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Integrated Project Management Framework for Green Buildings

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Abstract

With the increasing problem of environmental issues and growing concern over climate change, sustainable / green building construction is gradually put forth globally. However construction of green buildings still encounters barriers as there is a lack of proper project management framework for such projects. For this certain factors have been identified based on the literature review of previous research papers and then a questionnaire if formed in accordance with these factors. Response of the questionnaire is taken from 35 industry experts (project managers, architects, engineers, construction manager etc.) with the aim to identify the degree of influence of these factors on the success or failure of managing green building projects. Findings of this study are the guidelines which are formulated for the project management of green buildings.

Keywords: Project management, Sustainable Development, Green Building, Green Building Rating System, Sustainability Indicators and Integrated Management.

Chapter 1 Introduction

1.1 Definition

Green building is a type of construction that is environmentally friendly. According to Kibert (2008), sustainable construction tackles a building's ecological, social, and economic challenges in the context of its community. From preconstruction to demolition, sustainable construction is employed throughout the construction life cycle. The purpose of such development was to lower pollution levels.

1.2 Construction of Green Projects

Sustainable construction practises must be used in green building projects, which are often listed in green building rating systems such as GRIHA, LEED, and BREEAM, among others. A waste management plan to limit trash creation on the construction site is an example of such techniques. Buildings that are constructed in a green manner provide a lot of benefits as well. Green building construction also necessitates the use of sustainable practises such as recycled aggregates in concrete and timber from renewable sources. (CIRIA, 2001).

To guarantee that pollution from the construction is kept to a minimum, the main contractor and project manager must regulate soil erosion, river sedimentation, and airborne dust generation. Furthermore, the natural habitat should be protected by building placement that minimises disruption to the existing natural environment (USGBC, 2009). In traditional construction, these factors are frequently overlooked.

The survey was conducted relating to the construction industry. The respondents included Project Managers, Construction Managers, Architects and Engineers etc. The respondents had different work experience from different departments. The collected responses were used to conduct the Likert Scale Analysis to determine the degree of influence of success and the failure of these factors. Table 1.1 tabulate the mean of all the success factors.

Table 1.1 Mean of success factors for managing green building projects

Success Factors	SD	D	NAND	A	SA	Total	Mean
Skilled project participants	0	2	5	19	27	53	4.36
Effective collaboration among participants	0	2	8	13	30	53	4.36
Support from senior management	0	6	5	15	27	53	4.18
Design charrettes and community engagement	0	3	12	11	27	53	4.18
Innovative management approaches	3	3	7	14	26	53	4.12
Selection of companies relative to project size	0	3	7	30	13	53	4.00
Integrated and collaborative delivery process	0	5	11	18	19	53	3.97
Commitment of all project participants	0	3	13	19	18	53	3.97
Adequate financial resources	3	3	7	21	19	53	3.94
Effective environmental compliance and auditing programs	5	2	5	24	17	53	3.91
Early involvement of green building professional	3	7	3	19	21	53	3.91
Early involvement of project participants	3	2	10	22	16	53	3.88
Effective feedback and troubleshooting	2	2	19	16	14	53	3.76
Use of advanced machinery and innovative technologies	2	11	11	14	15	53	3.55

Here SD is Strongly Disagree, D is Disagree, NAND is Neither Agree nor Disagree, A is Agree and SA is Strongly Agree.

The major findings of this study are (1) Skilled project participants, (2) Effective collaboration among participants, (3) Support from senior management and (4) Design charrettes and community engagement are the major success factors in managing green building projects and table 1.2 tabulate the mean of all the success factors.

