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A Critical Review on the Theoretical Framework and Critical Success Factors in Green Construction through Reverse Logistics

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Abstract **-** Construction activities must conserved energy, land, water and material to successfully implementing green construction, while planning and managing the work regarding the minimization of environmental impacts related to the construction process. Notwithstanding this, many arguments and discrepancies between the ideal form of green construction and existing construction due to the practical difficulties in realizing the concept of green construction. This paper critically reviews the existing green building assessment tools, theoretical framework and the critical success factors based on literature review search. Investigating the existing green building assessment tools, theoretical framework and critical success factors are fundamental in determining the successful implementation of green construction in the Indian construction environment.

Keywords **-** Critical success factors, Green building assessment tools, Theoretical Framework, Green construction and Indian construction environment.

I. INTRODUCTION

The Construction industry of India is an important indicator of the development as it creates investment opportunities across various related sectors. The construction industry has contributed an estimated INR 6708 billion to the national GDP in 2011-12 (a share of around **9**%).The industry is fragmented, with a handful of major companies involved in the construction activities across all segments; medium-sized companies specializing in niche activities; and small and medium contractors who work on the subcontractor basis and carry out the work in the field. In 2011, there were slightly over 500 construction equipment manufacturing companies in all of India. The sector is labor-intensive and, including indirect jobs, provides employment to more than 35 million people. The construction sector continued to register impressive growth with expansion as a result from the geared up performance of residential and mixed housing development [4].Many different inconsistent definitions of green construction exist from the planning to the execution stage. Among the conflicting definition, [5]defines green construction as the planning and managing a construction project, meeting the requirement in a contract while minimizing the impact on the environment while [8] describes green construction as a modernized construction or improvement of traditional construction [6] with comprehensive resources and energy consumption.

In addition to that, [11] define green construction as reduce energy, resources and environmental pollution through scientific management and technological progress [10] without compromising quality and health and safety [10&11]. Subsequently, [14] observe that, green construction requires contractors to plan and manage the construction projects with regards to the minimization of energy, resources and the amount of waste. These strategies may improve the project's budget and schedule and therefore reduce costs, increase productivity and protect the environment.

II. OVERVIEW OF GREEN BUILDING ASSESSMENT TOOLS AND GREEN CONSTRUCTION

Different types green building assessment tools are available worldwide for instance, BREEAM in United Kingdom, LEED in United States, CASBEE in Japan, Green Mark in Singapore and Green Star in Australia.

Table 1 Comparison of green building rating tools

	Optimize Site Potential	Optimize energy use	Product and conserve water	Use environmentally preferable product	Enhance indoor quality	Maintenance practice	Others
BREEAM(UK)	√	√	√	√	√	√	√
CASBEE(Japan)	√	√	√	√	√	√	√
GBI(Malaysia)	√	√	√	√	√	-	√
GREENMARK (Singapore)	-	√	√	-	√	√	√
GREENSTAR (Australia)	√	√	√	√	√	√	√
LEEDS(USA)	√	√	√	√	√	-	√

Table 1 demonstrates the comparison between green assessment tools for various countries. From this table, the areas that are more crucial in assessing green building worldwide are energy, site, water and indoor quality optimization, the use of environmentally preferable product or material and maintenance. These assessment tools are aim at

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improving occupant well-being, environmental performance and economic returns of buildings.

A. EDGE Program in India

The IFC, a member of the World Bank Group, and the Confederation of Real Estate Developers Associations of India (CREDAI), apex body of private real estate developers, have partnered to promote green buildings in the country through IFC's EDGE certification. An MoU was signed in the presence of Minister for Environment and Forests Prakash Javadekar on November 25, 2014.

B. BEE certification

The Indian Bureau of Energy Efficiency (BEE) launched the Energy Conservation Building Code (ECBC). The code is set for energy efficiency standards for design and construction with any building of minimum conditioned area of 1000 Sq mts and a connected demand of power of 500 KW or 600 KVA. The energy performance index of the code is set from 90 kW·h/sqm/year to 200 kW·h/sqm/year where any buildings that fall under the index can be termed as "ECBC Compliant Building". Moreover the BEE launched a five-star rating scheme for office buildings operated only in the day time in three climatic zones, composite, hot &dry, warm &humid on 25 February 2009. IGBC rated green buildings are also able to meet or exceed the ECBC compliance. The CII Sohrabji Godrej Green Business Centre is a BEE 5 star-rated building.

The Reserve Bank of India's buildings in Delhi, Bhubaneswar in Orissa and in Kerala has been star rated. In Tamil Nadu 11 buildings were star rated by BEE, in the year 2010, including RBI buildings.

