energy Efficiency.

Table 6.4 Energy Efficiency

Credit No.	**Description**	**Points Credited**	**Available Points**
EE Mandatory Requirement 1	Ozone Depleting Substances	Mandatory	Mandatory
EE Mandatory Requirement 2	Minimum Energy Efficiency	Mandatory	Mandatory

EE Mandatory Requirement 3	Commissioning Plan For Building Equipment & System	Mandatory	Mandatory
EE Credit 1	Eco-Friendly Refrigerants	1	1
EE Credit 2	Enhanced Energy Efficiency	2	15
EE Credit 3	On-Site Renewable Energy	2	6
EE Credit 4	Off-Site Renewable Energy	0	2
EE Credit 5	Commissioning, Post -Installation of Equipment & Systems.	2	2
EE Credit 6	Energy Metering & Management	2	2

Table 6.5 shows the credit points achieved for directional intent as given by IGBC for Building Materials and Resources.

Table 6.5 Building Materials and Resources

Credit No.	**Description**	**Points Credited**	**Available Points**
BMR Mandatory Requirement 1	Segregation of Waste, Post Occupancy	Mandatory	Mandatory
BMR Credit 1	Sustainable Building Materials	6	8
BMR Credit 2	Organic Waste Management, Post Occupancy		2
BMR Credit 3	Handling of Waste Materials, During Construction.	1	1
BMR Credit 4	Use of Certified Green Building Materials, Product & Equipment	5	5

Table 6.6 shows the credit points achieved for directional intent as given by IGBC for Indoor Environmental Quality.

Table 6.6 Indoor Environmental Quality

Credit No.	**Description**	**Points Credited**	**Available Points**

IEQ Mandatory Requirement 1	Minimum Fresh Air Ventilation	Mandatory	Mandatory
IEQ Mandatory Requirement 2	Tobacco Smoke Control	Mandatory	Mandatory
IEQ Credit 1	Co_2 Monitoring	1	1
IEQ Credit 2	Day lighting	1	2
IEQ Credit 3	Outdoor Views	1	1
IEQ Credit 4	Minimized Indoor & Out Door Pollutants	1	1
IEQ Credit 5	Low-Emitting Materials	3	3
IEQ Credit 6	Occupants Well Being Facilities.	1	1
IEQ Credit 7	Indoor Air Quality Testing, After Construction & Before Occupancy.	1	2
IEQ Credit 8	Indoor Air Quality Management, During Construction.	1	1

Table 6.7 shows the credit points achieved for directional intent as given by IGBC for Innovation and Development.

Table 6.7 Innovation and Development

Credit No.	**Description**	**Points Credited**	**Available Points**
ID Credit 1	Innovation in Design Porcess	1	4
ID Credit 2	Optimization in Structural Design	1	1
ID Credit 3	Water Use Reduction for Construction	1	1
ID Credit 4	IGBC Accredited Professional	1	1

6.3 Credit Achievement

Table 6.1 shows the credit points achieved for the intent as given by IGBC for Credit Achievement and upon compliance of the intended points a gold rating is achieved for the IOCL, AO/DP Office Building. Below are the credit points achieved are as follows:

Table 6.8 Credit Achievement

Credit Points	Description
Earned 64	The IOCL, AO/DO office building has provided the mandatory documentation which supports. Achievement of the credit requirements and associated points. For Version 3.0, The documentation of this credit is complete. And the points which are considered as achieved are designated as 'Earned'.
Denied 00	The IOCL, AO/DO office building has not applied for a certification. Thus, the project has not demonstrated achievement of these credits and are designated as 'Denied'
Final Rating: 'Gold'	

From the above table, it can be noted that the green consultant has complied for the intents as given by IGBC to achieve credit points so as to obtained gold rating.

Figure 6.1 Sample green building certificate (*source:* IGBC)

The above Figure 6.1 shows a sample of green building certificate with the achieved rating for the type of green building certification with the date of issue of certificate along with the details of the project with complete address.

Chapter 7

Summary and Conclusions

7.1 Summary

The IGBC New Green Building Rating System, version 3.0 intents to satisfy all the mandatory requirements and the minimum number of credit points as per the threshold criteria for certification levels. The project is expected to give supporting documents at preliminary and final stage of submissions for all the mandatory requirements and the credit attempted. This method of calculating credit points is purely based on the credits interpretations. The Microsoft Excel Sheet also gives the total points credited to check the certification level.

7.2 Conclusions

From the above procedure and Microsoft Excel Programme it can be concluded that, the computation of credits based on the compliance options selected by the users, a near to certified credit rating can be achieved (±10%). This is very in terms of saving Engineers/Architect or Green building consultant to save on their professional man-day hours thereby, saving in the

organizational resources and raising the output. The interpretations scheduled in the Microsoft Excel Programme gives an ease to the users to select the options for the compliance of the modules as given by IGBC Green New Building Rating System checklist.

7.3 Future scope

The above simplified Microsoft Excel gives inconsistent results when various parameters other than set are simulated in terms of the result and it is also difficult to use for an average building professionals and lacks transparency in terms of auditing the calculation process, thus the need for a detailed and user friendly software using computing methods is desired for the professional use. The future work will include as follows.

1. Study of IGBC rating system for new green building and other 13 green building rating systems such as IGBC Green Existing Building O&M, IGBC Green Homes, IGBC Green Schools, IGBC Green Factory Building, IGBC Green Township, IGBC Green Special Economic Zones, IGBC Green Landscape, IGBC Green Mass Rapid Transit System, IGBC Green Campus, IGBC Green Cities, IGBC Green Interiors and IGBC Green Residential Societies.
2. Study and find a methodology to appropriately calculate the credit calculations with respect to the IGBC Abridge Reference Guide.
3. Study html and other information technology tools for online software.
4. Study and find out the methods of storing data input through html (online) and preparing report (backend for further research and frontend inform of report as a Pdf for users.

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LIST OF APPENDIX

Appendix VIII- IGBC Accredited professional certificate


Confederation of Indian Industry
CII-Sohrabji Godrej Green Business Centre

Indian Green Building Council
Greening India since 2001

The Indian Green Building Council

hereby certifies that

Ashish Suresh Srivastava

has successfully demonstrated knowledge on the Green Building Design & Construction, Building Standards & Codes, IGBC Resources & Processes and Green Design Strategies & their Impacts,

required to be awarded the title of

IGBC Accredited Professional

K S Venkatagiri
Executive Director
CII-Godrej GBC

15-Apr-17

Dr Prem C Jain
Chairman
Indian Green Building Council

172186

LIST OF PUBLICATIONS

1. “A Review of IGBC Rating System for New Green Buildings”, International Conference on Emanations in Modern Technology and Engineering (ICEMTE-2017), Vol. 05, No. 03, pp. 14-17, 2017.
2. “Design of New Green Building Using IGBC Rating System”, International Journal

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