Table 1.2 Mean of failure factors for managing green building projects

Failure Factors	SD	D	NAND	A	SA	Total	Mean
Lack of interest from client and market demand	0	9	5	22	17	53	3.85
Setting ambitious green targets	0	6	13	23	11	53	3.73
Lack of information regarding green technologies	3	8	12	11	19	53	3.67

Lack of financial incentives	0	8	13	23	9	53	3.64
High premium cost	5	2	17	16	13	53	3.58
Lack of collaboration within project team	0	9	13	21	10	53	3.58
Conflicts in selection of green building credits or process	2	9	15	13	14	53	3.55
Lack of integrated and collaborative delivery process	3	5	15	22	8	53	3.52
Lack of green building expertise	6	5	15	11	16	53	3.48
Complex green building codes and regulations	2	11	16	13	11	53	3.39
Lack of interest from project team members	0	11	19	13	10	53	3.39
Lack of time for green construction practices	5	8	10	22	8	53	3.36
Resistance to change to green practices	5	6	19	13	10	53	3.31

Here SD is Strongly Disagree, D is Disagree, NAND is Neither Agree nor Disagree, A is Agree and SA is Strongly Agree.

The major findings of this study are (1) Lack of interest from client and market demand, (2) Setting ambitious green targets, (3) Lack of information regarding green technologies and (4) Lack of financial incentives are the major failure factors in managing green building projects.

1.3 Problem Statement

The various organisation which are responsible for the formulating guidelines in the construction industry often neglects the green aspects for example CPWD, NAC, FIDIC, AIA etc. does not any guidelines for the project management of green buildings.

1.4 Aim

The research paper aims to formulate guidelines for integrated project management framework for green buildings in the context of India.

1.5 Objectives

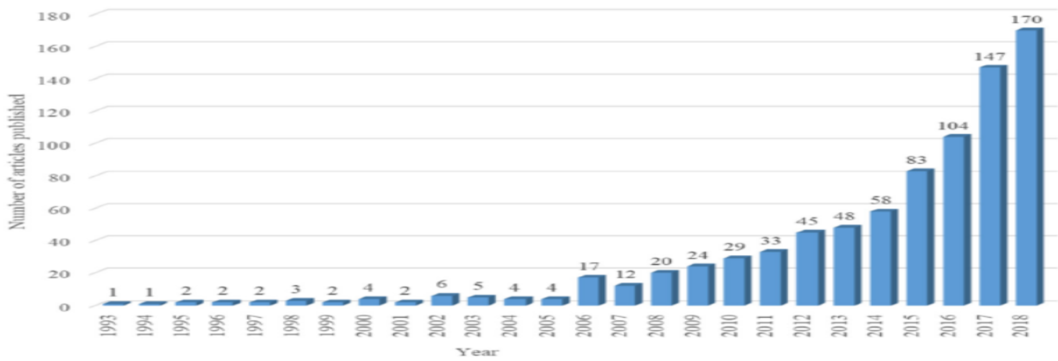
- To study & understand the elements & requirements of sustainable buildings.
- To identify criteria for the procurement of sustainable buildings.
- To analyze techniques for project management of sustainable buildings from a life cycle perspective.

- To take up case studies of best practices of integrated project management of sustainable buildings.
- To formulate guidelines for integrated project management of sustainable buildings in the context of India.

1.6 Validity of the project

On a local and global scale, buildings have a significant impact on the environment. The mining and transportation of materials to the construction site, the construction process itself, the waste removal and disposal process; and the continuous use of natural resources such as energy and water for the entire operating life of the building all have measurable environmental impacts.. Figure 1.1 shows the increasing study on sustainable integrated projects.

Figure 1.1 shows the increasing study on sustainable integrated projects. Source: Adopted (Araújo et al. 2020)



1.7 Scope

The Scope of this research paper is limited to formulate guidelines and techniques for procuring and constructing green sustainable buildings.

1.8 Significance

- It can help in analyzing environmental requirements concerning the reduction of environmental impact.
- It can help in embedding sustainability in the project's execution plan, schedule, and change management processes.
- It can help in incorporating guidelines from various rating agencies such as GRIHA, LEED, BREEAM, CASBEE etc. during the procurement and construction phase and to develop a proper residual waste management system.