The major energy saving measures implemented includes following:

- Optimized building design as per climate conditions
- EE building envelope o LEDs for lighting system
- Lighting controls integration such as occupancy sensors, daylight controls, and programmable timers.
- Increased set point temperatures to reduce energy consumption
- EE air conditioning systems o Energy management controls, and
- BMSs

C. Green houses

In Tamil Nadu, the government is planning to build solar-powered green houses for rural poor. It has allotted Rs.1,080 crore for construction of 60,000 houses. In Maharashtra, near Mumbai in the Thane District, Govardhan Eco Village, a community in India, has built buildings with compressed stabilized Earth blocks, Rammed Earth Technique, Cob Houses (ADOBE Bricks) with traditional thatched roofs. These buildings have received a five-star rating from GRIHA, an Indian Nationwide Green Standards for Buildings, a wing of the famous TERI.

D. Traditional building

Traditional buildings were energy efficient because architecture depended on the places. Buildings in the hot and dry regions, had corridors directing the wind to cool naturally. In wet regions, structures using natural light and breeze were used. Some examples are

- Hawa Mahal - Articulated windows provides cool breeze in a desert area.
- Golkonda - Ventilation is designed to let in fresh cool breeze, in spite of summer.

The traditional building practices were utilized in constructing the Dhyanalinga. Mud mortar stabilized with lime, sand, alum and some herbal additives was used. It has been suggested that, the current practices in green construction are OSHAS 18001, ISO 14001, material saving plan, water saving plan, energy saving plan and natural resources to mention but a few [1]. The finding from this study indicates the ISO 18001 practices are high among the current practices in green construction, followed by the rest of the practices which marked as moderate.

III. Investigating the Theoretical Framework

Having defined the term green construction, it is important to discuss the concept and theoretical framework of green construction. Shi et al. [10] describe the concept of green construction as the reflection of sustainable development with the comprehensive application of technology. Brundtland [2] defines the sustainable development as a development that meets the needs of the present and future generations. The sustainable development in the construction industry is a long term task and the green construction plays a key role in green building [11]. Tam and Tsui [13] observe that, the management and operational performance is an indicator for a successful implementation of green construction. Qi et al. [14] suggest the theoretical framework of green construction include environmental regulations, managerial concern and project stakeholder pressure. Figures 1 and 2 illustrate the concept and theoretical framework of green construction based on initial literature search.

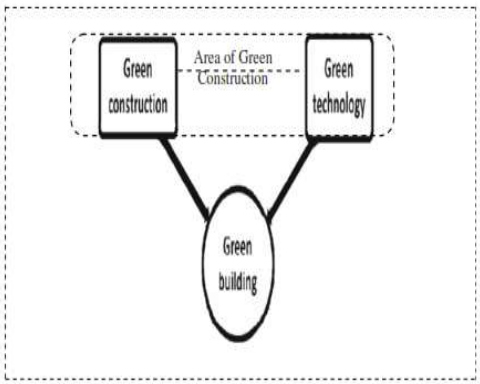

Fig. 1 Concept of sustainable development (Adapted from [9&10])

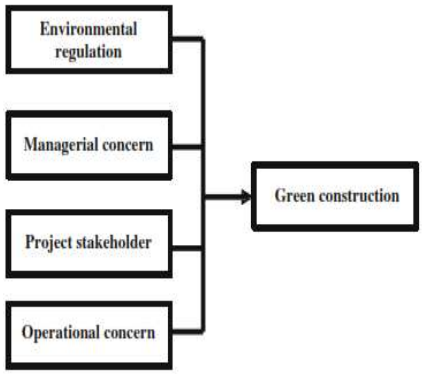

Fig. 2 Theoretical framework of green construction (Adapted from [13&14])

From this theoretical framework, all factors that lead to the successful implementation of green construction are further discussed as below.

1) Environmental Regulation

Specifying the technologies that must be used Stipulating specific environmental targets that must be achieved Introducing economic measures through distributing environmental costs and benefits Fines and penalties for non compliance with regulations have led to a more respectful attitude towards the environment More regulated industries will tend to include more environmental concerns

2) Managerial Concern

1. Commitment of top level management
2. Team effort on site, which includes involvement and support from min contractors, subcontractors and head offices
3. Adapt an environmental innovation strategy.
4. Place high value and concern on the environment and its protection
5. Raising environmental awareness is an important role for implementing ISO 14000 and EMS in construction industry
6. Scope and speed of firm' responses to environmental issues
7. Appropriate training to ensure companies implementing the environmental concepts and eliminate confusion on environmental issues.
8. Investment on environmental associated facilities and equipment and setting up related management structures for long term benefits
9. Investment for Research and Development (R&D) in order to maintain a privilege over other competitor
10. Comprehensive environmental planning