Chapter 2 Case Study

2.1 National Renewable Energy Laboratory

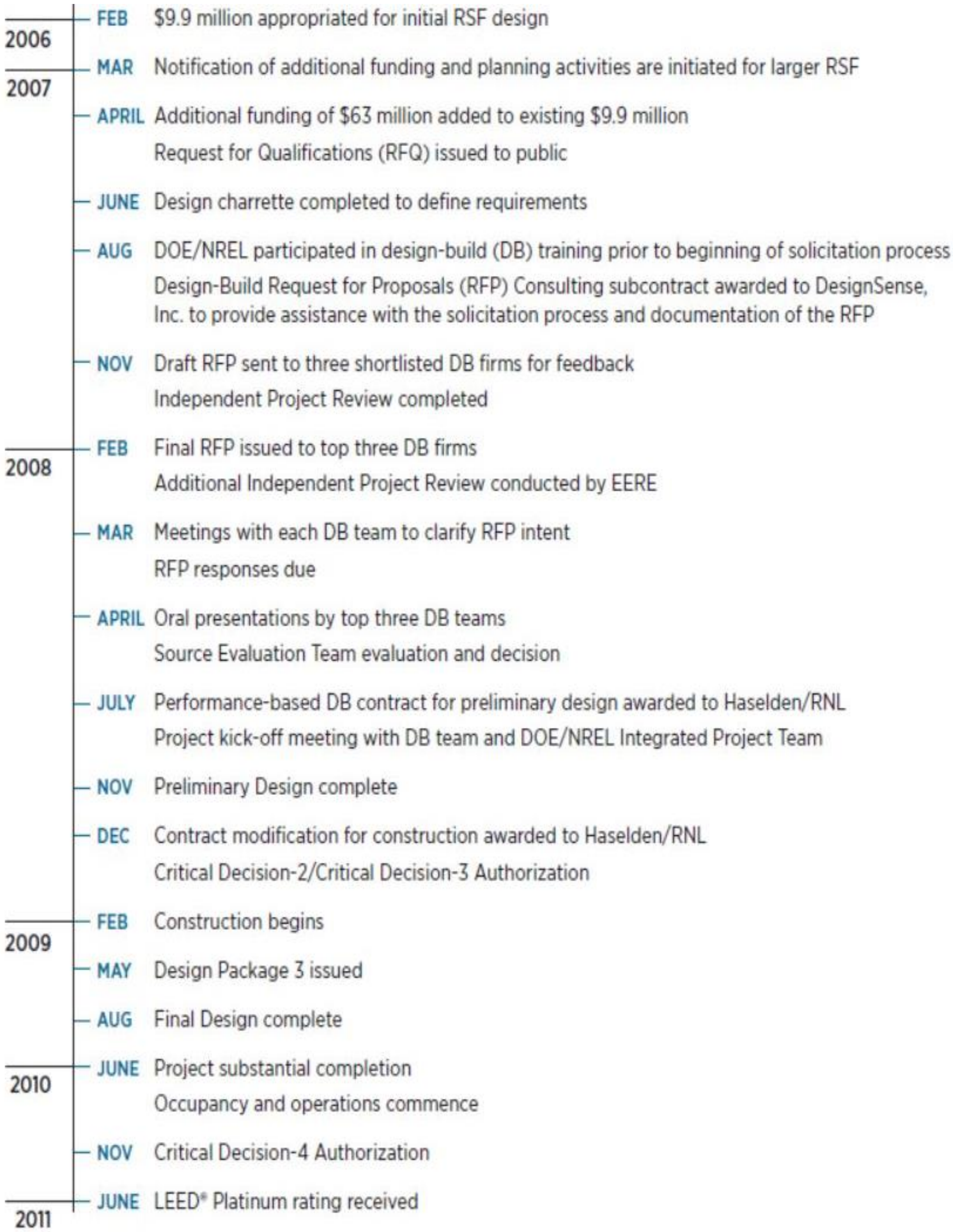
"NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC". It is a Research Support Facility which is having three years of Net Zero Operations, Occupants and Analytics. Arial view of the National Renewable Energy Laboratory is shown in figure 2.1.


Figure 2.1: Arial view of National Renewable Energy Laboratory

2.1.1 Project Details

- **Client:** DOE / NREL
- **Location:** NREL, Colorado
- **Primary Use:** Office
- **Size and Occupants:** 222,000 sqft and 825 employees
- **Project Cost:** $ 80 million
- **Design Build Team:**
  - **Architect:** RNL
  - **MEP Engineering and Energy Modelling:** Stantec
  - **General Contractor:** Haselden Construction
  - **Structural Engineering:** KL & A
  - **Project Manager:** Northstar Project Management Incorporated
- **Daylight Modelling and LEED Commissioning:** AEC
- **Solar Consultant:** Namaste Solar
- **LEED Rating:** Platinum
- **Energy Budget:** 35.1 kBtu/sqft/year
- **Energy Performance:** 50% better than ASHRAE 90.1, 2004 Standard.

2.1.2 Project Timeline



2.1.3 Building Features

The superior energy performance of the Research Support Facility (RSF) was fueled by an integrated whole-building design strategy that prioritised energy efficiency. Renewable energy was added after the building met its efficiency goals, bringing it to net zero energy. Today, anyone can design an energy efficient building. The following are examples of energy-saving features:

• "Building siting, orientation form and massing driven by energy and environment.

• Daylighting, low energy consumption and energy efficient lighting.

• Natural ventilation

• Night purging

• Transpired solar collector

• Radiant slabs and thermal basement labyrinth

• Evaporative cooling

• Heat recovery from data center

• Renewable energy generated via photovoltaics on rooftop and parking**."**

This structure demonstrates how an integrated design process can significantly improve the energy performance of commercial buildings. "The RSF project team developed an innovative performance-based design build approach that relied on integrated design and construction, extensive up-front planning, a national design competition, energy modelling, and a firm fixed-price contract to meet stringent time and performance goals while mitigating costs and risks".

2.1.4 Procurement process

- Specific energy performance requirements in the Request for Proposal.
  a) For office: 35 kBtu/sqft/year.
  b) Net-zero energy for the guard house.
- Goals must be supported by energy modelling.
- End-of-use energy metering is required.
- Voluntary incentive programme to ensure that measurement and verification results are on track to meet expectations.
- 50% energy cost savings over ASHRAE 90.1.

2.1.5 Acquisition Contracts

NREL hired an architectural programming consultant to assist in the development of the RSF programme, specifically to assist NREL in defining "the space requirements for common areas and office needs in the RSF. Because it is the owner's responsibility to ensure that the design team's needs are prioritized. For projects using the firm fixed price, DB contracting method, this is a crucial step".

2.2 Assam House, Delhi

The Assam House is situated at No.1, Bordoloi Marg in Chanakyapuri, New Delhi. It was built on a plot of land allotted to Government of Assam in 1957. The old building of the Assam House was dismantled and reconstructed. The new Assam House Building that was inaugurated by Hon'ble Chief Minister, Assam on 2nd March, 2019. View from the courtyard is shown in figure 2.2.

Figure 2.2: Assam House, Delhi.

The site consists two residential buildings (Guest House and Staff Quarters).

2.2.1 Project Details

- **Client:** PWD (Building) Government of Assam **Location:** Chanakyapuri, Delhi
- **Primary Use:** Guest House for VIPs and VVIPs.
- **Site area:** 3569.30 sqm **Project Cost:** 72 crore
- **Design Build Team:**
  - **Architect:** DK & Associates, New Delhi
  - **Structural Engineering:** DK & Associates, New Delhi
  - **MEP Engineering:** DK & Associates, New Delhi
  - **Contractor:** SBP Commercial, Guwahati
  - **Project Manager:** DK & Associates, New Delhi
- **GRIHA Consultant:** Passive Design Consultants, Noida **GRIHA Rating:** 3 star

2.2.2 Project Insight

The project was carried through a design bid build procurement procedure, and one of the reasons for the Architect and Contractors part was the selection of businesses in relation to the magnitude of the project. As the client of the project was government of Assam therefore throughout the design process, the project had support from senior management & the design team was encouraged to get rating from GRIHA. The tier wash area at the entrance of the site as per GRIHA is shown in figure 2.3.