3) Project Stakeholder

3.1 Client

• The importance of clients can be reflected by the various ways for instance the clients can influence the adoption of innovation strategy and identify specific requirements for contractors

• Pressure on project participants to improve buildings' lifecycle performance Client strongly shapes the products and processes from the very beginning of construction projects

• Failure to meet the requirements on environmental protection may lead to the removal from the tender lists

3.2 Community

• Public opinion on firm's environmental performance represents an important factor affecting the way firms do business

• Failing to meet a good environmental performance may lead to a bad image for all companies involved

3.3 NGO

• Demand of occupational health and safety from the employees lead to positive measures in obtaining OHSAS 18001 and ISO 14001 certifications

3.4 Operational Concern

1. Maintenance and equipment

• Regular maintenance is required to ensure the equipment is functioning properly and to maintain its quality.

• Plants should be properly maintained to avoid creating disturbance to the environment

2. Air pollution control

• Water spray and screening (covering) to minimize flying dusts

3. Noise pollution control

• Avoiding site operations beyond allowable time limits.

4. Water pollution control

• Manage water quality properly on site. Prevent anything that has potential to pollute such as muddy water from entering surface water drainage

• Monitor water usage and promotion of water conservation, waste water collection and treatment and water reuse and recycle system

5. Waste pollution control

• Purchasing management to reduce excessive orders

• Waste reuse and recycling scheme

• Use of green construction technology such as chemical waste treatment

6. Ecological impact

• Degree of efforts in reducing ecological impact such as topsoil, trees and vegetation and living habitats

7. Energy Consumption

• Monitor the energy consumptions in both the construction process and the finished building

IV. REVERSE LOGISTICS

It is for all operations related to the reuse of products and materials. It is "the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics."Growing green concerns and advancement of green supply chain management concepts and practices make it all the more relevant.

V. INVESTIGATING THE CRITICAL SUCCESS FACTORS

Success factor is a set of facts or influences that contribute to the success or failure of a project [24]. Cooke-Davies [4] distinguishes success factors as inputs to the management systems that lead directly or indirectly to the success of the project or business. McCabe [16] identifies critical success factors as those input factors for the project which will most significantly influence project performance. The choice of critical success factors (CSFs) is important for any project development and should be established at the beginning of the project phase.

The review of literature search highlights the main areas of critical success factors for the successful implementation of green construction. Analysis from literature culminates the awareness and understanding is crucial to ensure a successful implementation of green construction [14].

In addition, the other critical success factors for a successful implantation of green construction established in the literature review includes a proper waste management system [14].

A few suggestions and strategies for the successful implementation of green construction were developed from [9]. Among the strategies are listed below:

1. Standardization of design
2. Stock control to minimize over-ordering
3. Environmental education for the workforce
4. Recycling and waste disposal companies as part of the supply chain
5. Practicing just-in-time delivery approaches
6. Penalties for poor waste management
7. Incentives and tender premiums for waste minimization
8. Waste auditing
9. Increased use of off-site techniques
10. Use of on-site compactors
11. Suppliers required providing materials and products in small batch sizes
12. Reverse logistics
13. Imposition of stricter regulations
14. Establishment of longer customer-supplier relationship
15. Increased awareness of environmental
16. Social and economic impact
17. Implementation of environmental management system
18. Support and push from top management
19. Implementation of ISO 14000 certifications
20. Regular audits on green environmental standards
21. Customer's willingness to pay extra for green construction and engagement by government bodies during the formulation of the regulations
22. Setting up energy saving objectives at operational levels
23. Consideration of energy objectives at the strategic planning level
24. Value management of energy plans
25. Lifecycle costing accuracy
26. Proved education/awareness of designers about energy efficient materials and techniques use of cost and environmental assessment tools

In addition, factors that are considered as critical to the successful implementation of green construction based on literature analysis are listed as below:

1. High return on investment
2. Role and responsibilities of stakeholders
3. Effective labour and material management
4. Financial well being and capital intensity of organization
5. Environmental policies and procedure
6. Clear client's specification design and production.
7. Strict environmental regulations
8. Manager's concern on the environment and its protection
9. Commitment of top level management
10. Education and training
11. Internal and external audit
12. Technology processes and development
13. Site environmental assessment
14. Requirement on green equipment and machineries
15. Financial investment in green technology

VI. CONCLUSION

It has been established that there are many different themes and definition of green construction, but they all aim at improving the existing way of constructing buildings. Green construction requires people who intend to implement it to spend more time to fully understand the benefits and major critical success factors of green construction. These factors should be treated as significant in the process of implementing and practicing green construction with the aim of improving the environment, health and safety, quality and long term investment.

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