Figure 2.3: Tyre wash area.

Sustainable consultants were not included in the initial stages of the project to discuss green building technologies & sustainable strategies. This relates to the failure factor lack of green building expertise and lack of integrated & collaborative delivery process. The sustainable consultants were only involved for the documentation of the work.

There were adequate financial resources as the government of Assam had a requirement of guest house for VIP's so as that the whole exterior façade is covered with white marble. Use of marble and metal on the facade is shown in the figure 2.4.

Figure 2.4: Use of marble and metal in the exterior façade.

AAC blocks were used during the construction of the project as the advanced building material and innovative technology along with solar power generation, solar hot water generation system, building management system and sewage treatment plant for recycling water. Solar power generation and hot water generation system is shown in figure 2.5.

Figure 2.5: Solar power generation and hot water generation system on terrace.

Innovative management approach was one of the main factor which led to the success of the project. Various modern amenities as used such as lighting automation to optimize power consumption, fire safety with smoke detection, sprinklers and fire hydrant system, automatic ventilation system for basement with CO2, video conferencing facility and separate dormitory facilities for gents and ladies.

Chapter 3 Provisions for Project Management

3.1 Provisions in GRIHA

3.1.1 Criterion - 4 Air and Soil Pollution Control

The intent of this criterion is to minimize air and soil pollution due to construction activities.

Ø Appraisal

Adopt at least six measures to minimize air and soil pollution during construction.

- Provide 3 m high continuous barricading along the site boundary. Provide wheel washing facility/gravel bed at all vehicular entrances and exits of the site.
- Ensure diesel generator sets are in compliance with CPCB norms and have an exhaust with stack height of at least 2 m from the top of the generator with a cap.
- Implement a spill prevention plan for storage of diesel, admixtures, curing compounds, bitumen and other hazardous material.
- Ensure that fine aggregate, excavated earth, & other construction material with a tendency to get airborne are covered or are sprinkled regularly with non-potable STP water. Ensure sprinkling of water on unpaved pathways on the site with non-potable water in order to mitigate air pollution. Limit the speed of vehicular movement on site to 10 km/h.
- Ensure that vehicles carrying waste materials out of the site are covered. Ensure that the soil erosion channels are constructed and they are connected to a sedimentation tank in order to reduce movement of soil outside the site throughout the construction phase of project.

3.1.2 Criterion 5 - Topsoil Preservation

The intent of this criterion is to ensure the preservation of available fertile soil on site and avoid its degradation during the process of construction.

Ø Appraisal

Ensure that 90% of fertile topsoil from disturbed area (including building footprint vehicular pathways and material storage areas) is preserved. Additionally, maintain its fertility, stabilize it and use it for landscaping activity post construction.

3.1.3 Criterion 6 - Construction Management Practices

The intent of this criterion is to ensure adoption of good management practices on site during the construction phase.

Ø Appraisal

- Adopt construction management practices and ensure safe disposal of waste generated during construction.
- Adopt at least two strategies from the list as given below, to minimize water consumption during construction.
  1. Use of gunny bags, ponding technique, or curing compound. Meter and monitor the consumption of water during construction.
  2. Use water-reducing admixture in concrete mix. Use of treated wastewater and/or captured storm water.

3.1.4 Criterion - 12 Indoor Air Quality

The intent of this criterion is to encourage design and monitoring of ventilation systems such that the indoor air quality meets minimum requirement as recommended by the relevant standards.

Ø Appraisal

- Ensure that the minimum requirements of CPCB (NAAQS) for assessing the quality of fresh air are fulfilled. Ensure that the minimum requirements of ASHRAE Standard 62.1–2010, Sections 4–7, Ventilation for Acceptable Indoor Air Quantity (with errata), or NBC 2016, Volume 2, Section 5, for quantity of fresh air are met.
- Ensure continuous monitoring of CO, CO2, temperature, and RH levels such that they meet the permissible thresholds as per ISHRAE standard 10001:2016,.
- Ensure that all interior wall and ceiling finishes such as primers, paints, putty, etc. have low VOC content as per Appendix 4C, Table 1 and are lead free.
- Ensure that all adhesives and sealants used have low VOC content. Ensure improved indoor air quality by adopting a minimum of three strategies from the following list;-
  1. Installation of indoor plants Promoting use of carpets and mats at all entrances
  2. Use of green cleaning products for housekeeping
  3. Installation of separate exhaust system for janitor/storage rooms for chemicals
  4. Installation of air curtains Air sanitization. Demand control ventilation

3.1.5 Criterion - 14 Wastewater Treatment

The intent of this criterion is to promote greywater and blackwater2 segregation and further treat them onsite to reduce the project's dependency on fresh water.

Ø Appraisal

- Ensure that 100% of wastewater generated on-site is treated through either a chemical-based or natural wastewater treatment system. Ensure that 100% of wastewater is segregated (into greywater and blackwater) and treated independently on-site.

3.1.6 Criterion - 23 Safety and Sanitation for Construction Workers

The intent of this criterion is to ensure safe, healthy, and hygienic working and living conditions for construction workers involved in the project.

Ø Appraisal

- Ensure compliance with the requirements of NBC, 2016 for all of the following:
    1. Part 1: Provision of necessary safety equipment and safety measures for construction workers.
    2. Part 2: Provision of clean drinking water, hygienic working and living conditions and sanitation facilities for the workers.
    3. Part 3: Provision of crèche facility for children of construction workers in case their families are allowed to work/live at the construction site.
- Adopt any one measure out of the following for the construction workers on-site:
    1. Provide a grocery store/canteen within the site premises.
    2. Organizes at least two events during the entire construction phase to create environmental awareness among the construction workers."

3.2 Provisions in CPWD

3.2.1 Security Deposit

The contractor shall submit an irrevocable performance guarantee of 5 % of the tendered amount in addition to other deposits mentioned elsewhere in the contract for his proper performance of the contract agreement, within the period specified from the date of issue of letter of acceptance.

3.2.2 Time Extension of Contract

The time allowed for carrying out the work as entered in the contract shall be strictly observed by the contractor and shall be reckoned from the day as mentioned in the NIT after the date on which the orders to commence the work is given to the contractor and can be extended by the Engineer-in-Charge if he opinion that the grounds shown for the extension of time are reasonable.

3.2.3 Health And Safety

The contractor shall comply with or cause to be complied with all the rules framed by government from time for the protection of health and sanitary arrangements for workers employed.

3.2.4 Performance guarantee

The performance guarantee shall be initially valid up to the stipulated date of completion plus 60 days beyond that. In case the time for completion of work gets enlarged, the contractor shall get the validity of performance guarantee extended to cover such enlarged time for completion of work.

3.2.5 Deviation in Quantity

The Engineer-in-Charge shall have power to make alteration in original specifications, drawings, designs and instructions that may appear to him to be necessary or advisable during the progress of the work. Substituted work which the contractor may be directed to do in the specified manner shall be carried out by the contractor on the same conditions in all respects including price on which he agreed.

3.2.6 Risk identification

Identified risks are risks due to riots, war invasion, act of foreign enemies, hostilities, civil war, rebellion revolution, insurrection, military or usurped power, any acts of government, damages from aircraft and acts of God such as earthquake, lightening and unprecedented floods over which the contractor has no control.

3.2.7 Commencement Of Work

The date for commencement of the work starts from 15th day after the date of giving order for its commencement or any other date specified. For slow performance or delay in the completion of the work, compensation, subject to a maximum of 10% of the tendered value, is recoverable.

3.2.8 Completion Certificate

Issue of completion certificates for works after 30 days of receipt of Contractor's notice Submission of final bills by the contractor or three months of the physical completion of the work whichever is earlier.

3.2.9 Payment Liability

Payment of verified final bills for works up to Rs 5 lacs is to be paid within 3 months of receipt of final bill from the contractor and for more than Rs 5 lac is to be paid within 6 months.

3.2.10 Bonus

In case, the contractor completes the work ahead of scheduled completion time, a bonus @ 1 % of the tendered value per month, computed on per day basis shall be payable to the contractor, subject to a maximum limit of 5 % (five percent) of the tendered value.

3.2.11 Defect Liability

The contractor or his working people shall break or destroy any part of building in which they may be working or any building, road, road kerb, fence, enclosure, water pipe, cables, drains, electric or telephone post or wires, trees, grass or grassland, or cultivated ground contiguous to the premises on which the work or any part is being executed or other faults appear in the work within twelve months falls under the liability of the contractor."

Chapter 4 Conclusion

4.1 Challenges in green construction projects

4.1.1 Higher costs for green construction practices and materials

"Green projects are typically more expensive to build than conventional projects. Capital costs for green projects are estimated to be 1 to 25% higher, according to one estimate. The higher costs are due to the complexity of the designs and the costs of modelling required to incorporate green practices into projects.

4.1.2 Technical difficulty during the construction process

A project manager puts a project plan into action by authorising the execution of tasks that result in project deliverables (Pettersen 1999; Ling, 2003). Green technologies frequently necessitate complex techniques and construction processes (Zhang et al., 2011).

4.1.3 Risk due to different contract forms of project delivery

According to Tagaza and Wilson (2004), the type of contract chosen for project delivery had a significant impact on the success of developing and implementing a green design. In green projects, the type of contract used must include all of the details of a fully integrated green design. If the design is locked before it is fully developed, this causes a problem.

4.1.4 Lengthy approval process for new green technologies and recycled materials

The market environment suggests that the planning process may take longer than expected, as the approval process for new green technologies and recycled materials can be lengthy (Tagaza and Wilson, 2004).

4.1.5 Unfamiliarity with green technologies

Many studies have shown that green technologies present some difficulties for developers, clients, and contractors. Insufficient knowledge or technical expertise, as well as unfamiliarity with the products, materials, system, or design, are two reasons suggested by Eisenberg et al. (2002).

4.1.6 Greater communication & interest required amongst project team members

The project manager must be able to manage a large number of suppliers, subcontractors, and team members in order to be successful. Communication is especially important for the green project because it allows the team members to understand the sustainable practices that are expected of them.

4.1.7 More time required to implement green construction practices on site

To ensure that sustainable practices are implemented on-site, project managers usually conduct random checks and on-site visits (Tagaza and Wilson, 2004). When time is of the essence, workers may be tempted to forego time-consuming sustainable practices in order to complete a project.

4.2 Integrated Project Management Framework for Green Buildings

Integrated – To bring together or incorporate parts into a whole

Project – Temporary with a defined beginning and end towards a singular goal

Management – The act or manner of managing; handling, direction or control

Putting all of these terms together, integrated project management refers to bringing together various elements in order to successfully manage a project from start to finish.

4.2.1 Green building project management frameworks should be more thorough and allow for more communication among all stakeholders than traditional building project management frameworks.

4.2.2 It is proposed that the research findings be integrated with traditional project management frameworks and the Sustainable Construction Framework (GRIHA, 2019) for the construction industry.

4.2.3 At the planning stage, project teams should assess the life cycle environmental costs of resources and products used so that they can decide and select appropriate products for use in green buildings.

4.2.4 Developing an organizational structure for a green construction project is the final step in the planning stage, and it determines the relationships between key personnel involved in the project. Contractors, engineering consultants, the environmental management team, the client, and the affected parties are all examples of these individuals.

4.2.5 During the construction of green buildings, an environment management programme based on GRIHA criteria for sustainable construction should be adopted. Sustainable construction procedures include the efficient use of natural resources for building aspects as well as the use of sustainable materials.

4.2.6 Penalties and incentives Schemes can be applied during the construction and operation of green buildings to ensure compliance with local environmental criteria. The project should be monitored and documented to improve the management of the entire construction process.

4.2.7 According to GRIHA, environmental performance audits should be conducted at regular intervals either internally by environmental managers or externally by consultants."

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